Strategies to Reduce Sodium Intake in the United States

Committee on Strategies to Reduce Sodium Intake
Food and Nutrition Board

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Willing is not enough; we must do."
—Goethe

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This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Research Council's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We wish to thank the following individuals for their review of this report:

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Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the final draft of the report before its release. The review of this report was overseen by **Elaine L. Larson,** Columbia University, and **Johanna Dwyer,** National Institutes of Health. Appointed by the Institute of Medicine, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the authors and the institution.

Preface

In 1969, the White House Conference on Food, Nutrition, and Health issued recommendations that, among other important nutrition concerns, highlighted the role of sodium in hypertension and marked the starting point of public health initiatives to address the high levels of sodium intake among the U.S. population. Forty years later, in January 2009, the first meeting of the Institute of Medicine (IOM) Committee on Strategies to Reduce Sodium Intake convened. In the intervening years, much had changed—what we eat, where we eat, and who prepares our food. However, in spite of the attempts of many in both the public health community and the food industry, what did not change is the amount of sodium we consume each day, largely in the form of salt. High sodium intake puts the whole population—young and old, male and female, all ethnic groups—at risk for hypertension and subsequent cardiovascular events such as heart failure and stroke.

Hypertension is extraordinarily common: 32 percent of adult Americans have hypertension, and roughly another third have pre-hypertension. The costs of these health conditions are staggering. Estimates place the direct and indirect costs of hypertension at $73.4 billion in 2009.

The committee's charge was to recommend strategies to reduce Americans' intake of sodium to levels consistent with the *Dietary Guidelines for Americans*. In the wake of the many unsuccessful and/or unsustainable efforts, this was no small task, but—in light of the potential public health benefit that could be achieved if the goal was met—it was a worthy one. Simply put, the task of the committee was broad, far-reaching, and complex. I am delighted that the assembled committee had the individual expertise and experience as well as the collective will to serve the health of the public and the willingness to meet the significant challenge of our charge. It was a privilege to be a part of this effort.

Over the course of the study, we met often and consulted many sources. Our first meeting set the tone as we heard from each of our study sponsors. A subsequent public hearing elicited needed input and was extremely useful to the committee's deliberations. Invited speakers and panelists included Paul Breslin, Cindy Beeren, Ed Roccella, Susan Borra, Michael R. Taylor, Fred Degnan, Philip Derfler, Cliff Johnson, Alanna Moshfegh, Eric Hentges, Corinne Vaughan, Vanessa Hattersley, Ed Fern, Chor San Khoo, Todd Abraham, Douglas Balentine, Deanne Brandstetter, Stephanie Rohm Quirantes, and Elizabeth Johnson. A host of persons chose to share their perspectives and experience with us on that day and afterward by input to the committee's website. We sought specific advice and analysis regarding current dietary patterns, a better understanding of restaurants and others in the foodservice industry, and the range of options available for consideration from a regulatory perspective. Each request was met fully and greatly facilitated our work.

On behalf of the committee, I extend our deepest thanks to the able project staff of the Institute of Medicine: Christine Taylor, study director; Caitlin Boon, program officer; Heather Del Valle, associate program officer; Emily Ann Miller, research associate; Marianne J. Datiles, senior program assistant; and Saundra Lee, senior program assistant. All gave generously of their talents and time. Our committee benefited greatly from their industry and guidance as we deliberated on our approach and challenges. In addition, the committee would like to thank other members of the Food and Nutrition Board staff including Linda Meyers, director; Sheila Moats, associate program officer; Alice Vorosmarti, research associate; Julia Hogland, research associate; Heather Breiner, program associate; Anton Bandy, financial officer; and Geraldine Kennedo, administrative assistant, who assisted at critical times during the project. On behalf of the committee, I would also like to thank David Vladeck for his service as a committee member from October 2008 until May 2009. Further, the committee would like to thank Mathematica Policy Research, Inc. for providing data analyses.

In the view of the committee, the recommendations in this report, when undertaken, will result in the desired decrease in sodium intake across the U.S. population. To this end, we are grateful to have been a voice for this important initiative that will now require the commitment of many.

Jane E. Henney, *Chair*
Committee on Strategies to Reduce Sodium Intake

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APPENDIXES*

*Appendixes A through L are not printed in this book, but can be found on the CD at the back of the report.

Summary

Activities to reduce sodium intake of the U.S. population have been ongoing for more than 40 years, but they have not succeeded. In retrospect, these activities were insufficient in the face of the nature of the public health problem they were meant to address. Without an overall reduction of the level of sodium in the food supply—that is, the level of sodium to which consumers are exposed on a daily basis from processed and restaurant foods—the current focus on instructing consumers to select lower-sodium foods and making available reduced-sodium "niche" products cannot result in intakes consistent with the *Dietary Guidelines for Americans*. Further, food industry (defined as both the processing and restaurant/foodservice sectors) efforts to voluntarily reduce the sodium content of the food supply face obstacles, are not consistently undertaken by all, are not readily sustained, and have proven unsuccessful in lowering overall sodium intake. These are significant failures given that excess sodium intake is strongly associated with elevated blood pressure, a serious public health concern related to increased risk of heart disease, stroke, congestive heart failure, and renal disease.

THE CHALLENGES

Americans average a daily intake of more than 3,400 mg of sodium (equivalent to 8.5 g, or about 1.5 teaspoons, salt). This substantially exceeds the existing maximum intake level (2,300 mg/d sodium or 5.8 g/d salt [about 1 teaspoon salt]) established by the 2005 *Dietary Guidelines for Americans*. Data show that dietary sources of sodium are plentiful, are derived largely from processed and restaurant foods, and include many foods not commonly perceived as sources of sodium. Data also dispel the misconception that excess salt intake is due to salt added by the consumer at the table. Such use appears to account for only about 5 percent of sodium consumed. Evidence suggests that reductions in sodium intake may be achieved by reducing salt in food and allowing people to use a salt shaker. A study has shown that on average, participants added back less than 20 percent of the sodium removed from the food when allowed unlimited use of salt shakers.

A key factor in the limited success of efforts to reduce sodium intake is that salt—sodium chloride, the primary source of sodium in the diet—has desirable characteristics from a culinary perspective. Added salt improves the sensory properties of foods that humans consume and is inexpensive. Americans rely heavily on processed foods and menu items prepared outside the home, making such foods the predominant source of sodium intake in the United States. Clearly, efforts to reduce the sodium content of the food supply are needed to improve public health. However, food industry representatives indicate that they cannot sell or serve products that are less palatable than those of their higher-sodium competitors; food flavor is the major determinant of food choice and usually overrides other factors that influence food selection. What is lacking is a way to coordinate reduction of salt in foods across the board by all manufacturers and restaurant/foodservice operations—a level playing field. The key question is: How can a level playing field be achieved while avoiding consumer dissatisfaction?

Importantly, the preference for added salt in food is mutable. Sensory preferences for salt can be decreased. This preference, which is beyond known physiological need, may be due in part to evolutionary pressures to consume salt that have shaped an innate liking for its taste and due in part to learning, particularly early learning. Indeed, a high-salt diet may actually increase the liking of salty foods, and the U.S. food supply, with its high salt content, may work against consumers successfully changing their flavor preferences and impede their acceptance of lower-sodium foods. Existing experiences with decreasing the sensory preference for salt suggest it could be successfully accomplished through a stepwise process that systematically and gradually lowers salt levels across the food supply.

Thus, if strategies to reduce sodium intake in the United States are to be successful, they must embrace an approach that emphasizes the entire food system and emphasizes sodium intake as a national concern. This report recommends the use of regulatory tools in an innovative and unprecedented fashion to *gradually* reduce a widespread ingredient in foods through a well-researched, coordinated, deliberative, and monitored process. The current level of sodium added to the food supply—by food manufacturers, foodservice operators, and restaurants—is simply too high to be "safe" for consumers given the chronic disease risks associated with sodium intake for all population segments. To succeed, however, the approach must be supported by a strong federal government commitment to sodium reduction and leadership from the Department of Health and Human Services (HHS) in cooperation with other agencies and groups to ensure coordination with all stakeholders including the food industry and consumers. The goal is to carefully achieve over time, and without loss of consumers' acceptance of foods, the "safe" levels of sodium in the diet that are consistent with public health recommendations. Implementation will be challenging and will require both resources and a sustained, high-level commitment to making these important changes a reality. The effort must include more effective ways of reaching consumers about the importance of sodium intake reduction and approaches for selecting healthful diets.

APPROACHING THE TASK

This report focuses on strategies to reduce the sodium intake of the U.S. population. In Fall 2008, a 14-member committee was convened at the request of Congress and supported by several agencies within the HHS. The committee's work was predicated on the importance of reducing sodium intake and the agreement that achieving lower intakes is a critical public health focus for all Americans. No segment of the population is immune from the adverse health effects, despite the common misunderstanding that sodium intake is a concern only for the "salt sensitive" and the elderly. Consistent with its charge, the committee relied upon consensus conclusions from numerous authoritative bodies as support for the health benefits related to population-based sodium reductions.

The committee was asked to make recommendations about various means that could be employed to reduce dietary sodium intake to levels recommended by the *Dietary Guidelines for Americans*—currently, less than 2,300 mg/d (see Box 1-1, Statement of Task). The recommended strategies were to include actions by food manufacturers, government approaches such as regulations and legislation, and public and professional outreach and education. Figure S-1 illustrates the committee's approach to its task.

The committee began its study by evaluating the outcomes of past and current efforts to reduce sodium intake. It explored knowledge about sensory preferences for salt and its role in modulating overall food flavor, key factors in strategies to reduce sodium intake. Preservation and physical property roles of sodium in food were reviewed. Background information was obtained on food manufacturing and restaurant/foodservice operations and on factors important to understanding consumer food choices and behaviors. Given that regulatory options were to be considered, the

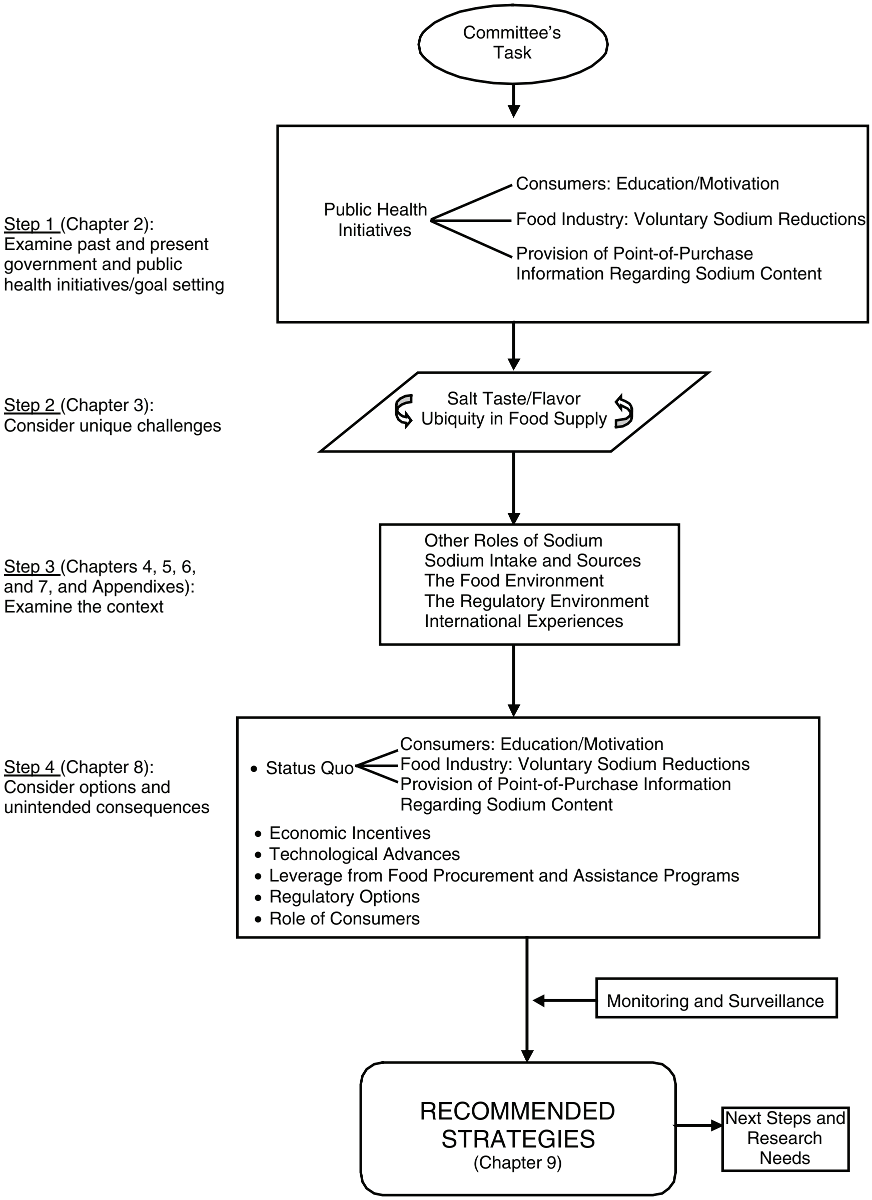

FIGURE S-1 Committee's approach to identifying recommended strategies to reduce sodium intake of the U.S. population.

committee also characterized the current regulatory framework. Further, the committee reviewed the possibility of leveraging activities through food specifications set by large government food purchasers, explored economic incentives such as a salt tax, and noted sodium reduction activities in other countries. It also considered the potential of innovative technologies for salt substitutes and enhancers as well as culinary advances.

Finally, the committee integrated the information into a series of discussions that led to conclusions about the strategies to be recommended, implementation tasks, and information gaps.

CONTEXT FOR THE RECOMMENDATIONS

This study was conducted against the backdrop of the unavoidable conclusion that existing strategies have not succeeded in achieving meaningful reduction of sodium intake. Efforts targeted at reducing sodium intake were initiated during the 1969 White House Conference on Food, Nutrition, and Health and have involved a range of organizations and a variety of activities. Overall, estimates of sodium intake have not decreased. In fact, as shown in Figure S-2, estimates reveal an upward trend from the early 1970s. Although some of the differences in intake estimates over time may

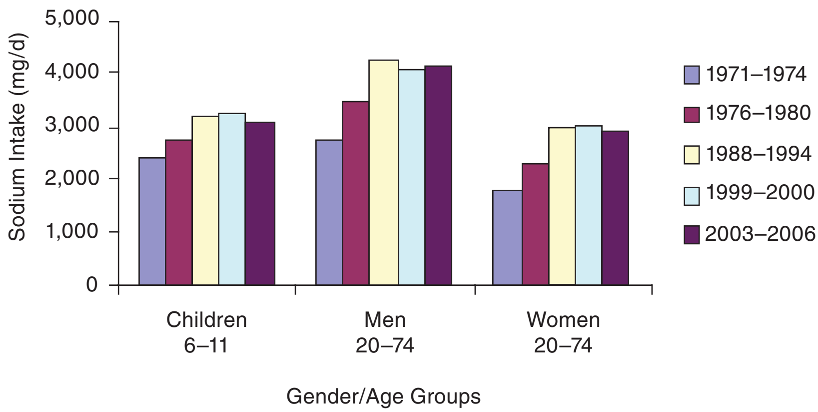

FIGURE S-2 Trends in mean sodium intake from food for three gender/age groups, 1971–1974 to 2003–2006.
NOTES: Analyzed using one-day mean intake data for the National Health and Nutrition Examination Survey (NHANES) 2003–2006 to be consistent with earlier analyses and age-adjusted to the 2000 Census; includes salt used in cooking and food preparation, but not salt added to food at the table. d = day; mg = milligram.
SOURCE: Briefel and Johnson (2004) for 1971–2000 data; NHANES for 2003–2006 data.

be due to differences in survey methodologies, increase in estimated intake has occurred. In any case, mean intakes over this 40-year period, except for women in the first two survey periods, are in excess of the upper intake limit specified by the 2005 *Dietary Guidelines for Americans*.

As expected, dietary sodium intake density measures—meaning the number of milligrams sodium per 1,000 calories consumed—show that the intake differences expressed as milligrams disappear among children and adults on a sodium density basis, indicating the relationship between calorie intake and sodium intake (Figure S-3). As compared to a sodium intake density of < 1,150 mg/d per 1,000 calories needed to match the recommended intake of < 2,300 mg/d sodium (and assuming a 2,000-calorie reference diet), most groups had mean intakes that exceeded guideline levels, even during the earlier time periods when sodium densities appeared lower than in more recent years.

Moreover, trends in hypertension demonstrate an upward climb since the 1980s (Figure S-4). Although increased obesity rates may be associated with the increase among men, they do not explain all of the increase among women.

Past initiatives placed considerable, if not the primary, burden on the consumer to act to reduce sodium intake. These included educational and

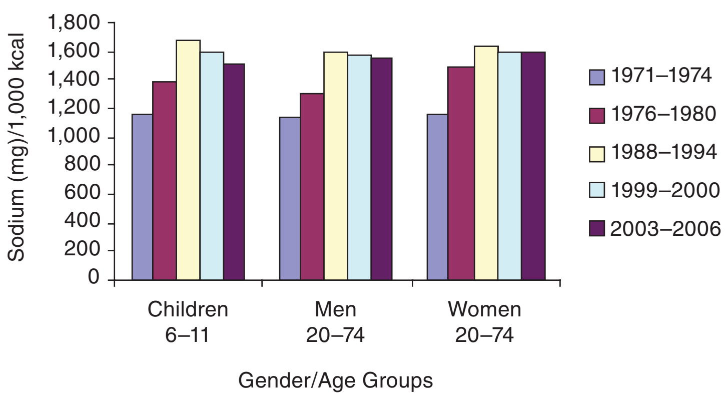

FIGURE S-3 Trends in mean sodium intake densities from food for three gender/age groups, 1971–1974 to 2003–2006.
NOTES: Analyzed using one-day mean intake data for the National Health and Nutrition Examination Survey (NHANES) 2003–2006 to be consistent with earlier analyses and age-adjusted to the 2000 Census; includes salt used in cooking and food preparation, but not salt added to food at the table; one-day mean intakes calculated using the population proportion method. kcal = calorie; mg = milligram.
SOURCE: Briefel and Johnson (2004) for 1971–2000 data; NHANES for 2003–2006.

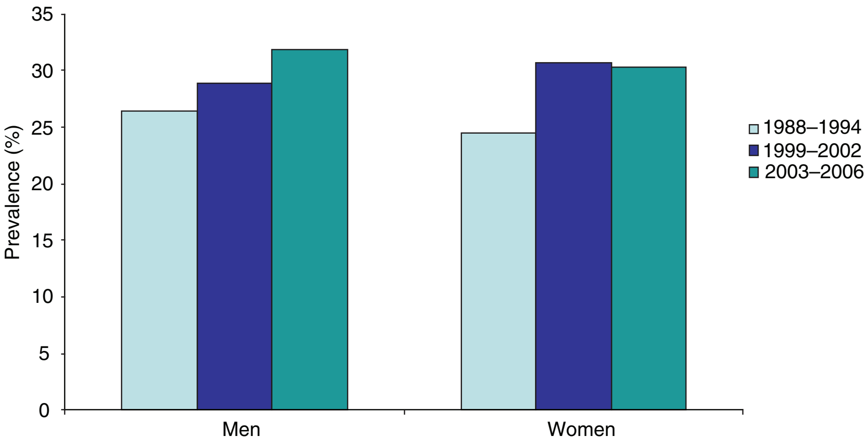

FIGURE S-4 Trends in elevated blood pressure/hypertension from the National Health and Nutrition Examination Survey (NHANES) for persons ≥ 20 years of age.
NOTES: Hypertension, as defined by the data source, is an elevated blood pressure (systolic pressure ≥ 140 mm Hg or diastolic pressure ≥ 90 mm Hg) and/or use of anti-hypertensive medications; data age-adjusted to 2000 population.
SOURCE: NCHS, 2009.

awareness campaigns, efforts to motivate consumers, and requests to the food industry to support these activities by marketing lower-sodium alternative products and voluntarily lowering the sodium content of its products. Overall, these approaches have not resulted in reduced sodium intake. As Figure S-2 shows, sodium consumption remains high. One reason is that the nature of the sensory preference for salt has likely resulted in lower-sodium products tasting less acceptable than "regular" products to many consumers. Also, the message about sodium appears to have been lost in an array of competing messages about fat, sugar, and cholesterol. A national survey conducted by the Food and Drug Administration (FDA) suggests that between 1982 and 1990—a time of intense educational programs on reduction of sodium intake and the only period with available data—the maximum percentage of Americans who reported attempting to reduce their sodium intake never reached more than about 30 percent. Voluntary reductions in the sodium content of the food supply have had limited success. Reports suggest that during the past 20 years some food companies have accomplished a 10–20 percent reduction in sodium for some products, with a few reportedly achieving reductions closer to 40–50 percent. While this is encouraging, the committee found the general picture to reveal little success for the industry as a whole. During the committee's public workshop held in open session, industry panel members described their efforts and reported varying levels of success, and identified the need for a level playing field within the industry. The panel highlighted the difficulty in marketing lower-salt foods when competitors' products that are not lower in salt are preferred by consumers. This situation is mirrored by available data indicating that relatively few foods bear sodium-related label claims and, over time, fewer newly introduced products bear sodium-related claims, compared to fat and calorie claims. Anecdotal reports suggest that to some consumers, such sodium claims signal that the food will not have a pleasing taste, and therefore they do not buy the product. Further, salt substitutes have limited applications.

Restaurant/foodservice operations—which contribute a significant amount of sodium to the American diet—have undertaken few organized efforts to reduce the sodium content of menu items. The reasons are believed to include the diverse nature of the operations coupled with little motivation to modify menu items to retain their appeal while reducing the salt content.

RECOMMENDATIONS

The committee organized strategies for reducing sodium intake by first identifying broad recommendations. The recommendations resulted in one set of primary strategies and several sets of interim or supporting strategies. These are listed in Box S-1.

Primary Strategies

Recommendation 1 encompasses the primary strategies and is linked to the fact that salt, as a substance added to foods marketed by the food industry, is regulated by FDA. Under the *Federal Food, Drug, and Cosmetic Act*, substances added to foods by manufacturers are subject to FDA pre-market approval unless they are generally recognized as safe (GRAS). The conditions under which a substance is GRAS can be specified by FDA to ensure safe use. Currently, the manufacturers' addition of salt to foods is considered a GRAS use, but no standards have been set concerning the levels that would constitute a "safe use" of salt.

The committee concluded that the ability to adjust the GRAS status of salt by setting standards for its addition to foods is a potentially powerful yet relatively adaptable regulatory tool. The potential of GRAS modification seemed particularly promising given the failure of the non-regulatory options to accomplish meaningful reductions in the sodium content of the food supply. In short, the primary strategies are linked to the following conclusions:

- Excess salt intake is a major public health problem.
- More than 40 years of voluntary initiatives have failed to reduce salt intake.
- Most salt consumed is in foods sold to consumers.
- Standards for the addition of salt to processed and restaurant/foodservice foods are the best strategy to protect the public health.

The goal is clearly not to ban salt use or to make foods unpleasant for consumers, but to begin the process of reducing the excessive addition of salt to processed foods and restaurant/foodservice menu items. If used judiciously and with careful preliminary analysis, setting standards for the levels of salt in food should reduce sodium intake. If the process of implementing such regulatory provisions is carried out over time in a stepwise manner, negative impacts on the consumer's enjoyment of food and response to food flavors should be minimized.

The starting point for use of the available regulatory tools is the conclusion first voiced in 1979 that salt—given the levels at which it is currently added to the food supply—is no longer a substance for which there is a reasonable certainty of no harm. However, rather than revoke the status of salt as a GRAS food substance, the committee recommends activities to modify the conditions under which salt added to foods can remain GRAS and by which total levels of sodium in the food supply can be reduced. That is, taking into account current dietary recommendations for its consumption, salt is a substance for which a safe use level in foods could be established. This approach is preferable to revoking the GRAS status of all uses of salt. First, salt is GRAS at some levels of consumption. Second, revoking GRAS status would cause disturbances in the food supply that could undermine consumers' support for regulatory actions to protect their health while increasing the regulatory burden on both FDA and the food industry to likely unacceptable levels. Further, revoking GRAS status is not consistent with the fact that sodium is an essential nutrient.

The committee regards modification of the GRAS status of salt as underpinning a new set of strategies that could effectively reduce sodium intake. It would address the concern that much of the sodium in the diet comes from sources largely outside consumers' direct control. There is evidence that "passive" changes in the environment can impact consumers' health and well-being more effectively than placing the entire burden on consumers to act to modify their environment and behavior in the face of many competing priorities and challenges.

Given the ability of the existing regulatory provisions to set standards

BOX S-1
Recommended Strategies

Primary Strategies

RECOMMENDATION 1
The Food and Drug Administration (FDA) should expeditiously initiate a process to set mandatory national standards for the sodium content of foods.

(1.1) FDA should modify the generally recognized as safe (GRAS) status of salt added to processed foods in order to reduce the salt content of the food supply in a stepwise manner.

(1.2) FDA should likewise extend its stepwise application of the GRAS modification, adjusted as necessary, to encompass salt added to menu items offered by restaurant/foodservice operations that are sufficiently standardized so as to allow practical implementation.

(1.3) FDA should revisit the GRAS status of other sodium-containing compounds as well as any food additive provisions for such compounds and make adjustments as appropriate, consistent with changes for salt in processed foods and restaurant/foodservice menu items.

Interim Strategies

RECOMMENDATION 2
The food industry should voluntarily act to reduce the sodium content of foods in advance of the implementation of mandatory standards.

(2.1) Food manufacturers and restaurant/foodservice operators should voluntarily accelerate and broaden efforts to reduce sodium in processed foods and menu items, respectively.

(2.2) The food industry, government, professional organizations, and public health partners should work together to promote voluntary collaborations to reduce sodium in foods.

Supporting Strategies

RECOMMENDATION 3
Government agencies, public health and consumer organizations, and the food industry should carry out activities to support the reduction of sodium levels in the food supply.

(3.1) FDA and the U.S. Department of Agriculture (USDA) should revise and update—specifically for sodium—the provisions for nutrition labeling, related sodium claims, and disclosure or disqualifying criteria for sodium in foods, including a revision to base the Daily Value for sodium on the Adequate Intake.

(3.2) FDA should extend provisions for sodium content and health claims to restaurant/foodservice menu items and adjust the provisions as needed for use within each sector.

(3.3) Congress should act to remove the exemption of nutrition labeling for food products intended solely for use in restaurant/foodservice operations.

(3.4) Food retailers, governments, businesses, institutions, and other large-scale organizations that purchase or distribute food should establish sodium specifications for the foods they purchase and the food operations they oversee.

(3.5) Restaurant/foodservice leaders in collaboration with other key stakeholders, including federal, state, and local health authorities, should develop, pilot, and implement innovative initiatives targeted to restaurant/foodservice operations to facilitate and sustain sodium reduction in menu items.

RECOMMENDATION 4
In tandem with recommendations to reduce the sodium content of the food supply, government agencies, public health and consumer organizations, health professionals, the health insurance industry, the food industry, and public-private partnerships should conduct augmenting activities to support consumers in reducing sodium intake.

(4.1) The Secretary of Health and Human Services (HHS) should act in cooperation with other government and non-government groups to design and implement a comprehensive, nationwide campaign to reduce sodium intake and act to set a time line for achieving the sodium intake goals established by the *Dietary Guidelines for Americans*.

(4.2) Government agencies, public health and consumer organizations, health professionals, the food industry, and public-private partnerships should continue or expand efforts to support consumers in making behavior changes to reduce sodium intake in a manner consistent with the *Dietary Guidelines for Americans*.

RECOMMENDATION 5
Federal agencies should ensure and enhance monitoring and surveillance relative to sodium intake measurement, salt taste preference, and sodium content of foods, and should ensure sustained and timely release of data in user-friendly formats.

Ensuring Monitoring

(5.1) Congress, HHS/CDC (Centers for Disease Control and Prevention), and USDA authorities should ensure adequate funding for the National Health and Nutrition Examination Survey (NHANES), including related and supporting databases or surveys.

Expanding and Enhancing Monitoring

(5.2) CDC should collect 24-hour urine samples during NHANES or as a separate nationally representative "sentinel site"-type activity.

(5.3) CDC should, as a component of NHANES or another appropriate nationally representative survey, begin work immediately with the National

continued

BOX S-1
Continued

Institutes of Health (NIH) to develop an appropriate assessment tool for salt taste preference, obtain baseline measurements, and track salt taste preference over time.

(5.4) CDC in cooperation with other relevant HHS agencies, USDA, and the Federal Trade Commission should strengthen and expand its activities to measure population knowledge, attitudes, and behavior about sodium among consumers.

(5.5) FDA should modify and expand its existing Total Diet Study and its Food Label and Package Survey to ensure better coverage of information about sodium content in the diet and sodium-related information on packaged and prepared foods.

(5.6) USDA should enhance the quality and comprehensiveness of sodium content information in its tables of food composition.

(5.7) USDA in cooperation with HHS should develop approaches utilizing current and new methodologies and databases to monitor the sodium content of the total food supply.

for the conditions of use of a substance added to foods in a manner that is responsive to a number of considerations, FDA could be charged with developing mandatory standards appropriate to the conditions within the food market and the reality of current (and future) technologies. Such standard setting could also stimulate the development of new technologies and flavor alternatives.

It is important that a decrease in the sodium content of foods be carried out gradually, with small reductions instituted regularly as part of a carefully monitored process that allows appropriate adjustments based on real-time data and outcomes. As salt levels in the overall food supply decrease there is likely to be a concomitant decrease in the population's sensory preference for salt, facilitating a further reduction in sodium intake.

Modifying the GRAS status of salt will be a complicated and challenging process for FDA. It will require considerable information gathering, detailed input from stakeholders, in-depth analysis of the food supply, use of simulation modeling of the effect of different levels of sodium content on total intake, examination of consumer eating behaviors, adjustments for food safety concerns, and studies of economic impact and potential unintended consequences. This will require resources and time, and it should be based on a step-down process with built-in feedback loops and routine monitoring to ensure that the efforts are working as planned and that the next step in the process is appropriate. It will also require FDA to liaison with USDA, which would have to undertake activities to implement the standards for the food products it oversees. On balance, the impact on reducing consumers' intake of sodium, its ability to provide a level playing field that has eluded the food industry when only voluntary activities are available, and its long-term sustainability are compelling arguments for recommending the modification of GRAS status of salt.

The significant contribution to sodium intake made by restaurant/foodservice menu items warrants Strategy 1.2, which extends GRAS standards to this sector of the food supply. The strategy is based on application of the *Federal Food, Drug, and Cosmetic Act* to foods whose components have moved in interstate commerce, thus making the food item subject to the standards relevant to processed foods. Such standards are only practicable with large, multiunit chain restaurant/foodservice operations. However, it is also likely that through the process of working with the large operations, ways will become clear for working with smaller operations over time. Given the extremely unfamiliar and inherently disruptive nature of reaching into independent restaurant settings, sodium reduction efforts can only be accomplished slowly as part of an informed experience.

Interim and Supporting Strategies

Interim strategies are reflected by Recommendation 2. While the primary strategies should be initiated immediately, as a practical matter enacting regulations requires time. In the interim, voluntary strategies could achieve meaningful reductions of sodium intake prior to implementation of mandatory standards for levels of salt added to foods by manufacturers and restaurant/foodservice operators. While identifying these strategies as important interim steps, the committee underscores that experience indicates that voluntary standards will not be sufficient to provide adequate breadth and sustainability of reductions and do not guarantee the level playing field that is important to realizing meaningful sodium reduction in the food supply.

Supporting strategies are not merely suggestions for rounding out sodium reduction activities, but play an essential role in accomplishing the goals. They require the integration of multiple government and stakeholder activities with HHS playing a leadership role. Supporting strategies are directed to a range of stakeholders. Major interests include national coordination of a comprehensive approach, involvement of the food industry, and innovative approaches to reaching consumers.

While a major interest of the recommended strategies is ensuring that the consumer does not bear an unreasonable burden in reducing sodium intake, the consumer nonetheless is a key player. Activities targeted to reducing the overall sodium content of the food supply are paramount, but they are not expected to be sufficient. Consumers must take personal actions to reduce sodium intake within the context of the recommended changes to the food supply. Past initiatives to assist consumers in reducing sodium intake may have included activities that were not well researched, designed, or effective in reaching consumers. These limitations must now be explored and overcome. Relevant activities requiring exploration include sustainable diet-related behavioral changes through selection of lower-sodium foods, portion control, and other healthful food choices by (1) increasing consumer understanding of the importance of elevated blood pressure as a public health problem and the value to health of reducing sodium beginning at the earliest ages and continuing throughout the lifespan; (2) increasing consumer understanding of the ubiquitous nature of sodium in the food supply and the importance of supporting government and industry activities to reduce sodium in foods; (3) changing consumer attitudes toward and perception of lower-sodium foods; and (4) facilitating consumer understanding of the role of sodium reduction as part of an overall healthful diet. The development of appropriate messages needs new and focused attention and will require innovative consumer research, including possibilities for integrating reduction of sodium intake into existing, broad messages about diet and health.

Additionally, there is a critical need to ensure the continuation of monitoring and surveillance relevant to sodium intake as well as to initiate efforts to immediately establish baseline data. Existing activities should be expanded to include the use of better methods, such as urinary sodium measures, and the inclusion of new measures, such as salt sensory preferences of consumers. The committee also considered the potential for unintended consequences associated with population-wide reduction of sodium intake. Negative impacts on iodine status or food safety, the two most common concerns for sodium reduction efforts, were not regarded as likely, although monitoring would be warranted. Funding will be needed for preliminary data-gathering and research, implementation, and monitoring. Specific funding levels cannot be quantified at this time, but the availability of resources is essential to the success of the strategies.

IMPLEMENTATION OF RECOMMENDATIONS AND INFORMATION GAPS

The committee outlined a number of implementation approaches, but recognized that the level of detail needed to convert the overall strategies into effective action is beyond its scope and requires information not currently available or as yet not researched. Implementers therefore will have to explore these approaches and related options as they become apparent, but should begin with information gathering and modeling of effects and outcomes.

- The committee concluded that modification to the GRAS status of salt in food could be accomplished best if FDA (1) specifies as GRAS the uses and use levels of salt that allow persons to consume such foods as part of a normal diet with a reasonable likelihood of keeping their total daily intake of sodium consistent with the *Dietary Guidelines for Americans*; (2) implements disclosure or labeling statements as part of a stepwise process for GRAS modification, provided research demonstrates that the labeling is effective; (3) provides for exemptions as appropriate; and (4) considers petition options. Estimation of costs and specific funding recommendations were outside the committee's charge, but these tasks and associated coordination and preliminary research will require considerable resources and a renewed national focus on sodium.

Other implementation factors address practices to reduce sodium content of processed foods and menu items and the factors important to a national campaign targeted to consumers. Both areas are seen as appropriate for targeted public-private partnerships.

Finally, this study revealed urgent and diverse research needs. These are grouped into four areas: (1) understanding salt taste reception and taste development throughout the lifespan; (2) developing innovative methods to reduce sodium in foods while maintaining palatability, physical properties, and safety; (3) enhancing current understanding of factors that impact consumer awareness and behavior relative to sodium reduction; and (4) monitoring sodium intake and salt taste preference.

CLOSING REMARKS

The recommended strategies deliberately set a new course for efforts to reduce sodium intake. This will require not only careful implementation and resolution of many technical and non-technical issues, but also a renewed commitment to reducing sodium intake. These large but important tasks will be most readily accomplished if they are undertaken in the spirit of collaboration and cooperation. The ultimate goal is improvement of America's health.

1

Introduction

Reducing Americans' intake of sodium has been an important but elusive public health goal for many years. The U.S. population consumes far more sodium than is recommended, placing individuals at risk for diseases related to elevated blood pressure. Since 1969, initiatives to reduce sodium intake have driven an array of public health interventions and national dietary guidance recommendations. To date, these activities have failed to meet their goal. Americans' intake of sodium remains at best unchanged and has even trended upward since the early 1970s. Meanwhile, the incidence of hypertension has not decreased.

The major federal nutrition policy guidance, *Dietary Guidelines for Americans*, specified quantitative limits for dietary sodium intake for the first time in 2005. It recommends consuming < 2,300 mg/d of sodium for the general population 2 or more years of age. The *Dietary Guidelines for Americans* further identifies at-risk subgroups within the general population—persons with hypertension, African Americans, and middle-aged and older adults—and recommends a sodium intake of no more than 1,500 mg/d for these individuals. New analysis of National Health and Nutrition Examination Survey (NHANES) data shows that this lower recommendation would apply to 69 percent of U.S. adults (CDC, 2009). The *Dietary Guidelines for Americans* also indicates that measures of salt use at the table and during cooking have remained fairly stable and relatively small compared to other sources of sodium, suggesting that programs for decreasing the salt intake of a population may be most successful if they are designed to concentrate on reducing salt added during food processing and on changes in food selection.

The *Dietary Guidelines for Americans* quantitative recommendation of < 2,300 mg/d is consistent with the Institute of Medicine's (IOM's) Tolerable Upper Intake Level for sodium for adults as established by the report *Dietary Reference Intakes for Water, Potassium, Sodium, Chloride, and Sulfate* (IOM, 2005). Further, the IOM report identifies the need for public health strategies to reduce sodium intake as well as the development of alternative processing technologies to reduce the sodium content of foods. The report suggests that special attention be given to maintaining flavor, texture, consumer acceptability, and low cost.

The *Consolidated Appropriations Act* of 2008[1] targeted to the Departments of Labor, Health and Human Services, and Education and related agencies directs the Centers for Disease Control and Prevention (CDC) to undertake a study through the IOM of the National Academies "to examine and make recommendations regarding various means that could be employed to reduce dietary sodium intake to levels recommended by the *Dietary Guidelines for Americans*." CDC was joined by several other federal agencies in supporting this study, including the Food and Drug Administration; the National Heart, Lung, and Blood Institute; and the Office of Disease Prevention and Health Promotion.

THE TASK

The statement of task for the committee charged with carrying out this study is found in Box 1-1.

As part of its general task, the committee was requested to address

- dietary intake of sodium and the primary sources of sodium for the U.S. population overall;
- understandings about the physiology of taste and sensitivity, and their interface with consumer behavior and taste preferences;
- functions of sodium in foods and how these functions relate to product development, consumer preferences, and health;
- factors that could affect sodium reduction strategies;
- potential of food technology to develop innovative alternatives to current sodium use in processed foods, taking into account the physiology of taste as well as consumer behaviors and preferences;
- potential unanticipated consequences;
- sodium reduction efforts in other countries;
- policy levers such as regulation (including labeling), investment of public monies, education, incentives, support for local capac-

[1] Public Law 110-161.

BOX 1-1
Statement of Task

The committee will review and make recommendations about various means that could be employed to reduce dietary sodium intake to levels recommended by the *Dietary Guidelines for Americans*. The committee will consider a variety of options. These may include, but are not limited to, government approaches (regulatory and legislative actions), food supply approaches (new product development, food reformulation), and information/education strategies for the public and professionals. Attention will be given to opportunities for government and industry collaboration, along with input from health professionals, for the purposes of fostering innovation in this area. The committee will prepare a consensus report that (1) describes the state of actions to reduce sodium intake and factors to consider in sodium reduction strategies as learned from the committee's review and considerations and (2) recommends actions (with rationale) for public and private stakeholders in order to achieve sodium intake consistent with the *Dietary Guidelines for Americans*. The report will recommend options for long-term monitoring and identify research needs.

ity, health professional role, industry codes of conduct, research, monitoring progress (accountability), and leadership; and

- options for public-private partnerships in the context of fostering creative and innovative approaches and programs ranging from basic and consumer research to planning for and implementing sodium reduction in diverse populations.

It should be noted that the tasks assigned to this committee did not include reviewing the scientific evidence on the relationship between sodium intake and health or reevaluating dietary guidance on the levels of sodium that should be consumed. Instead, the committee relied upon conclusions from authoritative bodies to support the health benefits related to sodium reduction.

THE APPROACH

Scientific Rationale for Strategy-Setting Decisions

Consideration of the scientific basis for establishing the relationship between high sodium intake and elevated blood pressure is not within this committee's task and was not specifically reviewed or addressed. The charge to the committee is to make recommendations about means to reduce dietary sodium intake to levels recommended by the *Dietary Guidelines* *for Americans*. The charge reflects the conclusions of the widespread and numerous public health initiatives that began in the early 1970s and have continued through the present time, as discussed in Chapter 2. Overall, these initiatives, many of which relied on expert advisory committees for scientific expertise, concluded that there is strong scientific support for a direct and progressive relationship between sodium intake and blood pressure. They also voiced long-standing concerns about unacceptably high incidence of hypertension among U.S. adults and the associated increased risk for cardiovascular disease (e.g., stroke and coronary heart disease) and the persistence of high intake of sodium among the general U.S. population. All recommended reduced sodium intake as a public health strategy.

Although a primary scientific review to document the relationship between sodium intake and disease risk was not within the committee's mandate, the study required an understanding of the science relative to two key questions if the committee's strategy decisions were to be adequately informed. The first question relates to the seriousness and nature of the public health problem. The nature of the recommended strategies should be commensurate with the seriousness and extent of that problem. The second question relates to the nature of the target population—specifically, whether the strategies should focus on the general population or be limited to specified subpopulations.

To understand the nature of the scientific consensus among qualified experts on these two questions, it was deemed useful to review the scientific conclusions from the most current major authoritative consensus bodies, including the 2005 Dietary Guidelines Advisory Committee (DGAC, 2005), the IOM (2005), and the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (NHLBI, 2004), and to update these reports, where applicable and necessary, with other relevant evidence.

Seriousness of the Public Health Problem

The prevalence of hypertension is common and increasing among American adults. It is a condition associated with several factors including obesity, genetics, and food- and physical activity-related behaviors, some of which may be related to culture/ethnicity. While the definition of hypertension has changed over time, rates of hypertension have remained high. The age-standardized prevalence rate of hypertension was 24 percent in NHANES III (1988–1994) (Cutler et al., 2008) and increased to 28–30 percent during the continuous NHANES from 1999 to 2006 (Ostchega et al., 2008). More than half of persons 60–69 years of age, and approximately three-fourths of those 70 years and older, have hypertension (NHLBI, 2004). The number of adults with hypertension in 1988–1994 was approximately 50 million and is estimated to be 65 million in 1999–2000 (Cutler et al., 2008). Blood pressure levels among children and adolescents also increased between 1988 and 2000 (Muntner et al., 2004).

Although increases in the prevalence of hypertension in both adults and children were partially explained by increases in body mass index (BMI)—an indirect measure of body fat—over the corresponding periods of comparison, adjusting for increasing BMI levels cannot completely explain the increasing prevalences (Cutler et al., 2008; Muntner et al., 2004). This suggests that, separate from the issue of obesity, the overconsumption of calories (and the concomitant overconsumption of sodium) is problematic. Moreover, while the measurement of short-term absolute risk for hypertension is determined by incidence rates, the long-term risk for hypertension can be reported by using the lifetime risk statistic, defined as the probability of developing hypertension during the remaining years of life (NHLBI, 2004). The lifetime risk of hypertension is approximately 86–90 percent for women and 81–83 percent for men after adjusting for competing mortality (Vasan et al., 2002).

In assessing the nature of the public health problem associated with elevated blood pressure levels, it is also important to consider its major consequences—heart disease, stroke, and kidney disease. Heart disease is the largest cause of death in the United States (26 percent of deaths in 2006), and stroke is the third-largest underlying cause of death (5.7 percent of deaths in 2006) (Xu et al., 2009). Furthermore, available data from cross-sectional studies in hypertensive individuals have consistently documented a progressive, direct relationship between sodium intake and left ventricular mass (a powerful predictor of stroke and other forms of cardiovascular disease). Sodium may have a direct effect apart from an indirect effect mediated through blood pressure (IOM, 2005). While one controlled trial (Jula and Karanko, 1994) suggests that the association between sodium intake and left ventricular mass is causal, additional trials are needed (IOM, 2005).

Given the direct causal relationship between sodium intake, blood pressure, and associated cardiovascular disease risk, several analyses of cost effectiveness have assessed the health effects and costs of population-wide reductions in salt intake of the U.S. population. Danaei et al. (2009) concluded that smoking and high blood pressure are the risk factors responsible for the greatest number of deaths in the United States, with high blood pressure responsible for 395,000 deaths annually. They estimated that population-wide reductions in sodium intake could prevent more than 100,000 deaths annually (Danaei et al., 2009). High dietary sodium intake, compared to the other dietary risk factors examined (i.e., low omega-3 fatty acids, high *trans* fatty acids, alcohol use, low intake of fruits and vegetables, low polyunsaturated fatty acids as an indicator of high saturated fat intake), was associated with more attributable deaths than any of the other single dietary factors.

The potential societal and medical savings of reducing hypertension and related cardiovascular disease by way of a reduction in population-level sodium intake have been demonstrated in recent analyses (Bibbons-Domingo et al., 2010; Palar and Sturm, 2009; Smith-Spangler et al., 2010). Reducing the average population sodium intake to 2,300 mg/d from current intake levels was estimated to reduce cases of hypertension by 11 million, to save $18 billion in health-care dollars, and to gain 312,000 quality-adjusted life-years that are worth $32 billion annually (Palar and Sturm, 2009). Bibbons-Domingo et al. (2010) developed a projection model that showed a benefit for all population groups from a reduction of salt intake by 3 g (equal to 1,200 mg sodium) per day. This decrease was projected to reduce the number of new cases of coronary heart disease by 60,000, stroke by 32,000, and myocardial infarction by 54,000 per year. Smith-Spangler et al. (2010) estimated that decreasing mean population sodium intake by 9.5 percent would prevent 513,885 strokes and 480,358 myocardial infarctions over the lifetime of adults currently aged 40–85 years, saving $32.1 billion in medical costs.

In summary, the nature of the public health problem associated with excessive sodium intake is serious, directly affects large numbers of people, and is associated with high health-care and quality-of-life costs. Therefore, strong solutions are warranted if it is to be addressed effectively. Because sodium intake is causally related to high blood pressure, an established risk factor for cardiovascular disease, reductions in sodium intake have been seen as an essential component of national public health policy for the past several decades (Loria et al., 2001; USDA/HHS, 2005). Newer data document that this requires continued priority and attention; furthermore, the IOM committee on Public Health Priorities to Reduce and Control Hypertension in the U.S. Population found the evidence base to reduce dietary sodium as a means to shift the population distribution of blood pressure levels convincing (IOM, 2010).

Target Population for Sodium Intake Reduction

Initially, reduction of sodium intake focused on persons considered to be at high risk, such as those with hypertension and older adults. For this report, the committee considered the general population when making recommendations because as new science has emerged, the focus of public health policy has expanded to include the general population as well as high-risk subgroups (Loria et al., 2001). In addition, the lifetime risk of becoming hypertensive for adults is greater than 80 percent (after adjusting for competing causes of mortality) (Vasan et al., 2002), but currently there is no method for determining which individuals fall within the 20 percent of the population that will not become hypertensive. Furthermore, because excess sodium intake can gradually increase blood pressure throughout life, before individuals develop clinically defined hypertension, and taste preferences for salty foods may be established early in life, long before individuals are aware of their risk for hypertension, a focus on at-risk subgroups could potentially fail to reach individuals who would benefit from a reduced sodium intake.

Although the extension of recommendations from high-risk groups to the general population has engendered controversy (Alderman, 2010; Cohen et al., 2006; Loria et al., 2001; McCarron, 2000, 2008; McCarron et al., 2009), numerous expert advisory panels (see Appendix B), including the most recent Dietary Guidelines Advisory Committee (DGAC, 2005), have consistently and repeatedly concluded, after careful evaluation of stakeholder concerns and the available scientific evidence, that the evidence and public health concerns warrant extending recommendations for sodium intake reduction to members of the general population across the lifespan. Recent data, including results of a clinical trial that documented the long-term benefits of sodium reduction in terms of cardiovascular events (Cook et al., 2007), have only strengthened the scientific rationale for population-wide sodium reduction (Bibbons-Domingo et al., 2010).

While the clinical problem of hypertension most commonly affects middle-aged and older adults in developed countries such as the United States, the genesis of elevated blood pressure is a lifelong process in which blood pressure rises gradually with age. There is a progressive dose-response relationship, without an apparent threshold, between salt intake and increased blood pressure across a range of salt intakes (DGAC, 2005). Published findings indicate that the genesis of hypertension begins in childhood and that blood pressure-related vascular disease is already evident at early ages (Cutler and Roccella, 2006). Specifically, in autopsy studies of children and young adults, elevated blood pressure in children is directly associated with fatty streaks and fibrous plaques in the aorta and coronary arteries (Berenson et al., 1998). In young adults, there is a direct relationship between blood pressure and coronary artery calcium scores (Loria et al., 2007; Mahoney et al., 1996).

As in adults, sodium reduction during childhood lowers blood pressure. Therefore, decreases in sodium intake during childhood and early adulthood are thought to help blunt the well-documented increases in blood pressure that occur with age among the U.S. population and thereby prevent the development, or delay the onset, of clinical hypertension (Cutler and Roccella, 2006; Ellison et al., 1989; He and MacGregor, 2006).

In addition to the progressive nature of increasing blood pressure levels and associated cardiovascular disease risks throughout life as noted above, the most recent Dietary Guidelines Advisory Committee (DGAC, 2005) also noted that inclusion of children beginning at 2 years of age is based partly on concerns about the development of taste preferences for foods with added salt at young ages. As discussed in Chapter 3, preferences for salt taste begin as early as 4 months of age and are shaped by experiences with foods. Moreover, throughout the lifespan, adaptation to lower sodium intake can occur if introduced gradually.

An additional point of controversy concerning extension of the reduction of sodium intake to the general population is the issue of salt sensitivity. This concept refers to differences between individuals in the way that their blood pressure responds to changes in dietary salt intake (Strazzullo, 2009). Although some argue that if salt sensitivity were taken into account as part of dietary recommendations, such recommendations would not need to be expanded to the general population, the major national authoritative consensus bodies have not supported the conclusion that salt sensitivity mitigates the concern for a general population approach (DGAC, 2005; IOM, 2005). There is variation in responses to changes in salt intake (IOM, 2005). However, such changes do not reflect a threshold effect, but rather have a continuous distribution (DGAC, 2005). There are no established standardized diagnostic criteria or tests, and there is no biological basis for deriving meaningful cut-points (Cutler et al., 2003; DGAC, 2005). Further, the responses are modifiable by factors such as potassium and other dietary intakes. For these reasons, there is no validated or scientifically defensible basis on which persons could be identified as "salt sensitive" or "salt resistant." As such, the concept of salt sensitivity does not provide a basis to identify a subgroup of the total population as a target group (IOM, 2005).

Based on the consensus reports from expert advisory committees and relevant published literature, the strategies to be developed are to be targeted to the general population and consistent with the statement of task. The goal is an overall population-wide intake of sodium consistent with the levels specified by the *Dietary Guidelines for Americans*.

Development of Recommended Strategies

The steps followed by the committee in recommending strategies to reduce sodium intake are illustrated in Figure 1-1. At the outset, it is important to clarify key terminology. Although the term "salt" (sodium chloride) is not interchangeable with the term "sodium," many reports use them synonymously because the most significant contributor to dietary sodium is salt. This report uses the term "salt" when the intended reference is to sodium chloride, and the term "sodium" when the intended reference is to sodium. Further, the term "food industry" is meant to encompass

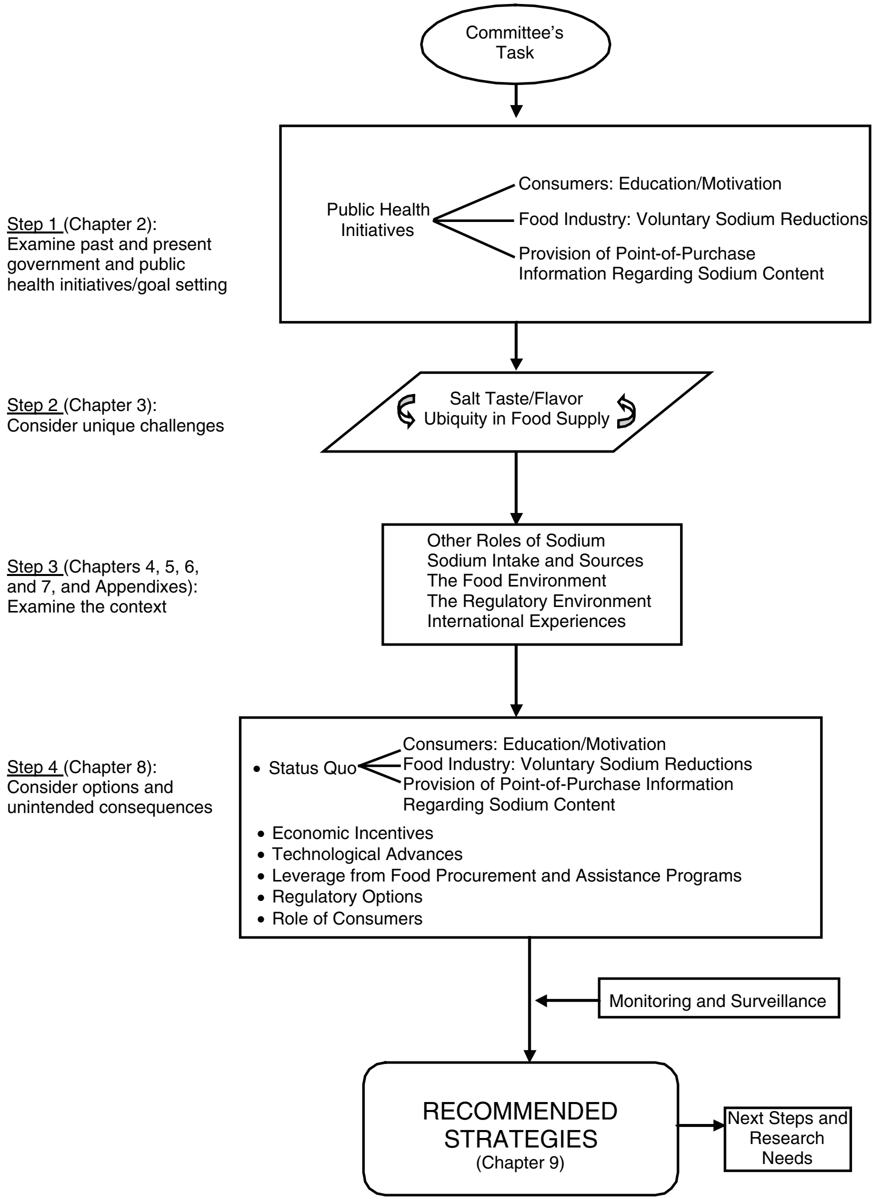

FIGURE 1-1 Committee's approach to identifying recommended strategies to reduce sodium intake of the U.S. population.

both processed food manufacturers and restaurant/foodservice operations. "Salt taste preference" is used to mean the preference for foods to which salt has been added. Terms used in this report are defined in the Glossary (Appendix A).

The committee began its work by reviewing the past and current major national public health initiatives and international efforts (see Appendix C) targeted to the reduction of sodium intake, and integrated summaries of the key outcomes so as to provide an overall but focused picture of the current situation. This effort, as presented in Chapter 2, along with considerations of the special nature of salt taste and flavor (Chapter 3), sets the stage for the committee's more in-depth examination of factors important to recommending strategies to reduce sodium intake

Importantly, these long-standing public health activities have been oriented primarily toward affecting the behaviors of consumers through consumer education and motivating consumers to alter food behaviors. However, these initiatives included calls for supporting activities in the form of (1) efforts by members of the food industry to voluntarily reduce sodium in their products and (2) information about the sodium content of foods to be made available at the point of purchase. As a sequel to its initial consideration of past and current initiatives, the committee next examined the taste and flavor effects of salt, as well as the nature of salt taste and the preference for foods to which salt has been added, notably in the context of the high levels of salt in the food supply and the role that preference for foods to which salt has been added may play in impacting the success of strategies to reduce sodium intake. In this way, Chapters 2 and 3 served as stage-setting activities for the committee.

The committee next turned to an in-depth review of the data underlying the outcomes, as well as additional background information, reviewing the following topics: the nature of the roles of sodium in food beyond taste and flavor effects (Chapter 4); current estimates of sodium intake and characterization of dietary sources of sodium (Chapter 5); the food environment as it relates to the processed food and restaurant/foodservice industries and consumers (Chapter 6); and the regulatory environment and legal provisions that pertain to the addition of salt to foods and related labeling information (Chapter 7). The committee also considered international experiences related to the reduction of sodium intake, compiled in Appendix C.

This information allowed the committee to fully consider the lessons learned and provided a basis upon which to consider relevant strategies (Chapter 8). The committee targeted this integrative discussion to focus first on the status quo and then on the potential for economic incentives, technological advances, and for leverages from large-scale government procurement and assistance programs. Regulatory options were considered as were potential roles for consumers. Recommendations are presented in

Chapter 9, and Chapter 10 discusses activities for the implementation of the recommended strategies and research needs. Chapter 11 contains the committee member biographical sketches.

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2

Sodium Intake Reduction: An Important But Elusive Public Health Goal

For 40 years, the numerous public health initiatives to reduce sodium intake of the U.S. population focused on consumer education and behavior change. These activities were accompanied by requests to the food industry (defined as both the processing and restaurant/foodservice sectors) to assist consumers by marketing lower-sodium alternatives and voluntarily reducing the amount of sodium in its foods, as well as requests to provide information on the sodium content of foods at the point of purchase. Efforts to provide such point-of-purchase information relate to both the consumer-oriented strategies and the supporting strategies associated with voluntary changes in the food supply. That is, nutrition labeling—which includes information about sodium—is intended to assist consumers at the point of purchase; the ability to make claims on food labels about the sodium content of the product was historically viewed as providing an incentive to the processed food industry to voluntarily reformulate its food products, while at the same time informing consumers at the point of purchase.

This chapter highlights these past and current U.S. initiatives and considers whether the intended outcome of reducing the sodium intake of Americans has been achieved. More information about the data presented in this chapter as well as other factors important to strategies for reducing sodium intake can be found in the background chapters that appear later in this report. In addition, Appendix C provides a summary of past and current efforts to reduce sodium intake internationally.

PAST RECOMMENDATIONS AND MAJOR INITIATIVES

Initiatives

The 1969 White House Conference on Food, Nutrition, and Health is often regarded as the starting point for national initiatives to reduce sodium intake. Beginning in 1969 and continuing through the present time, numerous initiatives have been developed by a myriad of government public health agencies (FDA, 1975–2007; HHS, 1979–2000; NHLBI, 1972–2006; Senate, 1977; state and local agencies, 2008–2009; USDA, 1993–2008; USDA/HHS, 1980–2005; White House, 1969); independent national and international authoritative scientific bodies (NRC/IOM, 1970–2010; WHO, 1990–2003); and health professional organizations (ADA, 2007; AHA, 1973–2008; AMA, 1979–2006; APHA, 2002). These initiatives have ranged in scope from sweeping national dietary recommendations and goal-setting activities to fact sheets for consumers and health professionals, to calls for food industry and government actions to create or alter policies that might help to reduce sodium intake. When combined, these various initiatives have played a role in attempting to reduce the sodium intake of Americans.

Too numerous to describe in detail, these efforts are listed in Table 2-1 and summarized in Appendix B. Many of these initiatives were developed as part of a public process that involved scientists, consumers, and members of the food industry. Their existence demonstrates the level of resources and effort that have been mustered to reach the goal of lowering sodium intake. Many of these activities disseminated relevant information to consumers directly as well as to the food industry and to "multipliers" such as health professionals and the media. Some of the messages about sodium were linked to other public health messages and campaigns focusing on dietary factors (e.g., increased consumption of fruits and vegetables, decreased saturated fat intake) and chronic diseases and other health conditions with diet-related risk factors (e.g., heart and other cardiovascular diseases, obesity and overweight, cancer, diabetes, osteoporosis, bone health). The food industry and consumer advocacy groups also provided consumer information on the topic.

At the federal level, the National Heart, Lung, and Blood Institute (NHLBI) within the National Institutes of Health has served as a federal leader in the area of dietary sodium reduction by providing a number of enabling tools for dietary change related to sodium intake. Early efforts included sponsorship of the National High Blood Pressure Education Program (NHBPEP). This was a cooperative effort involving professional and voluntary health agencies, state health departments, and community groups with the goal of reducing death and disability related to high blood pressure through programs of professional, patient, and public education. The NHBPEP published scientific reviews and recommendations in 1972, 1993, and 1995 and cosponsored a large national public information-gathering workshop in 1994 with other federal agencies (NHLBI, 1996). Auxiliary activities of the NHBPEP included the production of fact sheets, pamphlets, and brochures dealing with lifestyle changes, planning kits, posters and print ads, radio messages, and working group reports. More recently, scientific reviews, recommendations about sodium reduction, and auxiliary outreach activities have been part of the 1997 and 2003 activities of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Partnerships with state, local, and community-based organizations formed the basis for the recent development and dissemination of educational materials and the production of broadcast-ready public service announcements about fighting high blood pressure through dietary changes.

Initiated in 1980 by congressional mandate, the *Dietary Guidelines for Americans* provide science-based guidance to promote health and reduce risk for major chronic diseases through diet and physical activity. The U.S. Department of Agriculture (USDA) and U.S. Department of Health and Human Services (HHS) jointly sponsor the development of *Dietary Guidelines for Americans*, including the convening of an expert advisory committee. The recommendations are regularly revised and updated on a 5-year cycle; to date, six editions of the *Dietary Guidelines for Americans* have been published. Currently, an expert advisory committee is reviewing the science in preparation for the seventh edition. Since the document was first published in 1980, every edition has contained recommendations for Americans related to reduction in and moderation of sodium intake, but quantitative recommendations were not included until the 2005 edition. To assist consumers in implementing the *Dietary Guidelines for Americans* through informed food choices, USDA developed the MyPyramid program,[1] which is one of its major consumer initiatives for dietary change. Implementation of the sodium recommendations as an area of focus was particularly challenging. To help consumers meet recommendations from the *Dietary Guidelines for Americans*, USDA provides a menu planning program on its website[2] that allows individuals to enter information about the foods they consume and to compare their daily food intake with *Dietary Guidelines for Americans* recommendations. However, sodium as an area of focus is not included. That is, sodium levels are not factored into the MyPyramid

[1] Available online: http://www.mypyramid.gov (accessed November 16, 2009).

[2] Available online: http://www.mypyramidtracker.gov/planner/ (accessed November 16, 2009).

TABLE 2-1 Summary of Public Health Recommendations, Initiatives, and Actions That Address Sodium Intake in the United States, 1969–Present

	1969–1970	1971–1972	1973–1974	1975–1976	1977–1978	1979–1980	1981–1982	1983–1984	1985–1986	1987–1988
White House	R									
U.S. Senate		R								
HHS (Surgeon General)						R				R
HHS (Public Health)						I				
HHS (NHLBI)		A								
USDA/HHS						R			R	
FDA				A		R	I/A	A		
USDA										
CDC										
State/Local										
Gov't-Non-Gov't Organization Partnership										
NRC/IOM	R					R (*m*)				
WHO										
AHA			R						R	R
AMA						R				
ADA										
APHA										
AICR/WCRF										
WASH										
WHL/WASH										

NOTES: This table serves only as a snapshot of activity since 1969. See Appendix B for a comprehensive listing of the public health recommendations, initiatives, and actions summarized in this table, as well as a listing of references. A = action; ADA = American Dietetic Association; AHA = American Heart Association; AICR/WCRF = American Institute for Cancer Research/World Cancer Research Fund; AMA = American Medical Association; APHA = American Public Health Association; CDC = Centers for Disease Control and Prevention; FDA = Food and Drug Administration; Gov't = Government; HHS = U.S. Department of Health and Human Services; I = initiative; (*m*) = indicates multiple activities were undertaken during that year; NHLBI = National Heart, Lung, and Blood Institute; NRC/IOM = National Research Council/Institute of Medicine; R = recommendation; USDA = U.S. Department of Agriculture; WASH = World Action on Salt and Health; WHL = World Hypertension League; WHO = World Health Organization.

1989–1990	1991–1992	1993–1994	1995–1996	1997–1998	1999–2000	2001–2002	2003–2004	2005–2006	2007–2008	2009–2010
					I	I				
		R	R/I	R		R	R	A (*m*)		
R			R					R		
		A[a] →	→	→	→	→	→		I/A	
		A	A				I		A/I	
										I[b]
									A	A(*m*)
										A
R (*m*)								R		R
R							R			
			R (*m*)	R	R			R	R	
								R		
									R	
						R				
				R					R	
									A[c] →	→
								A[d] →	→	→

[a] Final rules under the Nutrition Labeling and Education Act (1990) commenced in 1993 and continued through 2005. The most recent rule (2005) was issued as a result of comments from stakeholders urging FDA to reconsider the strict sodium requirements for foods and meal and main dish items for "healthy" foods.

[b] The *Congressional Omnibus Appropriations Act* (2009) included language compelling CDC to work with food manufacturers and chain restaurants to reduce sodium content; CDC is in the process of responding to this charge.

[c] World Salt Awareness Week occurs annually.

[d] World Hypertension Day occurs annually.

Plan or the MyPyramid Menu Planner tools. There is a footnote[3] in the MyPyramid Menu Planner explaining that sodium cannot be accurately calculated using the tool because sodium levels can vary so much within a single food and it is difficult to estimate consumers' discretionary salt use.

Further, in 1995 USDA initiated sodium standards for 10 commodity food categories in its Commodity Distribution Program targeted to school meals (USDA, 1995). Starting in 2004, it implemented sodium reduction efforts into the HealthierUS School Challenge[4] and the Special Supplemental Nutrition Program for Women, Infants, and Children programs (USDA/FNS, 2007).

In parallel with federal efforts aimed at sodium reduction strategies, efforts by professional and health associations to develop and disseminate information about organization goals and recommendations have also been used to create awareness. Sodium reduction initiatives were started by the American Heart Association in 1973 and the American Medical Association in 1979 and have continued to the present. Their recommendations urge the public to aim for lower sodium intake (Havas et al., 2007; Lichtenstein et al., 2006). Other groups such as the American Public Health Association and the American Dietetic Association have also been active in promoting sodium reduction messages.

Many government-based initiatives have called on the industry and other stakeholders to assist consumers in reducing their sodium intake. Consumer advocacy groups, such as the Center for Science in the Public Interest (CSPI), have spread the message of the importance of reducing salt in the diet. Further, online health information sites are accessible sources of health information for many Americans. The food industry has included information on sodium and health on its websites. For example, Campbell's[5] and Kellogg's[6] have information on healthy sodium intake on their websites, and General Mills is a partner in sponsoring the Eat Better America website, which contains sodium and health information.[7]

[3] Available online: http://www.mypyramidtracker.gov/planner/planner_salt.html (accessed November 16, 2009).

[4] Available online: http://www.fns.usda.gov/TN/HealthierUS/all_chart.pdf (accessed November 16, 2009).

[5] Available online: http://www.campbellwellness.com/subcategory.aspx?subcatid=3 (accessed November 16, 2009).

[6] Available online: http://www.kelloggsnutrition.com/know-nutrition/sodium.html (accessed November 16, 2009).

[7] Available online: http://www.eatbetteramerica.com/diet-nutrition/heart-health/try-a-sodium-shake-down.aspx (accessed November 16, 2009).

Core Message to Consumers

The basic message to consumers about the role of sodium in the development of elevated blood pressure has not changed during the past 40 years, but changes in the target audience as well as the approach to reducing sodium intake have evolved as the science has matured. Many of the early messages and nutrition labeling initiatives focused on persons with diagnosed high blood pressure and those at high risk for high blood pressure or both (Loria et al., 2001), as well as elderly people.

As new science emerged, the focus expanded to include all adults as well as children. The extended focus for adults was based on evidence suggesting that generally reducing sodium intake could prevent or minimize age-related increases in blood pressure. The inclusion of children (2 or more years of age) was based on concerns about the development of preferences for salt taste at young ages and the increasingly earlier development of high blood pressure in adolescents and young adults (DGAC, 2005).

Further, messages for at-risk subgroups within the general population (e.g., persons with hypertension, African Americans, and middle-aged and older persons) continue to be provided because of the higher incidence rates and more serious consequences of excessive sodium intake for these subgroups (DGAC, 2005). These separate messages are based on the understanding that these at-risk subgroups benefit from a more stringent sodium reduction than that recommended for the general population.

Although, as discussed in Chapter 1, the expansion of recommendations to the general population has engendered considerable controversy from some stakeholders (Alderman, 2010; Cohen et al., 2006; Loria et al., 2001; McCarron, 2000, 2008; McCarron et al., 2009), the many expert advisory panels used in the development of sodium reduction recommendations and guidelines, including both those convened by government agencies and those convened independently, have consistently and repeatedly concluded, after careful evaluation of the available scientific evidence and stakeholder concerns, that the scientific evidence warrants extending recommendations for reduction of sodium intake to the general population and across the lifespan.

Over the years, the message content also changed from advice for consumers to reduce the addition of salt added to foods at the table or in home food preparation to choosing high-sodium foods in moderation and using the nutrition label when purchasing foods to enable selection of foods with lower sodium content (Loria et al., 2001). This change was based on evidence showing that the major sources of sodium in the U.S. diet were processed foods and foods obtained from restaurant/foodservice operations rather than from salt added by consumers during home food preparation or at the table.

Past Recommendations for Food Industry Actions and Point-of-Purchase Information

Many of the initiatives identified in Table 2-1 include recommendations that food processors voluntarily reduce the sodium content of their foods, market lower-sodium alternatives, and make information on the sodium content of their foods readily available at the point of purchase. More recently, calls have also been made for restaurants and other foodservice operations to do the same.

These earlier efforts focusing on the food industry were supported and heightened by the results from a small but frequently cited study published in 1991 (Mattes and Donnelly, 1991). It found that processing-added sodium provided more than 75 percent of the total sodium intake of individuals. Another 5 percent was attributable to salt added during cooking and 6 percent was due to salt added by consumers at the table. Subjects had control over the amount of salt added during cooking; during the 7-day study period they ate fewer than three meals away from home and prepared their own meals at home. Thus, the amount of sodium directly under the control of the individual was shown to be relatively small, and most dietary sodium was shown to come from sources beyond consumers' direct control. Consistent with this, Engstrom et al. (1997) reported that even with a 65 percent reduction in discretionary salt use (i.e., from 1,376 mg/d sodium in 1980–1982 to 476 mg/d in 1990–1992), average daily sodium intake remained > 3,000 mg/d—a level in excess of the *Dietary Guidelines for Americans* goal of < 2,300 mg/d.

As mentioned previously, these data put in motion a change in the emphasis of recommendations from encouraging consumers to reduce or avoid salt use at the table and in home food preparation to an emphasis on encouraging food processors to reduce the sodium content of their products. Calls for point-of-purchase information about the sodium content of foods increased. When the 1990 *Nutrition Labeling and Education Act* (NLEA) was enacted, the Food and Drug Administration (FDA) ensured that sodium was one of the nutrients that must be declared on the labels of processed foods.

At the same time that requests were being made to members of the food industry to voluntarily reduce sodium in their products to assist consumers in lowering their sodium intake, concerns were being raised about the safe use of salt in foods, specifically the levels of salt added by manufacturers. An independent expert panel evaluating this topic in 1979 (SCOGS, 1979) recommended, among other things, that FDA develop guidelines for the safe use of salt in processed foods. As described in more detail in Chapter 7, FDA deferred action on these recommendations, suggesting that the largely voluntary 1975 sodium-based nutrition labeling regulations coupled with newer 1982 regulations specifically targeting sodium information on food products would likely be effective in helping consumers reduce their sodium intake and stimulating voluntary reductions by manufacturers of sodium in labeled foods (HHS/FDA, 1982).

Later, in implementing the 1993 nutrition labeling regulations, FDA and others anticipated that the regulations relating to mandatory declaration of the sodium content of foods and sodium-related criteria for voluntary food label claims (described in Chapter 7) would further aid consumers in selecting lower-sodium foods and stimulate manufacturers to reduce the sodium content of marketed foods. However, despite these significant increases in labeling requirements and opportunities, sodium intake remained high. Concerns that FDA may still need to address the levels of salt added to foods resurfaced with a 2005 citizens' petition (CSPI, 2005a) and language in a congressional appropriations bill requesting that FDA take action in reviewing the regulatory options for salt added to foods. FDA held public hearings in 2007 to gather information relevant to a possible reexamination of the regulatory status of salt (HHS/FDA, 2007).

OUTCOMES

To assess whether public health initiatives over the past 40 years were associated with relevant changes, four major areas were examined: (1) consumer awareness and behaviors, (2) sodium levels in the food supply, (3) sodium intake, and (4) prevalence of hypertension. The data sources for the collation of this information were primarily published survey results from the national nutrition monitoring system. Some of these areas are described in more detail in other sections of this report.

Consumer Awareness and Behaviors

A common theme running through the myriad initiatives and programs described in Table 2-1 and Appendix B is that providing advice to consumers on the health risks associated with high sodium intake would result in increased consumer awareness and would motivate consumers to take action to reduce their sodium intake. It was also anticipated that providing consumers with information about the sodium content of processed and restaurant foods at the point of purchase would help them select lower-sodium foods and, thus, reduce total intake. The question then arises: How successful have the many initiatives carried out over the past four decades been in achieving these goals? Although the available evidence is limited, it does provide insights into the success, or lack thereof, of consumer education and information initiatives.

This section reviews available information on consumer understanding and behavior related to sodium and health over time. The topics covered include information on consumers with respect to the following:

- awareness of the relationship between salt/sodium intake and health;
- belief about the importance of the relationship to self and behavior intentions;
- accuracy of perceptions of sodium intake;
- use of nutrition label information; and
- use of table salt.

Awareness of the Relationship Between Salt/Sodium Intake and Health

An awareness of a diet/health relationship is generally considered a first step in motivating consumers to make dietary changes (Derby and Fein, 1995). As shown in Figure 2-1, a 1979 survey conducted by FDA showed that only 12 percent of Americans mentioned salt or sodium as a

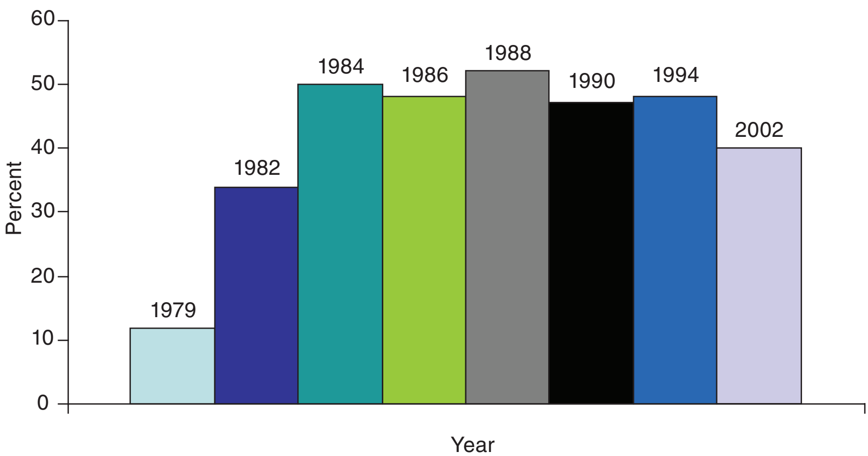

FIGURE 2-1 Consumer awareness of the relationship between salt/sodium intake and high blood pressure, 1979–2002.
NOTES: Teisl et al. (1999) expressed results as the mean of reported responses among men and women. The response for the total population in 2002 was calculated by multiplying the percentage of respondents reporting they had heard of dietary factors being related to high blood pressure (75 percent) by 0.526, the proportion of those who had heard of dietary factors related to high blood pressure and who identified salt/salty foods/sodium as the dietary factor (FDA, 2007).
SOURCES: 1979 and 1982: Heimbach, 1985; 1984–1994: Teisl et al., 1999; 2002: FDA, 2007.

likely cause of high blood pressure (Heimbach, 1985). In a 1982 follow-up survey, this level rose to 34 percent (Heimbach, 1985). The levels vacillated between 43 and 48 percent between 1984 and 1994 (Teisl et al., 1999) and subsequently dropped to 39 percent in 2002 (FDA, 2007).

Teisl et al. (1999) conceptualized the question of awareness as the relative position of a response in a hierarchy of responses, not a simple knowledge of a particular diet/health relationship (Teisl et al., 1999). The authors stated that declines in the awareness value "are evidence of competing messages, concerns about credibility, and/or habituation, not of decreased knowledge or understanding." Overall, this suggests that consumer awareness of the relationship between sodium/salt intake and health increased as the large-scale educational programs from Table 2-1 were implemented, but creating awareness in the U.S. population to levels greater than 50 percent may be difficult to achieve. Additionally, the results suggest that it may be difficult to sustain a relatively high level of awareness for a topic such as sodium and high blood pressure over long periods of time.

While almost half of U.S. consumers were aware of the link between salt/sodium intake and high blood pressure during the decade from 1984 to 1994, fewer made the link between salt/sodium intake and heart disease and heart attacks. In USDA's 1989–1991 Diet and Health Knowledge Survey, 57 percent of meal planners and preparers recognized the risk for hypertension[8] whereas only 26 percent recognized the risk for heart disease[9] (Cypel et al., 1996). Comparable questions in the 1994–1996 survey found that the higher recognition of the salt/sodium relationship to blood pressure compared to heart disease persisted (51 percent for hypertension and 24 percent for heart disease) (Tippett and Cleveland, 2001). FDA's 2002 Health and Diet Survey also reported a greater awareness of high blood pressure or hypertension than heart disease (39 percent for hypertension and 7 percent for heart disease or heart attack)[10] (FDA, 2007). However, this more recent survey also suggested lower percentages of awareness of salt/sodium and disease relationships (i.e., 39 and 7 percent, respectively) than had been observed in the earlier surveys (i.e., 51 and 24 percent,

[8]Fifty-seven percent is calculated by multiplying 86.8 (the percentage of persons who reported hearing of health problems being related to how much salt or sodium a person eats) by 0.653 (the proportion of the subgroup who identified hypertension as the health problem).

[9]Twenty-six percent is calculated by multiplying 86.8 (the percentage of persons who reported hearing of health problems being related to how much salt or sodium a person eats) by 0.301 (the proportion of the subgroup who identified heart disease as the health problem).

[10]Thirty-nine percent is calculated by multiplying 75 (the percentage of persons who reported hearing of high blood pressure being related to dietary intakes) by .526 (the proportion of the subgroup who identified salt, salty foods, or sodium). Seven is calculated by multiplying 83 (the percentage having heard of heart disease or heart attacks being related to dietary intakes) by 0.079 (the proportion who mentioned salt, salty foods, or sodium).

respectively, in 1994–1996). It is not possible to determine whether the differences in the percentage of persons recognizing the relationship between sodium/salt and hypertension or heart disease between USDA- and FDA-sponsored surveys are due to declines in awareness over time or to sampling and methodological differences between these surveys. The results do indicate, however, that consumers are more aware of the relationship of sodium intake to high blood pressure/hypertension risk than to the associated risk of heart disease.

Consumers' Belief About Importance of the Sodium-Disease Relationship to Self and Behavior Intentions

Knowing that excess sodium intake can cause adverse health effects does not necessarily mean that an individual will recognize a personal need for concern or that an individual will take action to reduce intake. As shown in Table 2-2, results from USDA's Diet and Health Knowledge Surveys indicate that the percentage of main food preparers/planners who felt it was very important for them personally to avoid salt or to use salt and sodium only in moderation was relatively high (62 percent) in 1989–1991, but decreased to 52 percent by 1994–1996 (Cypel et al., 1996; Tippett and Cleveland, 2001). The percentage indicating that it was of low or no importance increased from 13 to 19 percent between these two survey periods. Thus, the personal importance that consumers gave to the avoidance of salt or to using salt/sodium only in moderation declined over the 5 years between surveys. The more recent 2002 FDA Health and Diet Survey found that 46 percent of respondents felt that they personally did not need to worry about their sodium consumption (FDA, 2007).

In terms of behavior, the FDA's 2002 Health and Diet Survey (FDA, 2007) found that only 28 percent of respondents had attempted to reduce

TABLE 2-2 Personal Importance of Avoiding Salt or Using Salt/Sodium Only in Moderation

1989–1991		1994–1996	
Level of Importance	Percent of Respondents	Level of Importance	Percent of Respondents
High	62.2	Very important	51.8
Moderate	24.2	Somewhat important	29.1
Low	13.1	Not too important/ not at all important	18.8

SOURCE: USDA Diet and Health Knowledge Surveys, 1989–1991 and 1994–1996 (as reported by Cypel et al., 1996, and Tippett and Cleveland, 2001).

their sodium intake (22 percent indicated that they had already reduced their sodium intake by quite a bit and 6 percent indicated that they had been trying to reduce their sodium consumption but had not been very successful). Another 23 percent felt that they should probably reduce sodium intake, but they hadn't really tried. More recently, consumer surveys by the International Food Information Council (IFIC) between 2006 and 2008 found that only 7–9 percent[11] indicated that they had avoided eating or had eaten less salt/sodium in foods or ingredients over the few months prior to the survey (IFIC, 2006, 2007, 2008).

As consumers became aware of the importance of dietary factors in disease risk reduction, they reported that they had initiated efforts to alter their intake of relevant nutrients and food components (Derby and Fein, 1995). For example, about 25 percent of Americans reported trying to reduce their sodium intake in 1982; this level rose to 33 percent in 1986 and remained there through 1988. However, by 1990, the prevalence had dropped back down to 25 percent. This pattern of increasing, maintaining, and decreasing prevalence of self-initiated dietary changes was observed with cholesterol during the same time period.

Accuracy of Consumers' Perceptions of Their Sodium Intake

As Derby and Fein (1995) point out, for consumers to translate a concern about intake into appropriate action, they need an accurate understanding of their own sodium intake. However, consumers' conclusions about the appropriateness of their personal sodium/salt intake appear to be inaccurate. Results from USDA's Diet and Health Knowledge Survey in 1989–1991 and 1994–1996 indicated similar mean sodium intake for individuals who thought their sodium intake was "too high" as for individuals who thought their sodium intake was "about right" (Cypel et al., 1996; Tippett and Cleveland, 2001). Moreover, in the 1994–1996 survey, the percentages of persons exceeding the recommended intake was 71 and 76 percent for individuals who thought their intake was "about right" and "too high," respectively. Thus, both the groups who thought their sodium intake was about right and the groups who thought their sodium intake was too high appeared to have similar sodium intake, as well as intake well in excess of the recommendations of the *Dietary Guidelines for Americans*. In an experimental study in which participants consumed fast food meals from several national chains, participants estimated that, on average, the

[11] The population-based prevalence rates were obtained by multiplying the percentage of persons responding "yes" to the question of whether or not there were any foods or ingredients that they had avoided or eaten less of, by the proportion of this group indicating that they had avoided salt, sodium, or spices.

meals contained 820 mg sodium whereas the actual average sodium content was 1,831 mg (Burton et al., 2009). In short, consumers seem unable to accurately estimate their own sodium intake.

Use of Nutrition Label Information and Intake

Many of the major initiatives over the past years recommended that sodium information at the point of purchase would be useful to consumers in reducing their sodium intake and selecting more healthful diets. FDA responded to the early calls for nutrient content information on processed foods at the point of purchase with regulations permitting voluntary labeling of sodium and several other nutrients in 1973 (HHS/FDA, 1973) (see Chapter 7). The need served as a rationale to underpin Congress's enactment of the 1990 NLEA, which made nutrition information on food labels mandatory.

As shown in Figure 2-2, the advent of voluntary labeling in the 1970s resulted in about 40 percent of products carrying some form of permitted nutrition labeling as reported in 1978—increasing to about 63 percent in 1991, but these data do not distinguish between simple content declarations and the use of claims. With the initiation of mandatory nutrition labeling in 1993, virtually all processed food labels now contain nutrient content information, including sodium content (LeGault et al., 2004).

Given the ubiquitous presence of information about sodium content on

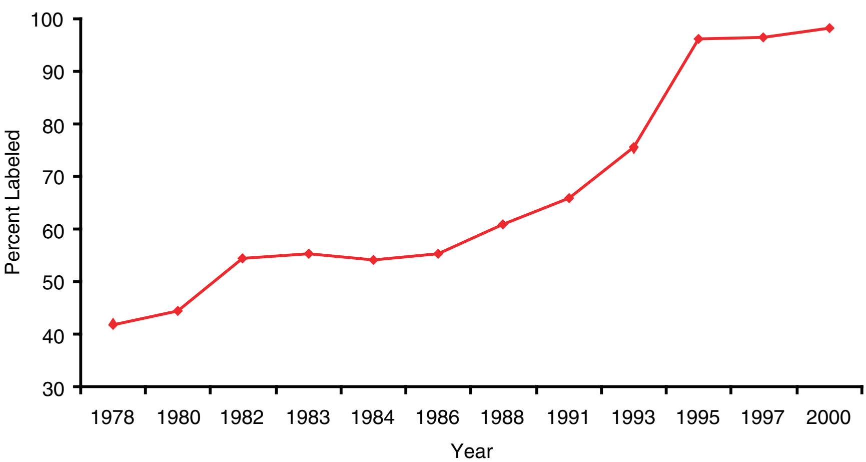

FIGURE 2-2 Percentage of products with nutrition labeling.
SOURCE: Reprinted from *Journal of the American Dietetic Association* 104(6), LeGault et al., 2000–2001 Food Label and Package Survey: An update on prevalence of nutrition labeling and claims on processed, packaged foods, pp. 952–958, Copyright © 2004, with permission from Elsevier.

packaged foods, the question then focuses on consumer use of such information. USDA's Diet and Health Knowledge Survey examined the question of frequency of use of nutrition labels in its 1995–1996 and 2005–2006 surveys (Todd and Variyam, 2008). The reported frequency of use of the information is shown in Table 2-3.

Consumer indications that they "always/often" used the Nutrition Facts panel increased by 4 percentage points between 1995–1996 and 2005–2006 but decreased by 2 percentage points for this category of use for salt/sodium information. In terms of responses to "never" using label information, there was a 5 percentage point increase for the Nutrition Facts panel and a 10 percentage point increase for the salt/sodium information. Therefore, during the 10 years between surveys, there was greater decline in the use of salt/sodium information than in the overall use of the Nutrition Facts panel. The decreased use of sodium information paralleled decreases in the use of information on calories, total and saturated fat, and cholesterol; conversely, increased use of information on fiber and sugar was reported during this same time period.

In today's environment, consumers are exposed to many diet and health messages that may seem contradictory or confusing (Derby and Fein, 1995). How do shoppers who are concerned about the nutritional content of the foods they eat rank concerns about sodium compared to other nutrients? As shown in Figure 2-3, compared to other nutrients, sodium does not appear to be the top concern in the minds of consumers (Food Marketing Institute, 2004). From 1997 to 2004, the major concern has been fat, with sodium and other nutrients of lesser concern.

These data also show that shoppers' concerns with salt and sodium intake declined from 24 percent in 1998 to 14 percent in 2004. Conversely,

TABLE 2-3 Reported Frequency of Use of the Nutrition Facts Panel and Salt/Sodium Labeling

	Frequency of Use (%)		Change
	1995–1996	2005–2006	(percentage points)
Nutrition Facts Panel			
Never	22	27	+5
Rarely	13	10	–3
Sometimes	30	23	–7
Always/often	35	39	+4
Salt/Sodium Information			
Never	12	22	+10
Rarely	22	19	–3
Sometimes	30	25	–5
Always/often	36	34	–2

SOURCE: Todd and Variyam, 2008.

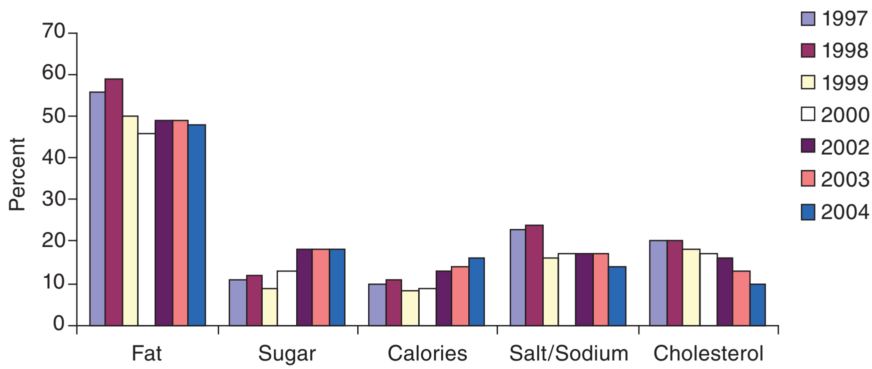

FIGURE 2-3 Shoppers who are concerned about the nutritional content of foods they eat.
SOURCE: Food Marketing Institute, 2004. Reprinted with permission.

respondents reported a 6 percentage point increase in concern with sugar and a 5 percentage point increase in concern with calories during this period (Food Marketing Institute, 2004). FDA's 2005 Health and Diet Survey (FDA/ODPHP, 2008) also found that sodium did not rank high in comparison to other dietary concerns. Results showed that more Americans were trying to limit their intake of sugar, saturated fat, cholesterol, and *trans* fat than were trying to reduce their sodium intake. Thus, the level of concern about sodium was not sustained over time and never achieved the level observed for fat.

To evaluate whether consumers who indicated using or not using label information differed in their sodium intake, Variyam (2008) assumed that sodium content information from Nutrition Facts panels would be available for foods consumed at home but not for foods consumed away from home. Individuals were classified from USDA's 1994–1996 Diet and Health Knowledge Survey as label users or non-users based on their response to the question of whether they use the panel's information on nutrient content when buying foods. The results suggested that users and non-users of the Nutrition Facts panel did not differ in sodium intake for food consumed at home; their sodium intake was also similar for food consumed away from home. However, Variyam (2008) did find that label use was associated with a modest but beneficial impact on intake of several other nutrients (i.e., higher fiber and iron intake) but not on intake of total and saturated fat or cholesterol.

Consumers' Use of Salt at the Table and in Food Preparation

Data published in 1991 suggested that salt added at the table and during cooking contributed only about 6 percent and 5 percent, respectively, to total sodium intake (Mattes and Donnelly, 1991). Because these data showed such practices to be a relatively small contributor to overall sodium intake, behavior change messages generally have not targeted home salt use. Use of table salt continues to be a relatively minor contributor to overall sodium intake. Current data suggest that table salt contributes 4.9 percent to total sodium intake (see Chapter 5). Data from the National Health and Nutrition Examination Survey (NHANES) III (1988–1994) suggested that 50 to 72 percent of adults "never" or "rarely" added salt to table foods (Loria et al., 2001). Similar results were seen in the 2005–2006 NHANES in which 68 percent of all persons reported never or rarely adding salt at the table (Moshfegh, 2009). Survey respondents were also asked how often ordinary or seasoned salt is used in cooking or preparing foods in the home; response options and the percentage of respondents choosing these responses in 2005–2006 included "never/rarely" (24 percent), "occasionally" (37 percent), and "very often" (40 percent). This information is applied to algorithms for recipes and sodium absorbed in cooking (Moshfegh, 2009).

Sodium Levels in the Food Supply

Many of the major initiatives of the past 40 years have called for a reduction in the sodium content of marketed foods through direct appeals to food processors and through the availability of labeling provisions to provide additional incentives for the development of lower-sodium foods. This section reviews available information on the following:

- sodium content of foods;
- relative contributions of different sources to total sodium intake;
- use of sodium-related label claims and advertising; and
- availability of lower-sodium food products.

Sodium Content of Food

Marketed foods influence the sodium intake of consumers in two primary ways: through their sodium content and through the amounts consumed. This section focuses on the sodium content of foods from various food channels—that is, the various sources of foods available to consumers. The following section focuses on how changes in portion sizes and energy intake have affected the relative contribution of different food channels to total sodium intake.

One way to directly compare the sodium content of foods from different sources without the confounding effect of variations in consumer use is to compare their *sodium intake densities*, defined as the number of milligrams of sodium per 1,000 calories. As shown in Panel A of Figure 2-4,

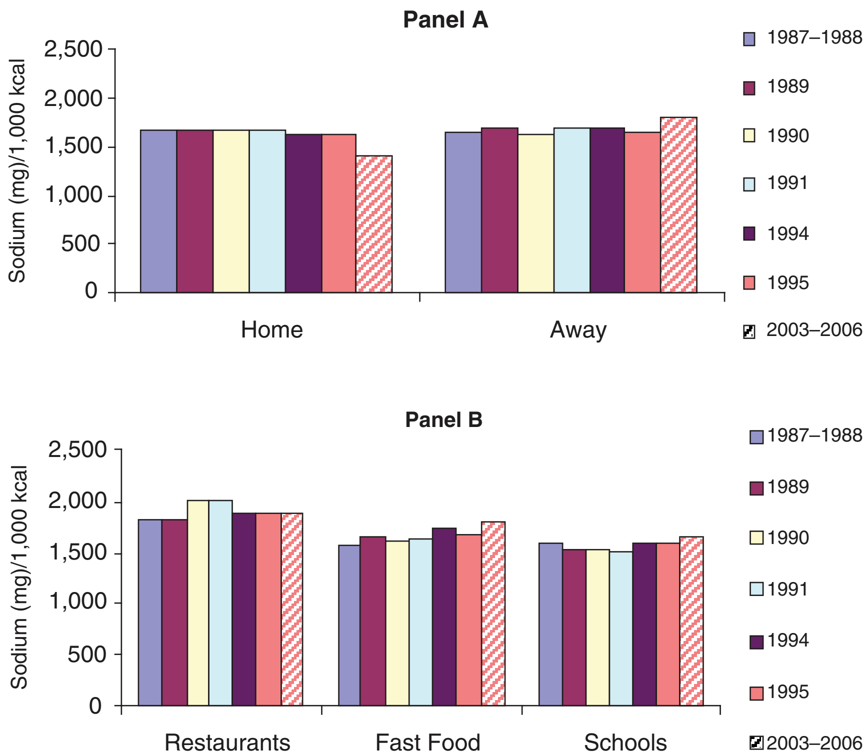

FIGURE 2-4 Mean sodium densities of home and away-from-home foods over time for persons 2 or more years of age.
NOTES: Restaurants, fast food, and schools reflect subsets of away-from-home foods. Restaurants are defined as those with waiter and waitress service, fast food includes self-service restaurants and carryout places, and schools include day-care centers and summer camps. Analyzed using 1-day mean intake data from NHANES 2003–2006 (also see Chapter 5 and Appendix F). kcal = calorie; mg = milligram.
SOURCES: Lin et al., 1999; NHANES 2003–2006.

nationally representative data collected between 1987 and 1995 reveal that the measures of sodium intake density of foods consumed either at home or away from home were similar (Lin et al., 1999). Likewise, foods obtained from fast food restaurants and schools have sodium densities that were not too different from those of the at-home food category, as shown in Panel B. Slightly higher sodium densities were reported for restaurant foods and slightly lower densities are seen for schools. These results suggest similar salt additions to foods from most locations during this time period.

As shown in Figure 2-4, more recent data prepared from the NHANES 2003–2006 suggest greater differences in the sodium densities of foods consumed away from home compared to foods consumed at home than seen in the earlier surveys. These data indicate that the sodium density of foods away from home was 1,825 mg/1,000 calories compared to 1,422 mg/1,000 calories for foods consumed at home. To interpret the sodium intake density data in Figure 2-4 with a reference intake of 2,000 calories per day, a density of < 1,150 mg sodium per 1,000 calories is consistent with the *Dietary Guidelines for Americans* recommendation of < 2,300 mg sodium per day. Within the away-from-home food sources, the rank order of restaurants as the highest and school meals as the lowest continues.

Crepinsek et al. (2009) used menu and recipe data from the Third School Nutrition Dietary Assessment Study to calculate the nutrient contents of nationally representative school breakfasts and lunches. According to their data for calories and sodium as the basis for calculating sodium intake density, school lunches served to students provided an average of 1,901 mg/1,000 calories. In addition, none of the schools offered lunches that met the benchmark for sodium content, which is set at one-third of the maximum daily intake recommended by the 2005 *Dietary Guidelines for Americans*. However, almost half of the breakfasts offered met the benchmark for sodium content, which is set at one-fourth of the maximum daily intake recommended by the 2005 *Dietary Guidelines for Americans*.

All of the sources identified above as well as all of the time periods for which data are available suggest that mean intakes are in considerable excess of the *Dietary Guidelines for Americans* goal. Taken as a whole, these data underscore the difficulty that consumers and meal planners have in meeting sodium guidelines using readily available foods. This is consistent with the concept that consumer taste preference for the saltiness of foods is fairly consistent regardless of where the food is obtained. Finally, these data suggest that all food channels will need significant sodium reductions to meet dietary sodium recommendations, and that sodium reduction strategies may be most effective if they include all food channels.

Relative Contributions of Different Sources to Total Sodium Intake

While sodium densities allow direct compositional comparisons across foods from different food channels, the full impact of these foods on *total sodium intake* is determined by the total amount of food consumed. The amount of food consumed is affected by several factors including portion size.

Recently, increasing portion sizes of food have received considerable attention as a likely contributor to the emerging obesity epidemic. Larger portion sizes also have the potential to deliver larger quantities of nutrients such as sodium. Portion size can be affected by packaging sizes in processed food, portion sizes served in restaurant/foodservice operations, and the behavior of individual consumers.

As shown in Figure 2-5, the portion sizes of sample foods generally increased between 1977 and 1996 (Nielsen and Popkin, 2003). In general, this same pattern of increasing portion size over time was seen for the same foods when consumed at home or at a restaurant or when obtained from fast food vendors—suggesting that increasing portion size is a phenomenon common to all food channels.

Moreover, increasing portion sizes are not limited to the sample foods in Figure 2-5. Smiciklas-Wright et al. (2003) found that increasing portion sizes are widespread across a number of food categories. Using the Continuing Survey of Food Intakes by Individuals (CSFII) from 1989–1991 and 1994–1996, they found that nearly one-third of the servings from 107 food categories exhibited this pattern. Clearly, larger portion sizes will deliver greater amounts of sodium if sodium densities are not reduced.

With limited data on portion sizes across food channels, another way of estimating relative changes in sources of nutrients is to look at changing patterns in sources of energy intake. As shown in Figure 2-6, overall energy intake increased between 1977 and 1996 (Nielsen and Popkin, 2003). This overall increase was associated with a decreasing intake from at-home foods and an increasing intake from foods consumed away from home. These data suggest that even though sodium densities were similar for foods defined as eaten "at home" and "away from home" (see Figure 2-4,

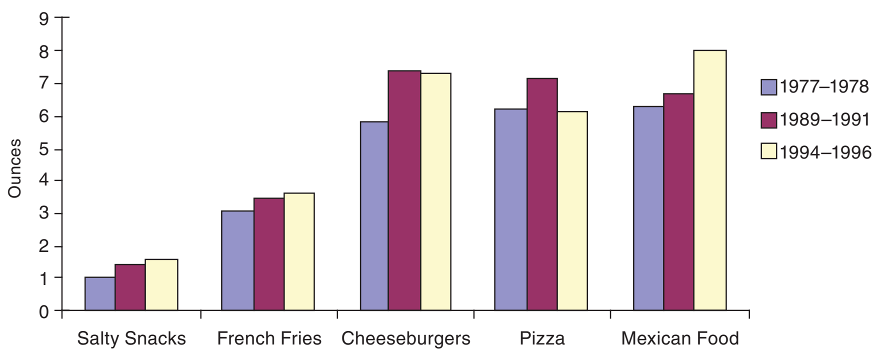

FIGURE 2-5 Differences in portion sizes 1977–1978 to 1994–1996 for key food items consumed by persons 2 or more years of age.
SOURCE: Nielsen and Popkin, 2003. *Journal of the American Medical Association* 289(4), pp. 450–453. Copyright © 2003 American Medical Association. All rights reserved.

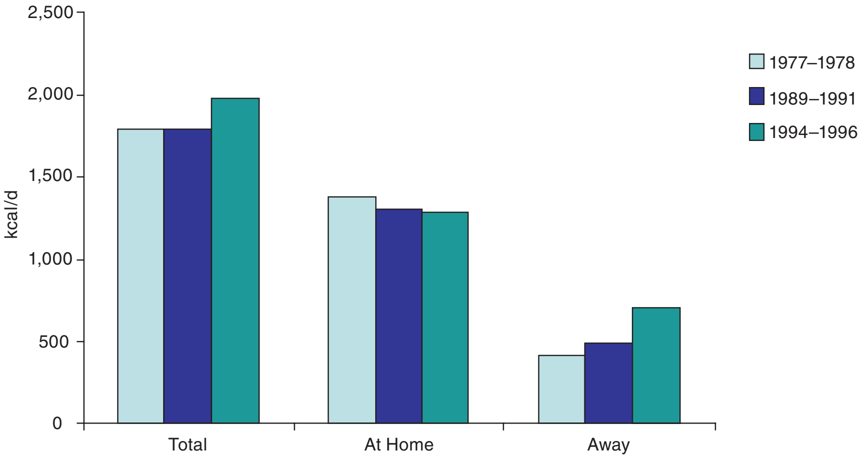

FIGURE 2-6 Mean energy intake 1977–1978 to 1994–1996 for foods eaten at home and away from home compared to total mean energy intake for persons 2 or more years of age, based on data from the 1977 National Food Consumption Survey and the 1989 and 1996 Continuing Survey of Food Intake by Individuals.
NOTE: d = day; kcal = calorie.
SOURCE: Nielsen and Popkin, 2003.

Panel A) during this time, their relative contributions to total intake were changing.

Current data on calorie and sodium intake from foods defined as eaten at home and away from home as collected in national surveys were assessed for this study (see Chapter 5 and Appendix F). The data from the 2003–2006 NHANES suggest that 63 percent of sodium intake comes from foods eaten at home and 37 percent from foods eaten away from home. Thus, both channels make a significant contribution to total intake. However, it is important to note that the at-home category is a mixture of processed foods (e.g., soups), prepared frozen meals and dishes, and carryout foods obtained from commercial restaurant/foodservice operations. Thus, the relative contribution of away-from-home foods is likely underestimated and the relative contribution of foods "prepared" at home is likely overestimated.

Overall, the above results underscore the potential benefit of a comprehensive approach to sodium reduction across all food channels. They also suggest that the effectiveness of sodium reduction programs will likely be enhanced if they are linked to other public health programs that focus on portion size and calorie control, as increased energy intake and portion sizes contribute to sodium intake in addition to the sodium density of the food supply.

Use of Sodium-Related Label Claims and Advertising

As part of the common message over the past 40 years about the need for food manufacturers and, increasingly, restaurant/foodservice operators to reformulate and reduce the sodium content of their foods and to introduce new foods with lower-sodium content, it was assumed that the ability to use nutrition claims on food products would motivate food producers to offer products bearing sodium nutrient content or health claims. While declarations of the sodium content per serving of all processed foods became mandatory with the implementation of nutrition labeling in 1993, a manufacturer's use of descriptive claims about the sodium content (i.e., nutrient content claims) and claims about the usefulness of low-sodium intake in reducing the risk of hypertension (i.e., health claims) is voluntary.

Figure 2-7 shows that nutrient content claims for sodium[12] were most popular during the time the NLEA was being implemented in the early 1990s. Subsequently, their use dropped sharply, although there was a transient increase in 2000–2001. The use of sodium content claims in 2006–2007 was only slightly more than half their use in 1991–1993. Fat label claims have been the most popular, with 22.5 percent of products bearing these claims in 1997 and 17.2 percent in 2000–2001. The least used claims are fiber (2.5 and 2.0 percent in 1997 and 2000–2001, respectively) and saturated fat (3.8 and 2.0 percent, respectively).[13]

Information on the product categories showing the most extensive use of sodium content claims in the U.S. marketplace is periodically collected in FDA's Food Labeling and Package Survey. Comparisons of the sales-based percentages within the top food categories that carry sodium content claims for two different time periods are displayed in Table 2-4.

In 1997, the food category with the highest number of brands carrying a sodium content claim was carbonated soft drinks and water—specifically 47.3 percent of brands in this category (Brecher et al., 2000). The percentage of two beverage categories carrying sodium content claims was considerably higher in 2000–2001, with 83.7 percent of the category titled "beverages, water" and 62 percent of the category titled "beverages, carbonated soft drinks" (LeGault et al., 2004). The data in Table 2-4 also suggest that although sodium nutrient content claims were used for diet and health benefit foods in 1997 (24.6 percent of brands in this category), this

[12] These claims include the terms sodium free, low sodium, very low sodium, reduced sodium, no added salt, salt free, and light in sodium.

[13] Personal communication, M. Brandt, FDA, December 17, 2008.

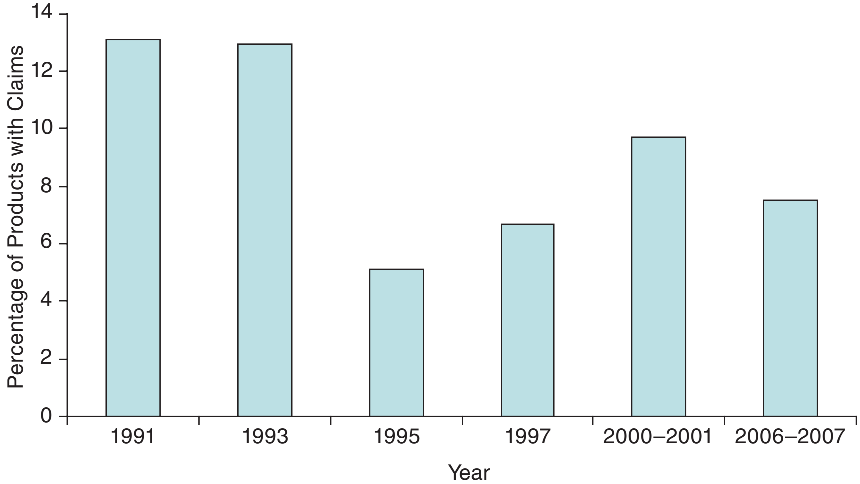

FIGURE 2-7 Processed, packaged foods with sodium content claims.
SOURCE: Personal communication, M. Brandt, FDA, December 17, 2008.

category appears to have dropped out of the top categories using sodium content claims in the 2000–2001 survey. Thus, most of the sodium content claims in 2000–2001 appear to have been used primarily for foods that are likely to be naturally low in sodium (e.g., beverages, sugar substitutes) rather than for products reformulated to reduce their sodium content (e.g., diet and health benefit foods). One possible exception is the apparent availability of unsalted nuts and seeds carrying sodium content claims in 2000–2001.

TABLE 2-4 Sales-Based Percentages of Brands with Sodium Content Claims

Percentage, 1997		Percentage, 2000–2001	
Carbonated soft drinks and water	47.3	Beverages, water	83.7
Fluid milk	26.7	Beverages, carbonated soft drinks	62.0
Diet and health benefit foods	24.6	Sugars and sugar substitutes	44.9
Baby foods	15.0	Nuts and seeds	34.8
Soft drink and beverage mixes	11.1	Beverages, juices/drinks, refrigerated	32.8

SOURCES: Reprinted from *Journal of the American Dietetic Association* 100(9), Brecher et al., Status of nutrition labeling, health claims, and nutrient content claims for processed foods: 1997 Food Label and Package Survey, pp. 1057–1062, Copyright © 2000, with permission from Elsevier; Reprinted from *Journal of the American Dietetic Association* 104(6), LeGault et al., 2000–2001 Food Label and Package Survey: An update on prevalence of nutrition labeling and claims on processed, packaged foods, pp. 952–958, Copyright © 2004, with permission from Elsevier.

It is worthwhile to briefly consider the topic of food advertising, which is regulated by the Federal Trade Commission. Advertising of nutrient and health claims, unlike food product labeling, can be used freely by manufacturers and retailers provided the message is truthful and not misleading. Advertising of the healthfulness of food products was in use before implementation of the NLEA in 1990 and continued afterward. There is a common perception that manufacturers prefer to use claims for "positive nutrients" (e.g., vitamins and minerals that one should eat more, or products that are useful in weight control and loss) rather than "negative nutrients" (e.g., sodium and saturated fat that one should eat less). The data in Figures 2-8 and 2-9 are from a study on the types of claims made in food advertisements found in magazines from 1977–1997. These data show that the use of "negative" nutrient content claims was generally greater than the use of "positive" nutrient claims (Ippolito and Pappalardo, 2002) in magazine advertisements.

In general, the use of specific nutrient content claims seems to trend upward and then decline. There also appears to be some trade-off among nutrients in the timing of claims—as the peaks of use for different nutrients occur during different years. Specifically, these data (Ippolito and Pappalardo, 2002) show that the use of sodium claims on processed and packaged foods peaked at 13.3 percent in 1991 and subsequently fell to 6 percent in 1997. Sodium content claims were never as commonly used as fat and cholesterol claims, but they were used more often than saturated fat claims in magazine advertising.

This same study also tracked the use of health claims (referred to as

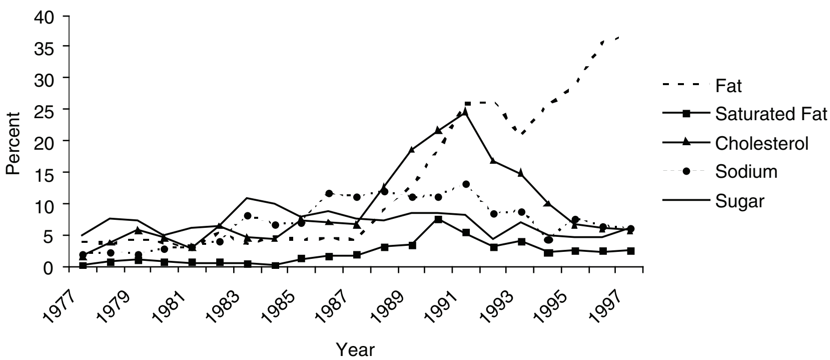

FIGURE 2-8 Percentage of magazine advertisements with "negative" nutrient content claims, 1977–1997.
SOURCE: Ippolito and Pappalardo, 2002.

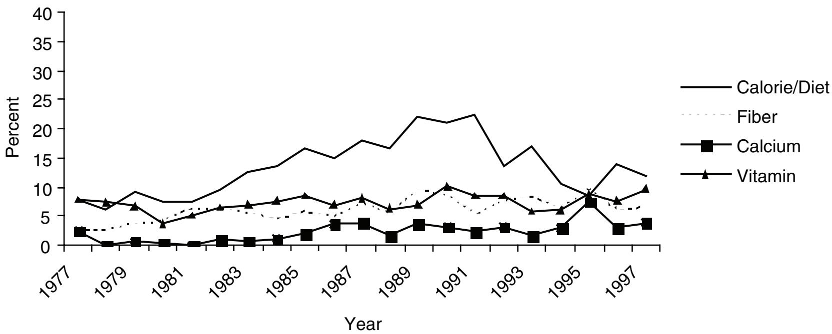

FIGURE 2-9 Percentage of magazine advertisements with "positive" nutrient content claims, 1977–1997.
SOURCE: Ippolito and Pappalardo, 2002.

"disease claims") in advertising. The use of heart disease claims peaked in 1989 at 2.9 percent of ads, cancer peaked in 1997 at 2.2 percent, blood pressure peaked in 1995 at 1.2 percent, and osteoporosis peaked in 1997 at 0.5 percent. Thus, nutrient content claims are far more commonly used in magazine ads than are claims linking food products to reduction of disease risk, and sodium-related and/or hypertension claims are less commonly used in advertising than are claims for other nutrients and/or other diseases.

Availability of Lower-Sodium Food Products

The question arises as to whether the marketing of foods specifically labeled to indicate their usefulness in lower-sodium diets has increased over the past 40 years. In this regard, the number of lower-sodium foods (foods labeled as no-, low-, or reduced-sodium) introduced between 1989 and 2004 is shown in Figure 2-10.

The number of such foods introduced into the marketplace has declined significantly since 1990, with approximately half as many new products introduced in 2004 as in 1990 (CSPI, 2005b). In 2007, a survey of packaged food products reported that 209 low-sodium or low-salt products were introduced, although this was an increase from 102 such products in 2002 (Packaged Facts, 2008).

As a percentage of all new food introductions into the marketplace, foods labeled as "no salt," "low salt," "no sodium," or "low sodium" fluctuated between 2.5 and 3.5 percent of all new food products (excluding beverages) from 2000–2006, peaked in 2007 at 4.3 percent, and declined

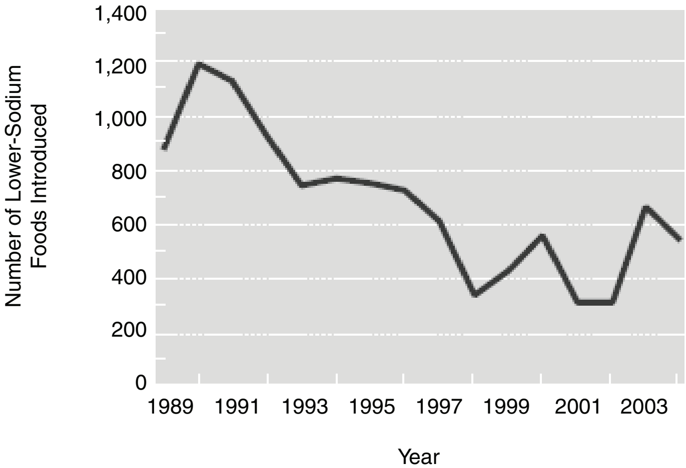

FIGURE 2-10 Number of lower-sodium (no-, low-, or reduced-sodium) foods introduced each year (as indicated by the y-axis), 1989–2004.
SOURCE: CSPI, 2005b. "Salt: The forgotten killer." Reprinted with permission.

to 4.1 percent in 2008 and further to 3.8 percent in 2009.[14] Although the percentage of new food introductions making sodium claims has changed little over the past decade, manufacturers report that they have decreased the sodium in their products without advertising the changes. This may be because some consumers tend to associate low- and reduced-sodium foods with poor taste (Heidolph, 2008; IFIC, 2009), as stated by participants at the committee's public information-gathering workshop (March 30, 2009). The interest in using sodium content claims compared to other types when introducing new food products that bear nutrient content claims is shown in Figure 2-11. The data in Figure 2-11 (Weimer, 1999) show that new product introductions use sodium-related claims less frequently than fat and calorie claims. Also, consistent with the discussion above on the general use of nutrient content claims, salt and other nutrient claims on newly introduced products generally follow a pattern of increasing, peaking, and decreasing trends in use.

Overall, the introduction of new products specifically labeled as low or reduced in sodium has been limited and has decreased over time. Given the interwoven nature of manufacturer motivations and consumer demand, there appears to be consistency in the relative rank order that consumers place on sodium concerns and their declining interest in sodium, as dis-

[14] Personal communication, T. Vierhile, Datamonitor, Canandaigua, NY, February 1, 2010.

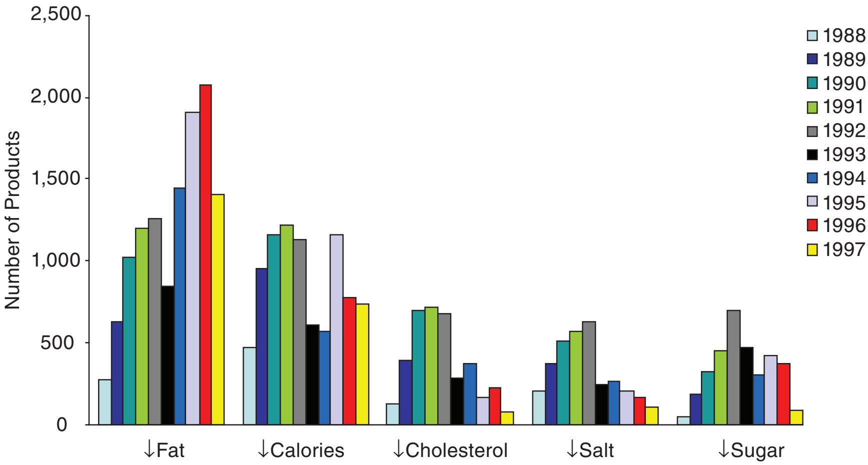

FIGURE 2-11 Number of new food products bearing nutrient content claims, 1988–1997.
NOTE: The ↓ indicates "reduced" or "low" for fat, calories, salt, and sugar, and "low" or "no" for cholesterol.
SOURCE: Weimer, 1999.

cussed previously in this chapter, and the low and declining introduction of new products labeled by manufacturers as reduced or low in sodium.

Sodium Intake

There are three approaches for assessing intake of a nutrient such as sodium: (1) population means based on the disappearance of the nutrient of interest into the U.S. food supply, (2) intake by individuals calculated from intake records or interviews, and (3) the measurement of a biomarker of exposure. Each approach has strengths and weaknesses. While any single approach alone is associated with considerable uncertainty, consistencies across methodologies in time trend patterns and assessments relative to public health goals provide greater confidence in the conclusions reached. This section provides an overview of sodium intake in a time trend context for the purpose of describing the outcomes of the public health initiatives. Current estimates of sodium intake developed for this study are described in more detail in Chapter 5.

Salt Disappearance Data

The advantage of monitoring intake from disappearance data is that it allows for a reasonably accurate estimate of time trend patterns because of common methods of collecting data and accounting for use over time. The disadvantage of using disappearance data to estimate nutrient intake is that it overestimates intake because it fails to capture food losses and wastage after the nutrient enters the food system (e.g., cooking and processing losses).

Salt disappearance data can be used to estimate time trend patterns in the availability of sodium for human consumption. The Salt Institute posts information on its website about food-grade salt sales in the United States.[15] These data are most useful if the tonnage of salt is converted to milligrams of sodium. With changing population numbers over time, it is also useful to convert annual results to per capita values. The annual per capita sodium disappearance numbers from 1978 through 2008 derived from data on salt disappearance are illustrated in Figure 2-12.

The salt disappearance data show a steady increase in per capita availability between 1983 and 1998. More recently, values appear to be leveling off or decreasing slightly. The peak levels in 1998 indicate that approximately 5,700 mg of sodium were available per person per day. The extent to which the disappearance values are an overestimation of actual intake is unknown but the fact that they are more than double the *Dietary Guidelines for Americans* level of < 2,300 mg/d sodium suggests that salt availability is in excess of public health goals for sodium. Moreover, given that the major advantage of disappearance data is the trend pattern that they reveal, the disappearance data in Figure 2-12 do not show a sustained reduction in response to the sodium-related public health initiatives identified in Tables 2-1 to 2-3. Although the pattern of use over time suggests that early educational and program initiatives carried out in the 1980s were associated with a reduction in salt use, subsequent programs—including the implementation in 1993 of mandatory declaration of sodium content on all food labels and multiple calls since 1969 for food processors to reduce the sodium content of foods—appear to have had little or no impact on salt availability for human use.

Intake by Individuals

Since 1971, NHANES has provided estimates of individuals' nutrient intakes from a nationally representative sample of the U.S. population. These estimates are based on 24-hour recalls. As shown in Figure 2-13, the trends in sodium intake between the 1971–1974 and 2005–2006 surveys are shown for three life stage groups. Similar patterns were seen across other life stage groups (Briefel and Johnson, 2004; see Chapter 5).

[15] Available online: http://www.saltinstitute.org/Production-industry/Facts-figures/U.S.-production-sales (accessed November 16, 2009).

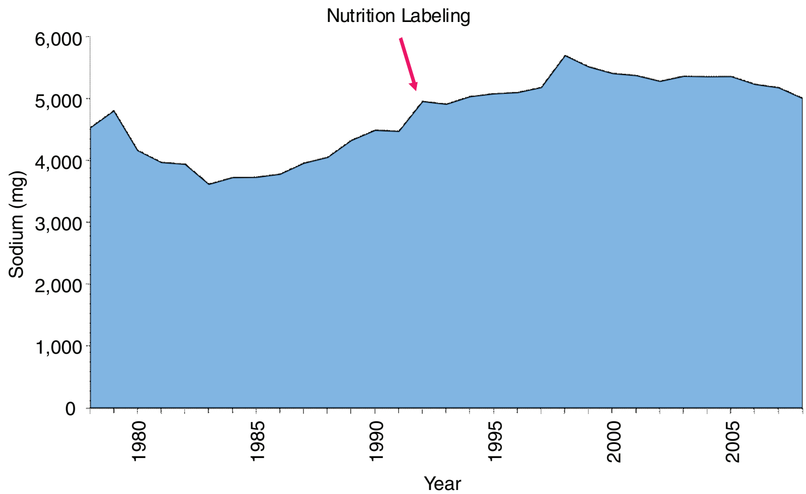

FIGURE 2-12 Annual per capita sodium disappearance based on salt disappearance, 1978–2008.
NOTES: Sodium (milligrams) shown on y-axis was determined by the following calculation: Salt disappearance data (tons of food-grade salt per year) was converted to grams of salt per day. That number was then divided by census-based per capita population estimates used by USDA's Economic Research Service in developing nutrient availability databases, 1978–2008, and grams of salt consumed per day was converted to milligrams sodium by multiplying by 39.3 percent.
SOURCE: Based on Salt Institute salt disappearance data (tons of food-grade salt per year) and USDA census data.

The results in Figure 2-13 suggest that intake increased between 1971–1974 and 1988–1994 and then plateaued between 1988–1994 and 2005–2006. Whether the early increases are real or due to methodological artifacts is uncertain. There were improvements in interview methodologies during that time that were associated with more complete reporting of intake (Loria et al., 2001). However, even with the caveat that intake by individuals tends to be underestimated and caution as to possible methodological sources of underestimation in the early surveys, the mean intakes, except for adult women in the first two survey periods, are all in excess of *Dietary Guidelines for Americans* recommendations.

One way of crudely evaluating whether or not underreporting biases have influenced time trends in estimates of sodium intake is to evaluate whether the differences in sodium intake over time and among subgroups are negated or minimized when the results are expressed as sodium densities. Using the same database as in Figure 2-13, Figure 2-14 provides data on the sodium densities for the same surveys.

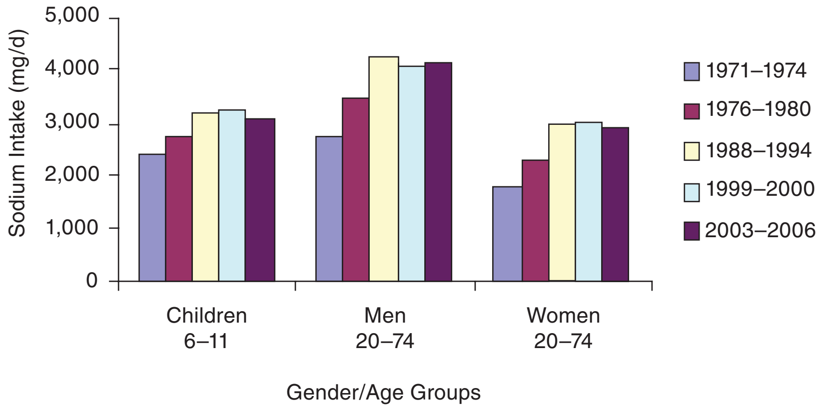

FIGURE 2-13 Trends in mean sodium intake from food for three gender/age groups, 1971–1974 to 2003–2006.
NOTES: Analyzed using 1-day mean intake data for NHANES 2003–2006 to be consistent with earlier analyses and age-adjusted to the 2000 Census; includes salt used in cooking and food preparation, but not salt added at the table. d = day; mg = milligram.
SOURCES: Briefel and Johnson (2004) for 1971–2000 data; NHANES for 2003–2006 data (see Chapter 5).

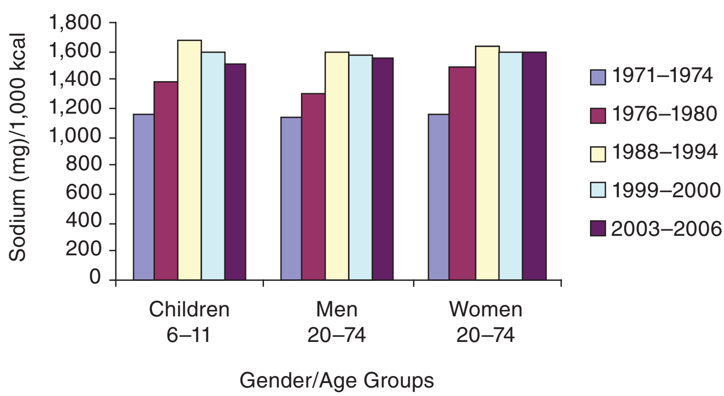

FIGURE 2-14 Trends in mean sodium intake densities from food for three gender/age groups, 1971–1974 to 2003–2006.
NOTES: Analyzed using 1-day mean intake data for NHANES 2003–2006 to be consistent with earlier analyses and age-adjusted to the 2000 Census; includes salt used in cooking and food preparation, but not salt added at the table; 1-day mean intake calculated using the population proportion method. kcal = calorie; mg = milligram.
SOURCES: Briefel and Johnson (2004), for 1971–2000 data; NHANES for 2003–2006 (see Chapter 5).

As shown in Figure 2-14, the differences in sodium intake that were observed among children and adult men and women disappear to a large degree when the intakes are expressed as sodium densities. This suggests that the intake differences among life stage groups at any time were related primarily to differences in their energy intake rather than to differences in the sodium densities of the foods they consumed. The increasing sodium densities between the 1970s and late 1980s also show that foods as consumed contained higher amounts of sodium between those time periods. However, since the early 1990s sodium densities appear to be stable. Although data are not available to allow the separation of the relative contribution of increasing energy intake over time (or improved measures of energy intake over time) from the relative contribution of increasing amounts of sodium in foods over time, these data suggest that at least some of the increases in sodium intake over time may be due to increases in the amount of sodium in foods. Changes in intake over time must be cautiously interpreted because of limitations in these data, particularly older data based on different methodologies. However, compared to a sodium intake density of < 1,150 mg/1,000 calories per day to be consistent with a *Dietary Guidelines for Americans* daily intake of < 2,300 mg sodium and assuming a 2,000-calorie reference diet, most groups had intakes that exceeded guideline levels, even during the earlier periods when sodium densities appeared lower than in more recent years.

Urinary Excretion of Sodium

As described in Chapter 5, mean urinary sodium excretion collected over a 24-hour period is generally considered to be the gold standard for accurately estimating the sodium intake of individuals. However, in the absence of such data from nationally representative surveys in the United States, the best source of data on urinary sodium excretion of Americans is carefully designed and monitored research studies. Results for U.S. adults participating in two observational studies and four clinical trials between 1980 and the late 1990s indicate that the median urinary sodium excretion per 24 hours across all studies was approximately 3,700 mg/d for men and 3,000 mg/d for women (Loria et al., 2001). Based on the average sodium excretion across all studies, all but one group had sodium excretions of more than 2,300 mg. Eleven of 12 groups of men had average sodium excretion levels greater than 3,000 mg/d, with 4 of these groups having a mean excretion greater than 4,000 mg/d. For women, 6 of 12 groups had sodium excretions between 2,500 and 3,000 mg/d; 6 of the 12 groups had sodium excretions between 3,000 and 3,612 mg/d. Thus, the sodium excretion of U.S. adults participating in research studies showed that almost all of the groups had mean sodium excretion levels well in excess of the

Dietary Guidelines for Americans recommendation of < 2,300 mg/d of sodium.

Prevalence of Hypertension

A solid body of diverse evidence has documented that, on average, as sodium intake rises, so does blood pressure. Furthermore, trials in children, non-hypertensive adults, and hypertensive adults have documented that sodium reduction lowers blood pressure. Although elevated blood pressure and hypertension are also related to other risk factors, reducing daily sodium intake is associated with significant reductions in population-based blood pressure values and prevalence of stroke mortality (DGAC, 2005).

What have been the time trends in prevalence of hypertension among U.S. adults over the past several decades? National trends in the prevalence of hypertension of men and women 20 years of age and older from three different time periods are shown in Figure 2-15.

Hypertension was defined as an elevated blood pressure (systolic pressure ≥ 140 mm Hg or diastolic pressure ≥ 90 mm Hg) and/or use of antihypertensive medications at the time of the individual's examination in

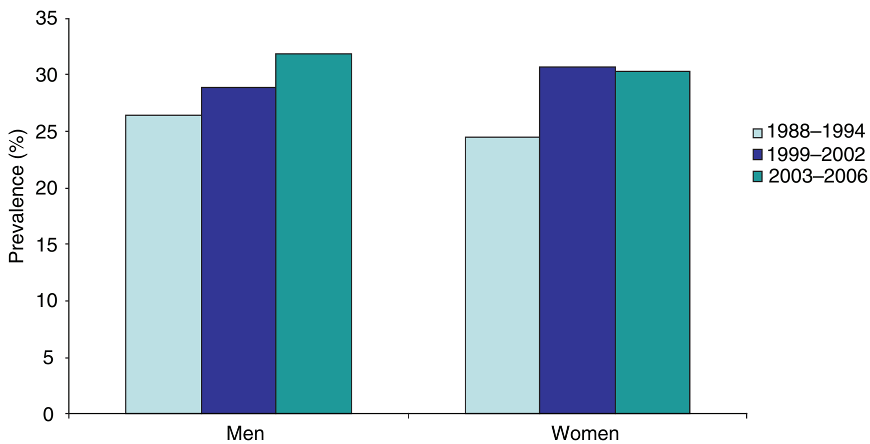

FIGURE 2-15 Trends in elevated blood pressure/hypertension from NHANES for persons ≥ 20 years of age.
NOTES: Hypertension, as defined by the data source, is an elevated blood pressure (systolic pressure ≥ 140 mm Hg or diastolic pressure ≥ 90 mm Hg) and/or use of anti-hypertensive medications; data age-adjusted to 2000 population.
SOURCE: NCHS, 2009.

the NHANES Medical Examination Center (NCHS, 2009). Results were age-adjusted to the 2000 population.

The results show an increase from 1988–1994 to 2003–2006 for both men and women (NCHS, 2009). Similar trends were seen across race/ethnicity groups and different income levels. Using age-standardized data from NHANES 1988–1994 and 1999–2004, Cutler et al. (2008) reported a relative increase of 18 percent in hypertension prevalence rates (from 24.4 to 28.9 percent). None of the age/gender or race/ethnicity groups in their analyses had declining prevalence rates. After adjusting for changes in body mass index (BMI) over the two surveys, there continued to be large relative increases in the prevalence of hypertension for women. These results indicate that some of the increases of hypertension in women were attributable to factors other than increases in BMI. These factors may have included increases in sodium intake, changes in alcohol and potassium intake, decreases in physical activity, suboptimal health literacy levels, and lack of access to health-care services. For men, increases in BMI accounted for most of the increased prevalence of hypertension between surveys. Thus, after controlling for BMI, prevalences of hypertension between 1988–1994 and 1999–2004 remained relatively stable for men and increased for women.

In summary, the prevalence of hypertension in the U.S. population appears to be increasing. Controlling for the possible confounding effects of increasing body weight over the same time suggests that the prevalence is stable for men but increasing for women, even after controlling for obesity. However, neither the stable prevalence pattern seen for men nor the increasing pattern seen for women is consistent with a declining pattern of hypertension prevalence that would be expected to be associated with significant reductions in sodium intake on a population-wide basis.

FINDINGS

From the descriptions in this chapter, it is clear that a myriad of sodium reduction strategies, programs, and initiatives have been implemented by numerous government agencies, health professional organizations, and the food industry—starting in 1969 and continuing to the present. These programs had common themes and a consistent message on the relationship between sodium intake and hypertension, with special emphasis on consumer education, sodium labeling of food products at point of purchase, and encouragement of reformulation by food processors and more recently by restaurant/foodservice operators. Audiences for these programs and initiatives included consumers, health professionals, the media, and the food industry.

To assess whether relevant population- and industry-based changes occurred during the 40 years since the first strategies, programs, and initiatives were begun, trends have been evaluated in several relevant areas: consumer awareness, knowledge, and behavior; the food industry; sodium intake; and the prevalence of hypertension. To assess changes over time, available data from the National Nutrition Monitoring System and, in a few cases, the scientific or trade literature were used. Despite the fact that the publicly available data were somewhat spotty and incomplete in all of the areas examined, the totality of available evidence reveals a consistency of findings across those areas.

From the available data, it is clear that past initiatives and recommendations have not been successful in achieving the ultimate goal of reducing sodium intake and sodium-related health concerns. Initially, consumer messages most strongly encouraged higher-risk groups (e.g., African Americans and older adults) to reduce sodium intake, and use of salt at the table and during cooking was emphasized. As evidence became stronger that sodium should be a concern throughout the lifespan and as new data emerged on major sources of intake, messages were adjusted to include the entire population, and to encourage consumers to consume processed and restaurant/foodservice foods that were lower in sodium. The results from the three different types of exposure estimates (salt disappearance, dietary recall, and urinary excretion) all consistently show that, despite the broad-based and long-term efforts, neither the salt disappearance nor the sodium intake data show a sustainable trend in declining sodium intake over the 40 years of carrying out the past and existing initiatives. Today, sodium intake by Americans is well in excess of the *Dietary Guidelines for Americans* recommendation of < 2,300 mg/d sodium. Similarly, significant declines in the prevalence of high blood pressure and stroke mortality have not been seen in the United States.

While the ultimate goal of sodium reduction initiatives has not been met, intermediate goals have seen some success. Public education campaigns in the early 1980s created a dramatic rise (from 12 percent to 48 percent) in consumer awareness of the relationship between sodium and hypertension. Many consumers also believed that sodium reduction was an issue of personal importance, with 62 percent of main meal preparers saying they were personally concerned about sodium. Over a third of the population has been found to always or often use sodium information on the Nutrition Facts panel. Past initiatives also saw some success in motivating the food industry to reduce sodium in some of its products, and make sodium content claims to indicate lower sodium options to consumers. Given these changes, the question becomes, what has kept the population from achieving actual reductions in intake.

As will be discussed elsewhere in this report, notably in Chapter 6, consumers live in a broad food environment in which social, organizational, and macro-level factors influence the types of foods consumed and, thus, sodium intake. The broad food environment can be linked to the reasons for the lack of effectiveness of 40 years of sodium reduction initiatives. The food supply itself is a key obstacle for consumers. The sodium densities of available foods—both in the marketplace and from restaurant/foodservice operations—make it difficult for consumers to meet dietary recommendations. Further, sustainability of consumer interest and concern is an obvious problem. This becomes intertwined with food producer interest in developing lower-sodium products and in using sodium-related claims and advertising. As a result of these developments, there is a manifest role for increased use of foods naturally low in sodium (e.g., fruits, vegetables) as well as linkages to other public health initiatives because of increasing portion size. Importantly, the number of food channels outside the home and the pervasiveness of salt use throughout the food supply—with average sodium intake density well in excess of that recommended by the *Dietary Guidelines for Americans*—make it very difficult for consumers and meal planners to achieve recommended sodium intake.

Overall, the outreach and educational efforts to date have failed to reduce the sodium intake of the American public; unfortunately, a lack of available data regarding the implementation and evaluation of these efforts prevents the drawing of firm conclusions about why they did not succeed. Currently, sodium intake remains well in excess of the goals in the *Dietary Guidelines for Americans*. It is now apparent that outreach and educational programs to consumers and food producers, although a necessary component of any strategy, are insufficient by themselves to achieve the public health goal of reducing sodium intake by Americans to < 2,300 mg/d. A new focus on changing the food supply to better enable consumers to reduce sodium intake may result in better outcomes in the future. While not completely analogous to sodium reduction, experiences with folic acid suggest a role for food supply changes in achieving public health goals. Years of educational efforts failed to make a significant impact on the intake of folic acid by the at-risk population (women of childbearing age). However, once folic acid fortification was instituted, folic acid intake increased without behavior changes (Johnston and Staples, 1995; Pfeiffer et al., 2007). At the same time, consumers have a role to play: the impact of any food supply approach can be enhanced by informed consumer choices. Therefore, efforts to ensure this role is supported may benefit from activities that are now more fully researched, better designed, and effectively implemented than past efforts.

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3

Taste and Flavor Roles of Sodium in Foods: A Unique Challenge to Reducing Sodium Intake

From a culinary perspective, salt has many desirable properties. Added salt improves the sensory properties of virtually every food that humans consume, and it is cheap. There are many reasons for adding salt to foods. The main reason is that, in many cases, added salt enhances the positive sensory attributes of foods, even some otherwise unpalatable foods; it makes them "taste" better. For people who are accustomed to high levels of salt in their food, its abrupt absence can make foods "taste" bad. If we are to successfully lower salt consumption in the population as a whole, it will be necessary to reduce salt levels in the human food supply with careful attention to their flavor-enhancing properties. Consideration of what is known about the effects of salt on food and flavor perception and why people like foods with added salt can help to inform efforts to lower salt consumption. Further, knowledge of how salt is detected by sensory receptors may aid in developing salt substitutes or enhancers that could contribute to an overall reduction of salt in the food supply.

SALT THROUGH ANCIENT TIMES

It is first important to set salt consumption in historical context. Adding salt to food is a specific human trait (although Kawai [1965] wrote about an apparently learned behavior of Japanese macaques that involved dipping potatoes in salt water rather than fresh water, presumably to improve the flavor). It is believed that the relatively high salt usage of virtually all societies today became common beginning between 5,000–10,000 years ago (He and MacGregor, 2007; MacGregor and de Wardener, 1998; Man, 2007). Most commentators believe that the reason for early salt use was food preservation (MacGregor and de Wardener, 1998; Multhauf, 1978) and that this early use was the origin of the current high consumption. Nevertheless, with the advent of extensive salt mining and improved transportation beginning in China more than 4,000 years ago (Adshead, 1992), the characteristic taste of salted food became widely expected and accepted (Multhauf, 1978). Indeed, it has been argued that many distinguishing characteristics of human society and culture owe their origins to the desire for salt and the salt trade (Beauchamp, 1987; Bloch, 1963; Fregley, 1980).

It is difficult to know how much salt was consumed by humans prior to recent times, since the only good way to estimate intake is to determine 24-hour urinary excretion (for the most part, excess salt is not stored in the body; therefore salt balance under most normal conditions is reflected by equal input and output). Nevertheless, estimates based on historical records have been made. In an estimate of early usage, the average daily sodium intake in certain parts of China in 300 B.C. was reported to be nearly 3,000 mg/d for women and 5,000 mg/d for men (Adshead, 1992). Multhauf (1978) estimated that, in France and Britain in 1850, the human culinary intake of sodium was 4,000–5,000 mg/d. These numbers, if reliable, are within the range of the amounts consumed in many societies today (INTERSALT Cooperative Research Group, 1988). Thus, high salt intake by humans does not have its origins in twentieth-century food processing, but instead likely reflects food processing needs, especially preservation of food, that originated thousands of years ago. It should also be acknowledged that similarities in intake over time and across many different ethnic groups have led to speculation that there may be some as-yet-unknown physiological or nutritional factor that predisposes humans to desire a high salt intake (Fessler, 2003; Kaunitz, 1956; McCarron et al., 2009; Michell, 1978), but there is little experimental support for this hypothesis (Luft, 2009), and some limited data are inconsistent with it (Beauchamp et al., 1987). Further experimental evaluation about whether human sodium intake at levels far above any known physiological need is under metabolic regulation will be of interest.

TASTE VERSUS FLAVOR

Taste and flavor are terms that are often confused. The word "taste" has two meanings, one technical and the other as commonly used in the English language, which encompasses the larger concept of flavor. In this chapter, the word taste is used in its technical sense, but in other chapters of this document, it is often used in its more generic sense.

Taste as a Technical Term

The sense of taste, one of the five major senses, is defined based on anatomy. In mammals, it is the sense subserved by taste receptor cells located primarily on taste buds in the oral cavity. These taste receptor cells are innervated by branches of the seventh, ninth, and tenth cranial nerves that synapse first in the brainstem prior to sending messages to other parts of the brain (Breslin and Spector, 2008).

Most investigators agree that the sense of taste is composed of a small number of primary or basic taste qualities, usually consisting of sweet, sour, salty, bitter, and savory or umami (Bachmanov and Beauchamp, 2007). It is thought that these specific classes or categories of taste evolved to help the animal solve two of its most primary problems: the identification and ingestion of nutrients and the avoidance of poisons. As a presumed consequence of these dedicated critical functions, positive or negative responses to taste compounds (tastants) are often genetically programmed. For example, sweet tastants are generally innately liked and ingested by animals that consume plants (herbivores and omnivores—some carnivores, such as cats, do not detect sweet compounds) (Li et al., 2005). In contrast, bitter tastants are generally disliked and avoided, since many are toxic (Breslin and Spector, 2008).

Common Use of the Word Taste as a Synonym for Flavor

Virtually all foods and beverages impart sensations in addition to taste. For example, a complex food such as soup not only has taste properties (e.g., it is salty, sour, or sweet) but also has volatile compounds that give it its specific identity (e.g., pea soup compared to potato soup), and it may also have burning properties, such as those caused by hot peppers. These sensory properties are conveyed by the sense of smell (cranial nerve 1), experienced mainly through the retronasal route—from the throat up through the nasal passages and up to the olfactory receptors in the upper regions of the nasal cavity—and the sense of chemesthesis (Green et al., 1990) or irritation (cranial nerve 5), respectively. In common parlance, the entire sensation elicited by this food is called its "taste." However, most scientists would instead use the term "flavor" to refer to this total sensation, and that is how it will be used here. It should be noted that many also include the texture of a food as a component of flavor. Taste molecules such as salt can influence flavor in many ways, some of which are described below.

Importance of Flavor in Food Acceptance

Although this chapter focuses on how the taste imparted by salt influences food palatability, it needs to be emphasized that the other chemical sensory systems (smell, chemesthesis) that contribute to overall flavor perception play a crucial role in food acceptance and thus may be useful to take into account in developing strategies to successfully reduce overall sodium in the diet (Koza et al., 2005). For example, certain volatiles detected by smell receptors are often judged as "sweet" and may contribute to judgments of a substance's overall taste of sweetness and acceptability (Schifferstein and Verlegh, 1996). An analogous phenomenon may also occur for saltiness (e.g., Manabe et al., 2009). Recent studies imaging the human brain (e.g., using functional magnetic resonance imaging) have shown that flavor information from these separate sensory systems comes together in several parts of the brain, most prominently in the orbitofrontal cortex (Rolls et al., 2010). This leads to a unitary percept of flavor despite its being made up of anatomically independent sensory systems and emphasizes the prominent role that overall flavor perception plays in judgments of a food's pleasantness.

More broadly, the addition of certain ingredients with high flavor impact to the cooking or manufacturing process may assist in reducing the need for added salt. For example, the addition of fresh herbs and spices, citrus, mustards, and vinegars that impart distinctive flavorings may sometimes be used instead of or in conjunction with added salt, as has been suggested by many authors writing about strategies for lowering sodium in the diet (e.g., Beard, 2004; MacGregor and de Wardener, 1998; Ram, 2008). Some cooking techniques (e.g., searing) may also help reduce the need for added salt in many foodservice operations and in home cooking, in part because they result in the production of new flavors (Ram, 2008). Whether these techniques are applicable to foods prepared by manufacturers and large foodservice operators requires study. Many foods prepared by manufacturers and in foodservice operations are necessarily highly processed; they are cooked at high temperatures for relatively long periods of time, and they must remain acceptable for extended periods. These contingencies may work against using certain flavoring techniques and fresh ingredients to reduce salt in some parts of the food supply. Further work to find alternative approaches is required.

Beyond the consideration of optimal sodium levels in a single manufactured food product, flavor issues need to be considered when evaluating the palatability of sodium levels in composite dishes, whole meals, and entire diets. The food supply contains a vast array of commercially successful products and ingredients—fresh, prepared, and manufactured—whose sodium levels range from very high to moderate to very low. The fact that the same individual, for example, might be fully satisfied with two snacks of widely varying sodium levels—one a fresh apple and the other a handful of salted pretzels—reminds us how dependent the sodium taste issue is on wider flavor contexts. The opportunities to successfully combine higher-sodium foods with other foods that are naturally low in sodium (e.g., fresh fruits and vegetables) in dishes or meals in ways that meet consumer taste demands suggest a set of flavor questions that have not been adequately studied. However, at least for foodservice and home cooking—if to a lesser extent for food manufacturing—the salt taste challenge might be as much a matter of reconsidering flavor options in recipe selection and menu development (e.g., less aggregation of high-sodium ingredients in a single dish) as needing to overcome technical challenges with salt substitutions.

SALT TASTE: HUMAN PERCEPTION AND PREFERENCE

Tastes have several sensory attributes that can be distinguished (Breslin and Spector, 2008). Each molecule detected by the sense of taste is characterized by one or more *qualities*—for example, salty, sweet, and bitter. Sodium chloride, the prototypical salt taste molecule, imparts an almost pure salt taste, whereas potassium chloride, often used in lowered-sodium formulations, tastes both salty and bitter (this bitterness is one reason it is often not fully successful in replacing the sensory effects of salt).

In addition to their qualities, taste molecules impart *intensity*: as concentration is increased, the saltiness also increases, up to some maximum above which no further saltiness is perceived. Tastants also can be evaluated for their time course or *persistence*. In the case of salt, taste intensity increases within a few hundred milliseconds and then rapidly falls. This very sharp time course is generally valued by the consumer. Tastes can also be localized in the oral cavity. Salt taste can be identified by receptors throughout the oral cavity, although there is evidence that the front and sides of the tongue are more sensitive than the back (Collings, 1974).

A critical attribute of salt taste is its hedonic or pleasantness dimension. For many foods, adding salt increases the liking for that food up to a certain point, after which more salt reduces its pleasantness (palatability). This inverted "U" function of added salt can be used in formulating foods, by testing the acceptance of different salt concentrations with many consumers. For any one food, there are substantial individual differences in where the optimal point (which has been termed the "bliss point") resides (McBride, 1994). Some of these differences are most likely due to differences in experience with salt in that food and other foods. That is, the optimal level (the bliss point) can be shifted by altering one's salt exposure. As described later in this chapter, this theory provides a sensory basis for the committee's recommendations. Additionally, the term "bliss point" seems to imply that the optimal level is a very precise point, when in fact there may be a fairly wide range of concentrations of added salt that are judged fully acceptable. For this reason, there may be a wide range of sodium levels within seemingly similar food categories (Figure 3-1). Moreover, this phenomenon may

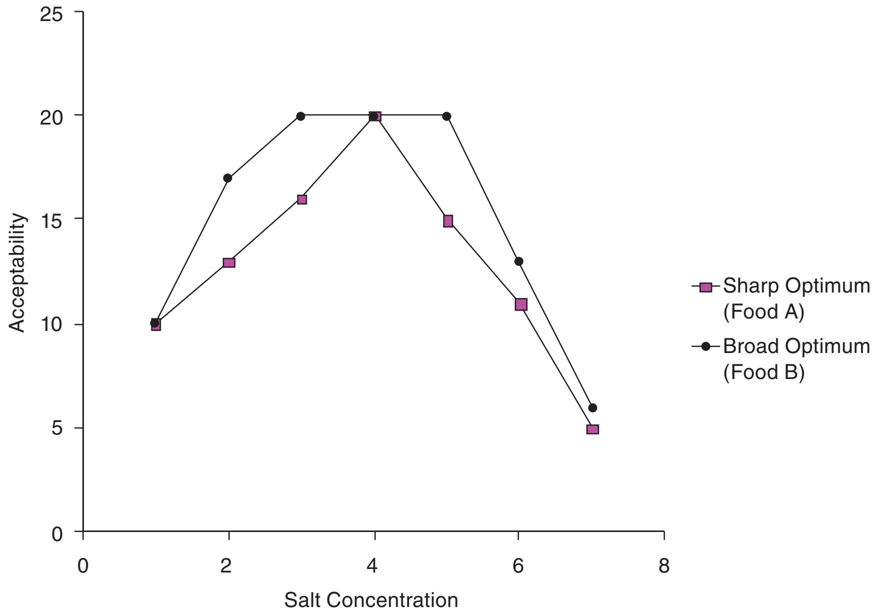

FIGURE 3-1 Hypothetical analysis of optimal salt levels in two foods, A and B. For food A, with a sharp optimum, it may be difficult to reduce salt levels quickly if it is now manufactured or served at concentration level 4. For food B, if it is currently manufactured or sold at level 4, it may be relatively easy to reduce it to level 3, since this is equally acceptable.

help to explain why it is relatively easy in some instances to substantially reduce salt in foods without reducing perceived pleasantness.

SALT FLAVOR EFFECTS

Salt imparts more than just a salt taste to overall food flavor. In work with a variety of foods (soups, rice, eggs, and potato chips), salt was found to improve the perception of product thickness, enhance sweetness, mask metallic or chemical off-notes, and round out overall flavor while improving flavor intensity (Gillette, 1985). These effects are illustrated in Figure 3-2, using soup as an example. In the figure, the distance of each of the points (e.g., "thickness," "saltiness") from the center point represents the intensity of that particular attribute. This figure shows that when salt is added to a soup, not only does it increase the saltiness of that soup (compare closed circles with open triangles and open circles for saltiness), but it also increases other positive attributes, such as thickness, fullness, and overall balance.

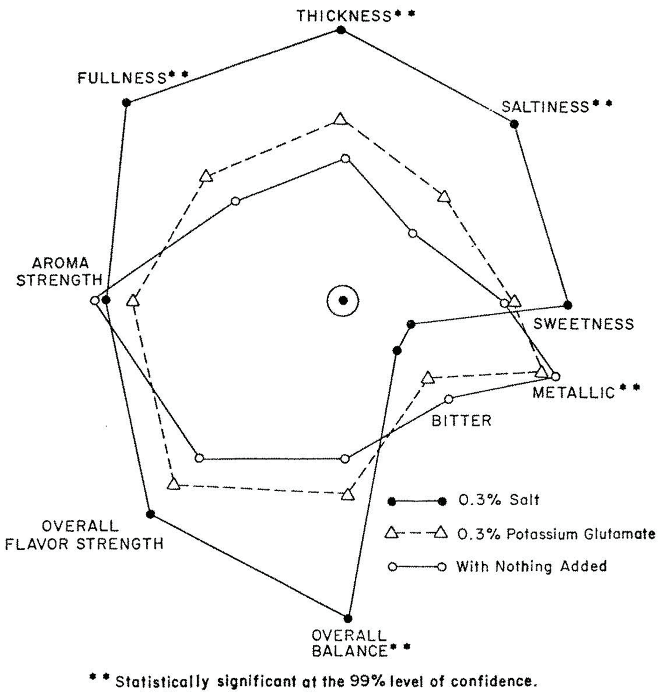

FIGURE 3-2 Aroma and flavor profiles for split pea soup with 0.3 percent salt, 0.3 percent potassium glutamate, or nothing added.
SOURCE: Gillette, 1985. Reprinted with permission.

The mechanisms underlying these varied sensory effects of salt in foods are not well understood. In particular, how salt increases the perceived body or thickness of liquids such as soups is a mystery. It is conceivable that in addition to interacting with salt taste receptor(s), salt could also activate somatosensory (touch) neural systems.

One understood mechanism by which sodium-containing compounds may improve overall flavor is by the suppression of bitter tastes. Various sodium-containing ingredients have been known to reduce the bitterness of certain compounds found in foods, including quinine hydrochloride, caffeine, magnesium sulfate, and potassium chloride (Breslin and Beauchamp, 1995). Further, the suppression of bitter compounds may enhance the taste attributes of other food components. For example, the addition of sodium acetate (which is only mildly salty itself) to mixtures of sugar and the bitter compound urea enhanced the perceived sweetness of this mixture as a consequence of sodium suppressing bitterness and thereby releasing sweetness, as illustrated in Figure 3-3. No change in sweetness was found when

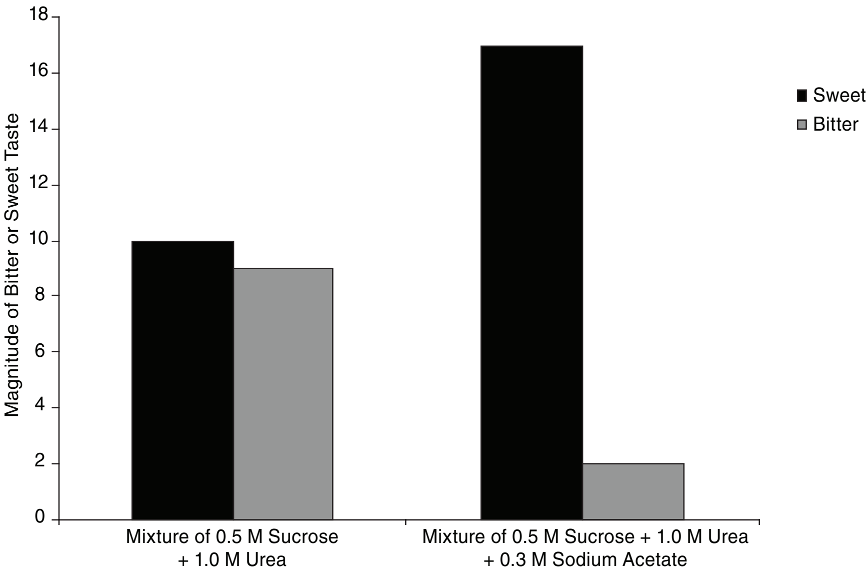

FIGURE 3-3 Magnitude of bitter or sweet taste of various solution mixtures. Adding sodium acetate to a mixture of sucrose and urea increases the sweet, sucrose taste while decreasing the bitter urea taste.
NOTE: M = molarity of solution.
SOURCE: Breslin and Beauchamp, 1997. Adapted by permission from Macmillan Publishers Ltd: *Nature* 387(6633):563, copyright 1997.

sodium acetate was added to sugar solutions without urea, indicating that it is the suppression of bitterness by sodium acetate that is responsible for the improved taste of those solutions (Breslin and Beauchamp, 1997).

Influence on water activity (the amount of unbound water) is another proposed reason that salt may potentiate flavors in foods. Use of salt decreases water activity, which can lead to an effective increase in the concentration of flavors and improve the volatility of flavor components (Delahunty and Piggott, 1995; Hutton, 2002). Higher volatility of flavor components improves the aroma of food and contributes greatly to flavor.

In short, salt plays a role in enhancing the palatability of food flavor beyond imparting a desirable salt taste. This non-salty sensory role may be magnified in products that have reduced amounts of other positive sensory properties (e.g., low-fat products) or increased amounts of non-preferred flavors (e.g., foods fortified with often bitter antioxidants). Consequently, in reducing salt in the food supply, it may often be necessary to identify ways to replace the flavor-modifying effects of salt. This illustrates the technological challenges that have to be met in successfully reducing salt in complex foods while maintaining their palatability. Further research is needed to understand all of the perceptual attributes of salt in foods.

MECHANISMS OF SALT TASTE

Sodium chloride—once dissociated into ions (individual atoms that carry an electrical charge)—imparts salt taste. It is now widely accepted that it is the sodium ion (Na^+) that is primarily responsible for saltiness, although the chloride ion (Cl^-) plays a modulatory role (Bartoshuk, 1980). For example, as the negatively charged ion (anion) increases in size (e.g., from chloride to acetate or gluconate), the saltiness declines. Many sodium compounds are not only salty but also bitter; with some anions, the bitterness predominates to such a degree that all saltiness disappears (Murphy et al., 1981).

It is believed that there are two or more types of receptors in the oral cavity, primarily on the tongue, that are responsible for triggering salt tastes (Bachmanov and Beauchamp, 2007), but major gaps in the understanding of salt taste reception remain. The most prominent hypothesis, which has been demonstrated in mice and rats, is that one set of receptors playing a role in salt taste perception involves ion channels or pores (Epithelial sodium [Na] Channels: ENaCs). ENaCs allow primarily sodium (and lithium) to move from outside the taste receptor cell, where it has been dissolved in saliva, into the taste cell. The resulting increase in Na^+ inside the taste cell causes the release of neurotransmitters that eventually signal salt taste to the brain (Chandrashekar et al., 2010; McCaughey, 2007; McCaughey and Scott, 1998) (Figure 3-4). Because sodium and lithium are the only ions known to produce a purely salt taste, it is believed that these sodium- and lithium-specific channel receptors play a major role in sensing saltiness (Beauchamp and Stein, 2008; McCaughey, 2007).

The body of evidence supporting sodium channel receptors as salt taste receptors is based largely on animal models, primarily rodents. These findings indicate that the diuretic compound amiloride, a molecule that blocks sodium channels, reduces salt taste perception in these animals. In humans, however, amiloride is much less effective in blocking salt taste perception (Halpern, 1998). Nevertheless, since human salt taste mechanisms are highly unlikely to differ in fundamental ways from those of rodents, most investigators are convinced that an ENaC is the most likely receptor in humans as well. If this hypothesis is correct, it has profound implications for the search for salt substitutes. Given the specificity of this channel for sodium, it is highly unlikely that any substance could fully replace sodium (with the exception of lithium, which is unacceptable because it is highly toxic).

At least one other type of taste receptor that detects sodium chloride and some other salts is thought to exist. The hypothesis for a second receptor is based in part on work showing that some salt taste is perceived even when cations that cannot fit into the ENaC (potassium, calcium, am-

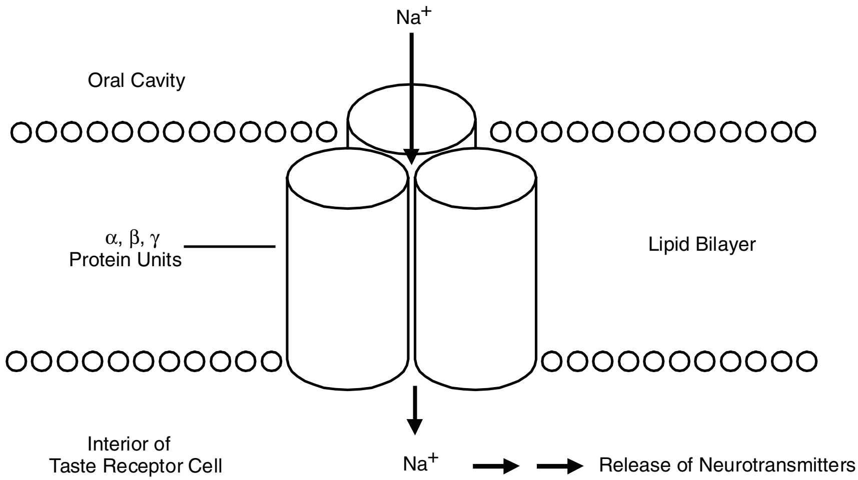

FIGURE 3-4 An epithelial sodium channel (ENaC). The epithelium is represented as a lipid (fat) bilayer (round circles), the area above the lipid bilayer (oral cavity) represents the outside of the taste receptor cell, and the area below the lipid bilayer is the interior of the taste receptor cell. The channel itself is made up of three protein units (alpha, beta, and gamma) that are represented by the cylindrical structures. This channel is thought to form a tunnel through the taste receptor cell that allows Na^+ ions outside the cell to move inside the cell. This channel is quite specific to sodium, which may explain why few compounds are purely salty. Once sodium is inside the taste receptor cell it causes a cascade of biochemical reactions that result in the release of neurotransmitters that signal salt taste to the brain.

monium) are present, rather than sodium or lithium. In addition, salt still elicits a taste in animal model studies, although to a lesser extent and with less specificity, when the ENaC is blocked by amiloride (DeSimone and Lyall, 2006; McCaughey, 2007). A full understanding of how salt taste is recognized by humans, a major gap in our understanding, could facilitate the discovery of effective and economically feasible salt taste enhancers.

EVOLUTION OF SALT TASTE PERCEPTION AND PREFERENCE

It is widely assumed that the ability to detect salt—hence, salt taste perception—arose in response to the need by plant-eating organisms to ensure an adequate intake of sodium (Denton, 1982; Geerling and Loewy, 2008). Sodium is crucial to many physiological processes, and the body cannot store large amounts. Moreover, outside the sea, salt is often hard to find or in low levels in the environment (Bloch, 1963).

There are two conditions under which animals, including humans, choose to consume salt. The first, which has been widely studied in experimental animals, occurs when there is a true sodium need, such as experienced by many plant-eating animals that live in low-sodium environments. This is called salt need (Denton, 1982; Geerling and Loewy, 2008). A number of hormonal, central nervous, and behavioral systems are engaged when an animal is truly deficient in sodium, which motivates it to search for sodium salts, avidly consume them based on their salt taste, and thereby restore sodium balance (Morris et al., 2008). Sodium-depleted animals have an innate ability to recognize, by its distinct taste, the needed nutrient. Although true sodium need may be experienced by humans under some conditions and has been studied experimentally (Beauchamp et al., 1990; McCance, 1936), it is a very rare occurrence under most circumstances. It thus cannot explain why humans consume as much salt as they do (Beauchamp and Stein, 2008; Leshem, 2009). A marginal deficiency of other minerals, particularly calcium, may play a role in stimulating human salt intake (Tordoff, 1992). If this proposed relationship is supported in further studies, it would suggest that one strategy to reduce salt liking and perhaps intake would be to encourage increased calcium consumption, which is already strongly recommended for bone health (HHS, 2000).

The second condition responsible for salt intake occurs in many species, including humans, even when there is no apparent need for salt—that is, when sufficient sodium for all bodily needs has been consumed. This has been termed salt preference (Denton, 1982), even though the desire does not reflect a conscious preference. Taste preference for salt (in the absence of need) has been identified in many animals. Humans generally consume far more salt than is actually necessary and continue to enjoy salty foods even when physiological needs are met. Thus, it appears that salt preference rather than a true physiological need drives salt intake in human populations. Why people consume so much more salt than they need is a concept that is not fully understood and needs explanation.

It has been argued that a preference for salt beyond physiological need is due primarily or exclusively to learning, particularly early learning, or even that it is an addiction (Dahl, 1972; MacGregor and de Wardener, 1998; Multhauf, 1978). In contrast, other investigators have argued that while learning may play a role, evolutionary pressures to consume salt have shaped people and some other animals to have an innate liking for its taste, even when sodium is not needed (Beauchamp, 1991; Denton, 1982). Denton (1982) noted that merely because salt is consumed in excess of contemporaneous need in no way mitigates against such consumption being driven by innate propensities, just as sexual activity occurs in the absence of intent to increase numbers of the species. Even under the first hypothesis, which proposes that high salt intake is due to powerful learning, salt consumption beyond need must necessarily provide some kind of strong reward. People generally do not become highly attracted to substances unless these substances have powerful positive physiological effects. Greater understanding of the basis for high salt preference would help guide efforts to reduce that preference. Thus, there is a need to examine the existing knowledge about the origin of preference during human development.

EARLY DEVELOPMENT OF HUMAN SALT TASTE

Although human infants need sodium in moderation (IOM, 2005), at birth, they are indifferent to salt or reject it, particularly at concentrations higher than found in human blood (hypertonic). By approximately 4–6 months of age, infants show a preference (relative to plain water) for saline solutions around the level found in blood (isotonic) or even higher (Cowart et al., 2004). This age-related hedonic shift may represent in part the maturation of the salt taste receptor cell. Some rodent studies have shown that the ability to detect salt taste matures after birth (Hill and Mistretta, 1990); this may also be the case for humans.

The amount of salt an infant consumes can influence the infant's salt taste preference (Harris and Booth, 1985). In a study by Geleijnse et al. (1997) it was reported that children who had been randomized to either a low or normal sodium diet during the first 6 months of life exhibited differences in blood pressure when tested after 15 years of follow-up, with the low sodium group having lower blood pressures. These data are consistent with the hypothesis that lowered exposure to salt in infancy results in lower preference and intake later in life. Unfortunately data were not collected to specifically test this hypothesis.

The most dramatic effects of early environmental variation on later salt preference and intake have been observed following large sodium loss (true sodium depletion, which is very rare in adulthood) during late fetal life or early infancy. Clinical observations (Beauchamp, 1991) and studies of clinical populations (Leshem, 2009) indicate that true sodium depletion during this period may enhance later salt liking, perhaps permanently. These human studies are consistent with a large body of experimental rodent studies indicating that early depletion causes permanent changes in neural circuits that mediate salt intake. Since there is very little evidence that adult salt depletion has comparable long-term effects on salt liking (Beauchamp et al., 1990; Leshem, 2009), one may speculate that variation in salt exposure during a critical period of maturation permanently alters peripheral or central structures or both and is thereby particularly potent in establishing childhood and perhaps even adult patterns of sodium intake.

Children have been reported to have higher preference for salt than do adults (Beauchamp and Cowart, 1990; Beauchamp et al., 1990; Desor et al., 1975). The behavioral and physiological basis for this age-related difference is not understood. It could reflect cohort effects if, for example, children were exposed to higher salt levels than adults, or it could reflect some underlying difference in the sensory or metabolic properties of salt for individuals of different ages.

Taken together, these data highlight the importance of understanding salt taste and salt taste preference in children and how early experiences modulate these sensory responses. It is likely that during infancy and childhood, the salt environment—and any changes in it that result from lowering the overall salt level in the food environment—will have the most profound effects. However, since research in this area has been limited, it is highly important that studies be conducted to evaluate how changes in salt exposure (while maintaining adequate intake) during this crucial period influence later liking.

MAINTAINING FOOD ACCEPTABILITY WHILE REDUCING SODIUM IN FOODS

In light of the considerable role that salt taste plays in food choice, it is necessary that sodium intake reduction focus on approaches that rely on modification or manipulation of salt taste along with the search for salt substitutes. Several approaches may be relevant to strategies to reduce intake.

Changes in Salt Taste Preference in Adulthood: A Potential Model for Population-Wide Reductions

Anecdotal reports, clinical impressions, and a limited body of experimental evidence suggest that when people assume a lower-sodium diet, they will gradually come to appreciate the lowered sodium and acclimate to it. For example, the Arctic explorer Stefansson (1946) reported that while he was living with Inuit groups who do not add salt to their food, he first found the foods insipid and craved salt; within a few months, however, he lost desire for added salt, and when he tasted food with it, he found it unpalatable.

Experimental evidence, albeit limited, supports these anecdotes and suggests that the preference for salt is a malleable trait. These studies reveal that when people undertake a low-sodium diet, the immediate response is to strongly dislike the foods with less salt (Beauchamp, 1991). However, the lower-sodium diet eventually becomes accepted, and in fact, foods containing the previous amount of salt may be perceived as too salty (Beauchamp et al., 1983; Blais et al., 1986; Elmer, 1988; Mattes, 1997; Teow et al., 1986). For example, one study that examined a very small number of individuals (Bertino et al., 1982) reported that after consuming a diet with a 30–50 percent overall reduction in sodium content for 2 to 3 months, volunteers gradually developed a preference for foods with lower salt levels. In other words, they acclimated to the lower-salt diet. In a study with many more subjects, Elmer (1988) reported very similar results, as shown in Figure 3-5.

This shift in preference may also be moved in the other direction: when people were placed on a higher-salt diet, they shifted preference upward to like more salt in their foods (Bertino et al., 1986). A number of lines of evidence suggest that these shifts are due to the actual sensory experience with salt rather than some sort of physiological regulatory process (Leshem, 2009).

Most of the research on the sensory effects of lowering sodium intake was conducted more than 20 years ago, and many important questions were never fully explored. For example, it is not known whether it is necessary to reduce total sodium intake to obtain sensory accommodation or whether it would occur if salt were reduced in a single product category, such as soup or bread. That is, would the consumer begin to prefer lower-sodium soup or bread if his or her overall sodium intake was not reduced at the same time? Also, would judicious consumption of very salty food items (e.g., olives, anchovies, certain cheeses, processed meats) in the context of an overall lower-salt diet inhibit these sensory changes? Furthermore, it is also not known how long such sensory changes persist or how resistant they

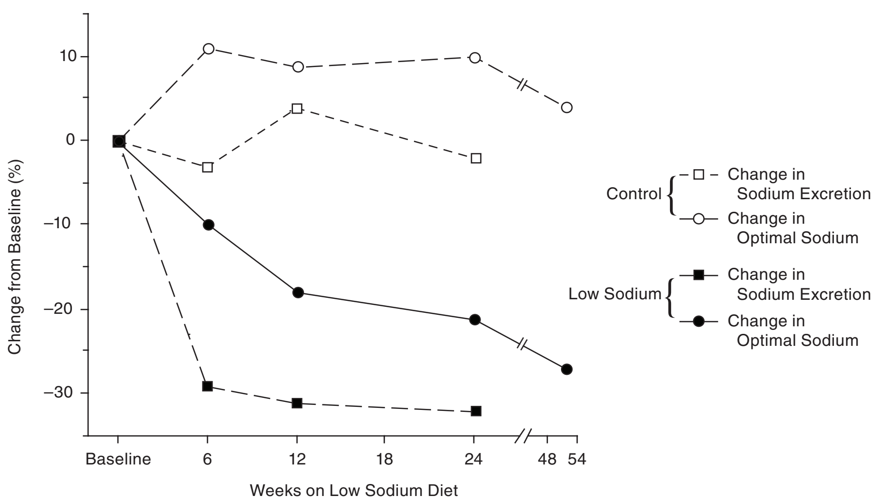

FIGURE 3-5 Shifting of salt taste preference in response to a lower-salt diet. Change in salt content of the diet indicated by the change in urinary sodium excretion.
SOURCE: Elmer, 1988.

would be to shifts back upward when an individual temporarily goes off the low-sodium diet. Finally, and perhaps most importantly, this mechanism of decreasing the desire for salt has not been tested in young children for whom, based on the arguments above, it might be particularly effective in reducing this desire. In this regard, it might have been expected that the elimination of added salt in virtually all commercially prepared baby food, which occurred more than 30 years ago (Barness et al., 1981), would have reduced salt preference in children. Unfortunately, there are no data available by which this hypothesis could be tested. And because many parents use table foods during weaning, the sensory effects of elimination of added salt to baby foods may not be easy to detect even if appropriate data were collected.

Despite these outstanding questions, it seems likely that if salt intake from foods could be reduced on a population-wide basis, consumers' preference for salty foods would also shift downward. It will be critical to monitor this proposed shift in preference along with monitoring changes in overall consumption in any nationwide salt reduction program.

Potential Sensory Approaches for Successful Reduction of Salt in the Food Supply

Gradual Reduction Without Consumers' Knowledge

One approach to changing ingredients in foods without the consumer noticing is to make the change gradually (Dubow and Childs, 1998). Perceptual studies with taste show that people are generally unable to detect differences between two concentrations of a taste substance when the difference is less than approximately 10 percent (called a Just Noticeable Difference [JND]; Pfaffmann et al., 1971). However, it may be the case that this estimate is misleading because it is based on sensory tests with pure taste solutions, not real foods. Foods are much more chemically complex and this complexity could make it more difficult to identify changes in individual ingredients. For example, M. Gillette[1] has suggested that the JND in foods is more likely 20 percent and thus a change of 15 percent would not be noticed. However, a representative at the committee's public information-gathering workshop (March 30, 2009) reported the opposite in some cases. Reductions in sodium content well below 10 percent in some food systems resulted in significant loss of palatability, indicating that these small changes could be perceived. A possible explanation for this is that, as discussed above, the other sensory actions of salt may be characterized by smaller JNDs. Apparently, for each food, this is an empirical question

[1] Personal communication, M. Gillette, McCormick & Co. Inc., January 2010.

that will require data to determine the size of a detectable salt reduction. More research in salt-flavor interactions may, however, reveal general principles that will permit predictions in different food systems. Based on this reasoning, it has been suggested that a gradual reduction of salt in food, in incremental steps, would be unnoticed by the consumer. According to this argument, if incremental reductions were instituted regularly (e.g., once each year or even more frequently), it would be possible to substantially reduce the salt content of foods over the course of several years without the consumer noticing. For example, Girgis et al. (2003) reported that 25 percent of the salt in bread could be eliminated, over a cumulative series of small decreases, without people recognizing a taste change (see also, Cauvain, 2007). All sellers of bread would have to make this reduction; otherwise, the changes would be noticed, and the reduced sodium version would be less preferred.

This is an attractive strategy for reducing salt in foods while maintaining their acceptability, and several food manufacturers are reported to have already undertaken it. However, advancements in several research areas may optimize the implementation of such a strategy. First, industry has not undertaken reduction of sodium across all foods, so there may be some individual products for which reductions may be limited. Second, it is likely that there will be a limit to reductions that can be achieved by simply lowering sodium content without additional reformulation and taste changes, but there are no published data testing the limits of this strategy. It seems likely for many foods that at some point further reductions may not be possible while maintaining consumer palatability. Determination of where the point of limited reductions resides will vary by food item and is a focus of industry research during the reformation process. Third, since salt has many sensory functions in foods in addition to making it taste salty, it is unclear whether changes in these other functions would go unnoticed following small reductions or whether additional changes in food formulations would be required.

Use of Low-Sodium Foods and Ad Libitum Salt Use

Reduction of sodium intake may be achieved by reducing salt in food and permitting people to use a salt shaker to add back to the food as much salt as desired (i.e., ad libitum salt use). For example, in one study (Figure 3-6), sodium intake from clinically prepared foods decreased from an average of 3,100 mg/d to an average of 1,600 mg/d over a 13-week period, and participants were permitted unlimited use of a salt shaker to salt their food to taste. Importantly, less than 20 percent of the overall sodium removed during food preparation was replaced by increased use of table salt—the use of which was measured without participants' knowledge (Beauchamp et al., 1987).

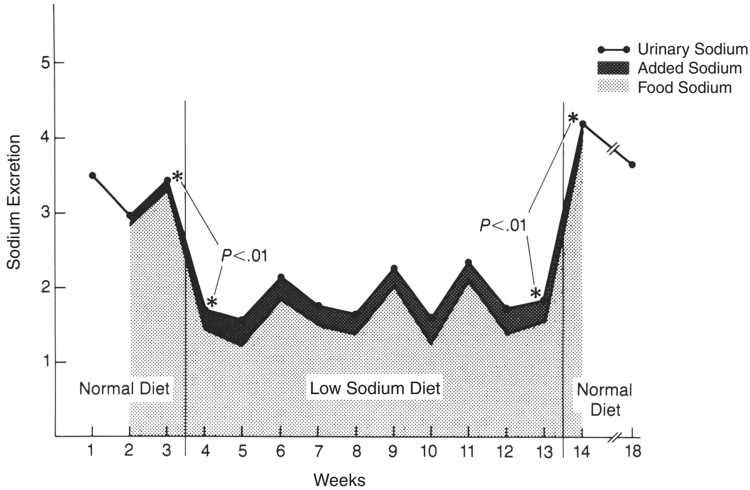

FIGURE 3-6 Failure to compensate decreased dietary sodium with increased table salt use in participants on a low-sodium diet. Sodium intake as measured by 24-hour urinary excretion is presented on the vertical axes. Participants in this study consumed approximately 3,100 mg of sodium per day (weeks 1–3, horizontal axis), a typical amount, prior to going on a low-sodium diet (1,600 mg/d on average) in a hospital (weeks 3–13). In week 14, 24-hour urines were again collected after the subjects were permitted regular foods in the hospital. The gray shaded area represents the total sodium consumed in food. The black shaded area represents the amount of sodium added by the participants from their ad libitum use of salt shakers.
SOURCE: Adapted from Beauchamp et al., 1987. *Journal of the American Medical Association* 258(22):3275–3278.

In another study, a similar lack of salt replacement by use of table salt was found when students were fed regular or reduced-sodium beef stew. When the lower-sodium stew was served, only 22 percent of the removed sodium was replaced by use of table salt (Shepherd et al., 1989).

In both of these studies, the failure to compensate was likely due in large measure to the fact that salt was added to the surface of the food and not suffused throughout it, thereby requiring less to obtain a sufficient salt taste. Because such a low percentage of salt in the U.S. diet comes from use of the salt shaker (see Chapter 5), it may be counterproductive to recommend, as some do (MacGregor and de Wardener, 1998), that the first step in salt reduction should be to cease using salt at the table. A better approach may be to use lower-sodium foods but permit judicious use of added salt when needed to reach a sufficiently salty and flavorful sensory profile.

Use of Other Flavors or Flavoring Techniques to Reduce the Need for Added Salt

It is possible to replace some of the salt in foods with other taste or flavor compounds or through other flavor strategies or techniques. Some of these compounds or strategic elements may be added by the processor, chef, or consumer, whereas others may be created during food preparation, such as cooking.

A prominent example of an added compound involves glutamic acid (an amino acid). Combining glutamic acid with sodium creates the well-known flavoring compound monosodium glutamate, or MSG. MSG imparts a savory taste (called "umami") as well as a salt taste to food. Some studies have shown that it is possible to maintain food palatability with a lowered overall sodium level in a food when MSG is substituted for some of the salt (Ball et al., 2002; Roininen et al., 1996; Yamaguchi, 1987). In these cases, less MSG is added back to the food than is removed by using less salt. Other possibilities for the use of glutamates are included in Appendix D, Table D-2. It should be noted that although the use of MSG is controversial (Fernstrom, 2007), it is a generally recognized as safe (GRAS) substance.[2] Beyond MSG, quite a wide number of naturally occurring or traditionally prepared foods exhibit these same "umami" qualities (e.g., mushrooms, tomatoes, vegetable extracts) that might displace some of the need for added sodium in food preparation or manufacturing (Marcus, 2005).

Potential Technological Approaches for Reduction of Salt in the Food Supply

Modification of the Size and Structure of Salt Particles

For surface applications of salt to foods (e.g., on potato chips), changing the size of salt particles can make it possible to provide the same salt taste with a lower amount of salt. Dissolution of salt in the mouth is needed to impart a salt taste, but ordinary salt particles often do not dissolve completely. Changing the size of salt particles can help improve dissolution and thereby increase the salt taste of the salt (Kilcast, 2007).

Changing the crystal structure of salt may also produce the same salt taste from reduced amounts of salt in the product (Beeren, 2009). Additional technologies being investigated to provide salt taste with less salt include mock salts and multiple emulsions. Mock salts are starch particles coated in a thin layer of salt. For topically applied salt applications, these particles can create surface coverage with less salt (Kilcast, 2007).

[2] 21 CFR 182.1(a).

Multiple emulsions are also being investigated as a way to maintain salt taste in sodium- and fat-reduced emulsion products. These emulsions consist of water droplets dispersed in fat droplets that are then dispersed in another outer layer of water that contains salt. The inner layer of water dispersed in the fat droplets can be sodium-free and can replace some of the volume of the product, requiring less of the outer, salted aqueous phase (Figure 3-7). As a result, consumers of these products will continue to enjoy the salt taste of the outer aqueous phase while consuming less total sodium.[3]

Use of Different Salt Sources: Sea Salt

It is possible that the crystal structure of sea salt may be responsible for its pleasing taste profile when used on the surface of foods (Kilcast, 2007). Sea salt usually contains minerals in addition to sodium that impart a variety of tastes that may be desirable in some cases, but may also impart bitter aftertastes. While unsubstantiated reports from trade journals suggest that sea salt may contain as little as 41 percent sodium chloride (Pszczola, 2007), sodium chloride is the main component of most sea salt and thus its composition is similar to table salt.

Use of Substitutes and Enhancers

One approach to reducing salt in the food system would be the development of salt substitutes with the same sensory properties as salt but without the sodium—a sort of aspartame or sucralose but for salt. Alternatively, one might develop a salt taste enhancer, a compound that magnifies the taste of low levels of salt. Adequate substitutes and enhancers for many uses do not yet exist, but one way to attempt to identify such molecules is to use the salt taste receptor to assay for such effects. Unfortunately, the molecular and cellular mechanisms underlying salt taste perception are not fully understood, and this represents a major gap in both our understanding and our ability to efficiently search for salt substitutes and enhancers.

The hypothesized specificity of the salt taste mechanism makes the existence of a true salt taste substitute unlikely, although not impossible. Thus, this differs in principle from a sweet taste, where the receptor mechanisms are more easily mimicked by other molecules; as a consequence, there exist many alternative sweeteners (Beauchamp and Stein, 2008). Many of the alternative sweeteners now used were discovered serendipitously, but no non-sodium, primarily salty-tasting molecule has ever been identified, with perhaps the single exception of potassium chloride.

[3]Personal communication, C. Bereen, Leatherhead Food International, March 30, 2009.

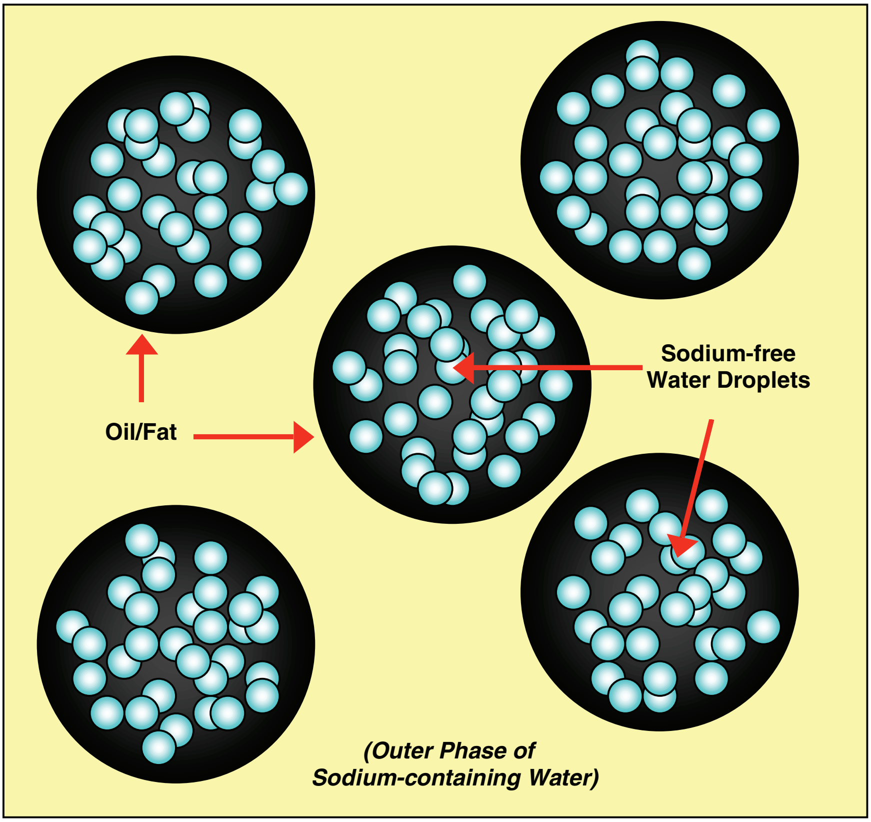

FIGURE 3-7 Multiple emulsion consisting of fat droplets dispersed in the outer phase of sodium-containing water and other water-soluble components. To expand the size of the fat droplets and create less need for the sodium-containing outer phase, sodium-free water droplets are dispersed within the fat.
SOURCE: Adapted from Beeren, 2009.

Potassium chloride has been proposed as a salt substitute either alone or in combination with table salt. However, in addition to tasting salty, many people find potassium chloride bitter (Beauchamp and Stein, 2008). Nonetheless, the interest in increasing potassium consumption among Americans has resulted in considerable interest in pursuing potassium chloride as a salt substitute. As shown in Appendix D, Table D-1, many foods use potassium chloride mixed with sodium chloride in up to a 50:50 ratio; a significant increase in bitterness is observed when a higher ratio is used (Desmond, 2006; Gou et al., 1996). Other salt substitutes have been proposed, but most of the claims remain scientifically unverified (see Appendix D, Table D-1).

Although identification of a salt substitute analogous to artificial sweeteners is thus unlikely, a salt enhancer—that is, a compound that does not taste salty itself but increases the taste intensity of a low amount of salt—is more likely. Indeed, the patent literature contains proposed examples, and recently some of the patent claims have been supported in peer-reviewed papers (Stähler et al., 2008). A concerted effort to identify salt taste enhancers could provide additional tools for overall reduction of salt in the food supply. Examples of putative salt enhancers are listed in Appendix D, Table D-2.

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4

Preservation and Physical Property Roles of Sodium in Foods

Historically, the main reason for the addition of salt to food was for preservation. Because of the emergence of refrigeration and other methods of food preservation, the need for salt as a preservative has decreased (He and MacGregor, 2007), but sodium levels, especially in processed foods, remain high. As discussed in Chapter 3, the tastes and flavors associated with historical salt use have come to be expected, and the relatively low cost of enhancing the palatability of processed foods has become a key rationale for the use of salt in food (Van der Veer, 1985). However, taste is not the only reason for the continued use of high levels of sodium in foods. For some foods, sodium still plays a role in reducing the growth of pathogens and organisms that spoil products and reduce their shelf life. In other applications, sodium levels remain high because salt plays additional functional roles, such as improving texture. A number of other sodium-containing compounds are also used for increasing the safety and shelf life of foods or creating physical properties.

This chapter begins with a review of the non-taste or flavor-related roles of salt and other sodium-containing compounds in food. The second part of the chapter briefly discusses the role that sodium plays in various food categories and provides examples of the sodium content of various foods.

FOOD SAFETY AND PRESERVATION

As mentioned previously, the first major addition of sodium to foods was as salt, which acted to prevent spoilage. Prior to refrigeration, salt was one of the best methods for inhibiting the growth and survival of undesirable microorganisms. Although modern-day advances in food storage and packaging techniques and the speed of transportation have largely diminished this role, salt does remain in widespread use for preventing rapid spoilage (and thus extending product shelf life), creating an inhospitable environment for pathogens, and promoting the growth of desirable microorganisms in various fermented foods and other products. Other sodium-containing compounds with preservative effects are also used in the food supply.

Salt's Role in the Prevention of Microbial Growth

Salt is effective as a preservative because it reduces the water activity of foods. The water activity of a food is the amount of unbound water available for microbial growth and chemical reactions. Salt's ability to decrease water activity is thought to be due to the ability of sodium and chloride ions to associate with water molecules (Fennema, 1996; Potter and Hotchkiss, 1995).

Adding salt to foods can also cause microbial cells to undergo osmotic shock, resulting in the loss of water from the cell and thereby causing cell death or retarded growth (Davidson, 2001). It has also been suggested that for some microorganisms, salt may limit oxygen solubility, interfere with cellular enzymes, or force cells to expend energy to exclude sodium ions from the cell, all of which can reduce the rate of growth (Shelef and Seiter, 2005).

Today, few foods are preserved solely by the addition of salt. However, salt remains a commonly used component for creating an environment resistant to spoilage and inhospitable for the survival of pathogenic organisms in foods. Products in the modern food supply are often preserved by *multiple hurdles* that control microbial growth (Leistner, 2000), increase food safety, and extend product shelf life. Salt, high- or low-temperature processing and storage, pH, redox potential, and other additives are examples of hurdles that can be used for preservation. As shown in Figure 4-1, no single preservation method alone would create a stable product; when combined, however, these methods result in a desirable, stable, and safe product. For example, a food might be protected by a combination of salt, refrigeration, pH, and a chemical preservative.

Multiple-hurdle methods offer the additional benefit of improving other qualities of some foods. For example, hurdle methods can be used to reduce the severity of processing needed, allow for environmentally friendly packaging, improve the nutritional quality of foods (by achieving microbiological safety with less salt, sugar, etc.), and reduce the use of preservatives that are undesirable to some consumers (Leistner and Gould, 2005).

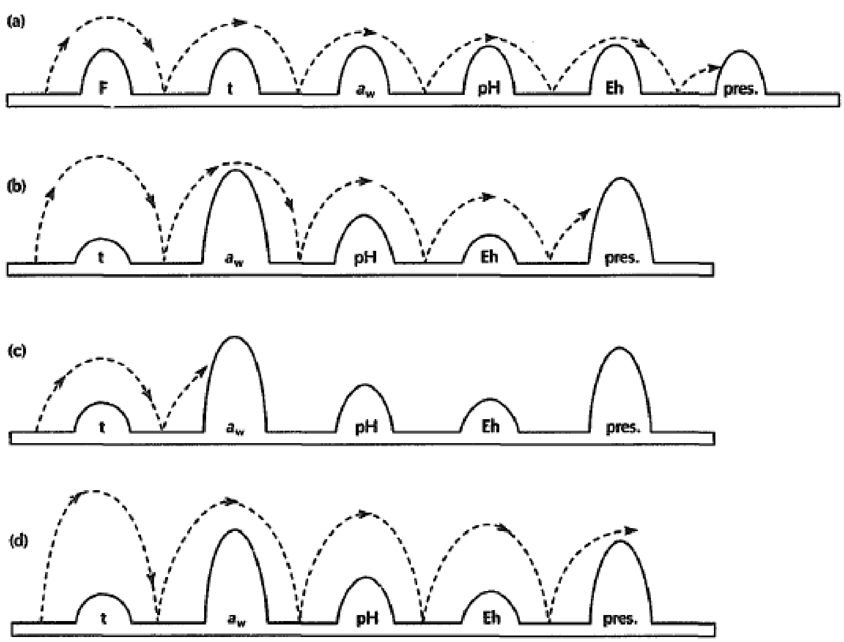

FIGURE 4-1 Examples of the multiple-hurdle method for reducing microbial activity in foods. At the level employed in many foods, individual hurdles may not provide adequate protection from spoilage or pathogenic microorganisms. When multiple hurdles are combined, each hurdle plays a role in reducing microbial activity (displayed as →) until, eventually, the microbial population is so weakened that it cannot cross any further hurdles and the food is protected from spoilage and pathogen survival (letters a, b, and c). If hurdles are insufficient to reduce microbial growth, food products may not be adequately protected (letter d).
NOTE: a_w = water activity; Eh = redox potential; F = heating; pH = acidity; pres = preservatives; t = chilling.
SOURCE: Reprinted from *Trends in Food Science and Technology*, 6(2), Leistner and Gorris, Food preservation by hurdle technology, 41–46, Copyright © 1995, with permission from Elsevier.

Salt's Role in Fermentation to Preserve Foods

Salt commonly plays a central role in the fermentation of foods. Fermentation is a common process for preserving foods, in which fresh foods are transformed to desirable foods that can be preserved for longer periods of time than their fresh counterparts due to the actions of particular types of microbes (Potter and Hotchkiss, 1995). Products such as pickles, sauerkraut, cheeses, and fermented sausages owe many of their characteristics to the action of lactic acid bacteria. Salt favors the growth of these more salt-tolerant, beneficial organisms while inhibiting the growth of undesirable spoilage bacteria and fungi naturally present in these foods (Doyle et al., 2001). Salt also helps to draw water and sugars out of plant tissues during fermentation of vegetables. This water aids fermentation by filling any air pockets present in fermentation vats, resulting in reduced oxygen conditions that favor growth of lactic acid bacteria. The release of water and sugars also promotes fermentation reactions in the resulting brine, increasing the rate of the fermentation process (Doyle et al., 2001; Potter and Hotchkiss, 1995).

Role of Other Sodium Compounds

A number of other sodium-containing compounds provide preservative effects in foods. There is a wide variety of these preservatives with various product uses. Preservatives can act to reduce microbial activity and also may, like salt, act as a hurdle to microbial growth and survival. Some additives may also play a role in preserving food quality by reducing undesirable chemical reactions, such as lipid oxidation and enzymatic browning. In some cases, the compounds can have more than one function in a food product, with preservative effects being one of several reasons for use.

A brief listing of common sodium-containing compounds used for food preservation and the foods with which they are associated can be found in Table 4-1.

TABLE 4-1 Common Sodium-Containing Compounds Used for Food Preservation

Compound Name	Food to Which the Compound Is Added
Disodium ethylenediaminetetraacetic acid (EDTA)	Salad dressing, mayonnaise, canned seafood, fruit fillings
Sodium acetate	Baked goods, seafood
Sodium ascorbate	Meat products
Sodium benzoate	Beverages, fermented vegetables, jams, fruit fillings, salad dressings
Sodium dehydroacetate	Squash
Sodium diacetate	Condiments
Sodium erythorbate	Meat, soft drinks
Sodium lactate	Meat products
Sodium nitrate	Cured meats
Sodium nitrite	Cured meats
Sodium phosphates	Meat products, cheese, puddings or custards
Sodium propionate	Cheese, baked goods
Sodium sulfite	Fruit and vegetable products, seafood

SOURCE: Doyle et al., 2001.

Challenges and Innovations for Lowering Sodium While Maintaining Safety and Shelf Life

For many foods, reducing the sodium content of the product should not create food safety or spoilage concerns. Such foods include frozen products, products that are sufficiently thermally processed to kill pathogenic organisms (e.g., canned foods), acidic foods (pH < 3.8), and foods in which water activity remains low when sodium is removed (e.g., foods with low water activity due to high sugar content) (Reddy and Marth, 1991; Stringer and Pin, 2005). For other foods, reducing sodium content has the potential to increase food spoilage rates and the presence of pathogens. For these foods, product reformulation, changes in processing, and changes in handling may be required to ensure that the product has an adequate shelf life and to prevent pathogen growth. Such efforts do incur additional costs and require careful attention to ensure that new formulations and processes are sufficient to ensure product safety. These issues are discussed further in Chapters 6 and 8.

Foods using sodium as a hurdle to retard microbial growth and survival present a reformulation challenge, since changing the sodium content alters the impact (or height) of the water activity hurdle. Changing this single hurdle may impact the safety and quality of the food because other hurdles that are present (pH, temperature, etc.) may work only in combination with the original sodium level. To maintain a safe, good-quality product, reformulation may have to include the introduction of additional hurdles or an increase in the impact of existing hurdles. If such additional measures are not taken during sodium reduction efforts, the remaining products may not be stable. For example, in cured meats, reducing the sodium content (by removing both salt and sodium nitrite) could allow for rapid growth of lactic acid bacteria and action by proteolytic microorganisms, resulting in a product that spoils more rapidly (Roberts and McClure, 1990; Stringer and Pin, 2005). In some foods, pathogen growth, rather than spoilage, may become a concern.

There is speculation that some past salt reduction efforts may not have adequately accounted for the need to adjust additional hurdles to microbial growth. In the United Kingdom, salt reduction efforts in chilled, ready-to-eat foods were cited as one factor that may have contributed to an increase in the incidence of listeriosis from 2001 to 2005 (Advisory Committee on the Microbiological Safety of Food, 2008). Listeriosis is caused by *Listeria monocytogenes*, which has a high thermal stability and is able to grow and survive at refrigeration temperatures and elevated salt levels (Zaika and Fanelli, 2003). To decrease the risk of listeriosis, a draft report of the United Kingdom's Advisory Committee on the Microbiological Safety of Food called on the Food Standards Agency to work closely with food manufacturers to ensure that the microbial safety of food products would not decrease with changes in formulation to reduce salt (Advisory Committee on the Microbiological Safety of Food, 2008).

There is also evidence suggesting that reductions in salt might result in greater risk of toxin formation by *Clostridium botulinum* (the organism responsible for botulism) in certain foods if additional hurdles are not incorporated. This is particularly the case for foods that have not been heated sufficiently to inactivate *C. botulinum* spores and have little oxygen present. Processed cheese (Glass and Doyle, 2005; Karahadian et al., 1985), meat products (Barbut et al., 1986), and sous vide products (products that are prepared in vacuum-sealed plastic pouches and heated at low temperatures for long times[1]) have been recognized as having potential for *C. botulinum* control problems when sodium is reduced (Simpson et al., 1995). For example, decreases in salt content from 1.5 to 1.0 percent by weight greatly reduced the time needed for *C. botulinum* type A and B spores to produce toxins in sous vide spaghetti and meat sauce products when stored at typical refrigeration temperatures. At salt concentrations at or above 1.5 percent, no toxin production was detected from the inoculated products during the 42-day storage period, while at 1.0 percent salt addition, toxins were produced within 21 days (Simpson et al., 1995). Similarly, turkey frankfurters inoculated with *C. botulinum* and held at 27°C showed more rapid toxin production when salt content was 2.5 percent than when it was 4.0 percent (Barbut et al., 1986).

In addition to *C. botulinum* and *L. monocytogenes*, the growth of other foodborne pathogens may be more rapid in foods with reduced contents of salt and other sodium-containing preservatives. These pathogens include *Bacillus cereus*, *Staphylococcus aureus*, *Yersinia enterocolitica*, *Aeromonas hydrophila*, *Clostridium perfringens*, and *Arcobacter* (D'Sa and Harrison, 2005; Reddy and Marth, 1991; Stringer and Pin, 2005).

While the pathogens described above must be taken into account, product developers and researchers have been able to accomplish sodium reductions even in products such as processed cheese and processed meats (Reddy and Marth, 1991). A number of hurdles can be added or increased when sodium is reduced to ensure that a product's safety is maintained. Examples of additional hurdles are listed in Table 4-2. This list includes a number of emerging technologies (e.g., high-pressure processing, electron beam irradiation) that may have wider applications in the future.

Compounds, such as potassium chloride (Barbut et al., 1986) and mixtures of potassium lactate and sodium diacetate (Devlieghere et al., 2009), that might be used to replace salt and other sodium-containing pre-

[1]Available online: http://amath.colorado.edu/~baldwind/sous-vide.html (accessed October 25, 2009).

TABLE 4-2 Hurdles That Could Be Added to Counteract Microbial Activity in Sodium-Reduced Foods

Chemical	Physical	Biological
Organic acids	Additional heating	Bacteriocins (e.g., nisin)
Nitrites	Cooler storage	Protective cultures
Phosphates	Drying	
Fatty acid esters	Irradiation (e.g., electron beam)	
Ingredients with natural antimicrobial properties (e.g., spice extracts, smoke)	Hydrostatic pressure processing	
	Controlled-atmosphere storage or packaging	
Potassium chloride		

SOURCES: Barbut et al., 1986; Doyle et al., 2001; Rybka-Rodgers, 2001.

servatives have been shown to be somewhat effective at retarding growth and toxin production by pathogens. The effectiveness of alternative salts relative to sodium chloride seems to vary based on the pathogen of interest (Barbut et al., 1986).

Partially replacing salt with other compounds, such as potassium chloride and calcium chloride, may also be possible in fermented products (Bautista-Gallego et al., 2008; Reddy and Marth, 1991; Yumani et al., 1999). However, these alternatives may be less effective than salt so higher concentrations may be needed in formulations to achieve the same functionality (Bautista-Gallego et al., 2008).

Some predictive models have been developed that may be promising methods of screening new product formulations for their potential to grow pathogenic microorganisms. A large study conducted by Kraft foods (Legan et al., 2004) modeled the impact of salt on the growth of *L. monocytogenes* and used this modeling technique to establish no-growth formulations of cured meat products that contain lactate and diacetate to prevent growth of *L. monocytogenes*.

PHYSICAL PROPERTIES OF FOOD

Salt can play a role in the development of physical properties of foods that are beneficial for processing or developing final product qualities. For example, salt levels play an important role in controlling the stickiness of some doughs, easing the processing of some baked goods (Hutton, 2002; Vetter, 1981). In meats, cheeses, and extruded snack products (e.g., cheese balls, shaped potato snacks), salt can help develop the characteristic texture expected by consumers (Desmond, 2007; Guinee and Fox, 2004; Guinee and O'Kennedy, 2007; Hedrick et al., 1994). For example, in cheeses, salt acts to remove excess water, creating a firmer texture and, in some cases, a rind (Guinee and Fox, 2004). Salt also contributes to characteristics such as meltability, shredding, stretching, and flow (Reddy and Marth, 1991).

Other sodium-containing compounds are also used to establish physical properties of food products. Some of the more common sodium-containing compounds are used in baked goods (e.g., sodium bicarbonate, also known as baking soda) for leavening and to condition dough for easier processing. For a variety of products, such as sauces and dressings, emulsification and thickening agents may contain sodium. Examples of sodium-containing compounds that impact the physical properties of foods, along with their functions, are provided in Box 4-1.

The practice of enhancing raw poultry, beef, pork (Baublits et al., 2006; Brashear et al., 2002), and seafood products (Rattanasatheirn et al., 2008; Thorarinsdottir et al., 2004) with solutions that contain sodium is also worth noting. Typically, these enhancement solutions include salt and sodium phosphates. One reason for the use of this processing technique is to improve the tenderness (which consumers may perceive as juiciness) of leaner cuts of meat. Such cuts of meat can become tough due to their low fat content, which, in the case of beef and pork, is a result of genetic advances made to produce leaner animals (Detienne and Wicker, 1999). Increasing product yield may be another driver for the use of this technique (Detienne and Wicker, 1999). Clearly, salt and sodium phosphates increase the sodium content of the overall product. For example, a regular serving of meat (114 g, reference amount commonly consumed) without enhancement contains 68 mg of sodium, but that same serving of meat injected up to 10 percent of its weight with brine containing 4.5 percent sodium tripolyphosphate and 3.6 percent salt results in 384 mg sodium per serving (DeWitt, 2007).

Challenges and Innovations for Lowering Sodium While Maintaining Physical Properties

The difficulty of reducing sodium without losing desirable physical properties is dependent on the specific food application and the availability of other ingredients that can fulfill similar functions. In some foods (e.g., certain cheeses and processed meats), the salt used to create special physical properties may be impossible to remove, given current technologies. As previously mentioned in the discussion of challenges to reduce sodium while maintaining food safety, reformulation has a number of costs that are described further in Chapter 6.

Still, for many products, more salt may be added than is truly needed for the desired physical property. In these cases, research to determine critical salt levels may be necessary to quantify the amount of salt that can be

BOX 4-1
Common Sodium-Containing Compounds and Their Functions in Food

Emulsifying Agents:
- Sodium pyrophosphate
- Dioctyl sodium sulfosuccinate
- Disodium hydrogen phosphate
- Sodium alginate
- Sodium caseinate
- Sodium phosphate
- Trisodium citrate
- Trisodium phosphate
- Sodium stearoyl lactylate

Buffering Agents:
- Aluminum sodium sulfate
- Disodium hydrogen phosphate
- Sodium adipate
- Sodium dihydrogen citrate
- Sodium dihydrogen phosphate
- Sodium DL-malate
- Sodium hydrogen carbonate
- Sodium phosphate
- Trisodium citrate
- Trisodium phosphate

Anticaking Agents:
- Sodium aluminosilicate
- Sodium ferrocyanide

Flavor-Enhancing Agents:
- Monosodium glutamate
- Disodium 5′-guanylate
- Disodium 5′-inosinate
- Disodium 5′-ribonucleotides

Leavening Agents:
- Sodium bicarbonate
- Disodium pyrophosphate
- Sodium acid pyrophosphate
- Sodium aluminum phosphate
- Sodium hydrogen carbonate

Dough-Conditioning Agents:
- Sodium stearoyl lactylate
- Sodium stearyl fumarate

Stabilizing Agents:
- Disodium ethylenediaminetetraacetic acid (EDTA)
- Disodium pyrophosphate
- Potassium sodium L-tartrate
- Sodium alginate
- Sodium carboxymethylcellulose
- Sodium caseinate
- Trisodium citrate
- Sodium stearoyl lactylate

Neutralizing Agents:
- Trisodium phosphate
- Sodium sesquicarbonate
- Sodium phosphate
- Sodium DL-malate
- Sodium dihydrogen phosphate
- Sodium dihydrogen citrate
- Sodium citrate
- Sodium adipate
- Aluminum sodium sulfate
- Sodium potassium tartrate
- Sodium acetate

Thickening Agents:
- Sodium alginate
- Sodium carboxymethylcellulose

Moisture-Retaining Agents:
- Sodium hydrogen DL-malate
- Sodium lactate
- Sodium lauryl sulfate

Texture-Modifying Agents:
- Sorbitol sodium
- Sodium tripolyphosphate
- Pentasodium triphosphate
- Disodium hydrogen phosphate

Bleaching Agent:
- Sodium metabisulfite

SOURCE: Lewis, 1989.

removed. For example, attempts to reduce sodium in natural and processed cheese products while maintaining desirable textures and achieving a safe product have been successful using new technologies, such as ultrafiltration (Reddy and Marth, 1991; Van der Veer, 1985). Similarly, in enhanced meat, some brine injection may be desirable to increase the palatability of leaner cuts of meat (Detienne and Wicker, 1999) and help consumers avoid fattier meats that are naturally more tender. However, it is likely that, for many of these products, additional brine is added to further reduce moisture loss (or purge) that normally occurs in the product during its retail shelf life. The benefit that may result from additional brine at that point may be more for economic than sensory reasons, and the brine may not be needed to create acceptable products. In other products, additional salt may be added for enhanced taste and flavor.

Table 4-3 shows the difference in sodium content of similar foods in

TABLE 4-3 Differences in Sodium Content of Similar Foods

Food	Serving Size (g)	Sodium (mg)	Sodium (mg/100 g product)
Hams			
Carl Buddig Honey Ham	56	460	821
Oscar Mayer Baked Cooked	63	760	1,206
Oscar Mayer Shaved Smoked	51	640	1,255
Pork Sausage, Sage			
365 Brown & Serve Links	56	380	679
Jimmy Dean Premium	56	420	750
Bob Evans Savory	56	570	1,018
Turkey, Fresh or Frozen			
Butterball Fresh Whole Turkey Breast	112	55	49
Shadybrook Farms Turkey Breast Cutlets	112	240	214
Marval Prime Young Turkey Breast (frozen)	112	390	348
Butterball Frozen Fully Cooked Whole Turkey Breast	84	500	595
Cheese, Cheddar, Sliced			
Kraft Cracker Barrel Natural Sharp Slices	28	180	643
Great Value (Wal-Mart) Mild	19	135	711
Kraft Deli Deluxe Sharp Slices	28	440	1,571
Buns, Hot Dog			
Pepperidge Farm	50	190	380
Wonder 8	43	210	488
Great Value (Wal-Mart) Enriched	43	230	535

NOTE: g = gram; mg = milligram.
SOURCE: CSPI, 2008. "Salt Assault: Brand-name Comparisons of Processed Foods." Reprinted with permission.

which sodium plays a role in creating a physical property or in preservation. The varied sodium levels suggest that the sodium levels in some products may be greater than those needed for these functions. Cases such as these may provide opportunities to lower the sodium content of some foods. A similar conclusion was reached by researchers who surveyed the sodium content of processed foods in Australia and found variation in the salt concentration of comparable foods, frequently ≥ 50 percent between the highest- and lowest-salt foods within a category (Webster et al., 2010). Another survey[2] found differences in the salt content of the same brand name foods, including fast food restaurant items, among different countries. Many branded food manufacturers operate internationally and may participate in sodium reduction programs in other countries.

Alternatives that can replace the texture development functions of sodium are limited. However, advances in ingredient technologies have made it possible to replace some salt. Restructured and emulsified items (e.g., sausages, deli meats), for example, are products for which lower-sodium ingredient options have been identified. In these products, functional proteins (e.g., soy or milk), hydrocolloids (e.g., gums or alginates), and starches have replaced some of the functionality of the salt-soluble proteins that form a gel network and "glue" the meat pieces together in higher-salt products (Desmond, 2006). In addition, sodium tripolyphosphate, potassium phosphates, and transglutaminase have been used to improve the stability of reduced-salt emulsified meats in which there may be less salt-soluble protein available to coat and stabilize fat particles (Ruusunen et al., 2002). In their review on sodium reduction, Reddy and Marth (1991) described several studies successfully demonstrating that sodium reduction in meats could result in products evaluated to have acceptable functionality and flavor. In pork, they described a modified processing procedure referred to as emulsion coating that reduced the salt content by 50 percent in chunked and formed ham products. Successful reductions in sodium were also reported for fresh pork sausage, frankfurters, bologna, and comminuted meat batters.

Another method of reducing sodium in foods is to find alternatives to other (non-salt) sodium-containing additives. A number of alternatives have been developed. Table 4-4 provides examples (although not an exhaustive list) of alternatives to sodium-containing compounds that are often used for leavening, dough conditioning, and emulsifying.

Some industries are conducting their own research or funding universities to research alternative processing methods as another strategy to reduce sodium. For example, these approaches include use of pre-rigor mortis muscle in emulsified and restructured meat products (Desmond, 2006)

[2] Available online: http://www.worldactiononsalt.com/media/international_products_survey_2009.xls (accessed February 22, 2010).

TABLE 4-4 Alternatives to Sodium-Containing Compounds

Sodium Compound(s)	Sodium Alternative(s)	Comments	Reference
Leavening Agents: Sodium bicarbonate Sodium acid pyrophosphate Sodium aluminum phosphate Sodium hydrogen carbonate	Monocalcium phosphate Dicalcium phosphate Potassium bicarbonate	Gas may be released at a different time than with sodium-based leavening compounds, and processing changes may be needed to accommodate these difference	Kilcast and Angus, 2007; Reducing sodium, a matter of taste, 2007
	Calcium acid pyrophosphate	Timing of gas release is closer to that of sodium-based leavening compounds	Reducing sodium, a matter of taste, 2007
	Ammonium bicarbonate	Has been found to increase the potential for acrylamide formation, creating concern about its use	European Commission, 2003
Sodium acid pyrophosphate (SAPP)	Glucono-δ-lactone	Suitable for use in combination with sodium bicarbonate to reduce use of SAPP in cake-like products	Reichenbach and Singer, 2008
Sodium metabisulfite as a dough conditioner	Cysteine	Provides similar dough-softening action, but is more costly than sodium metabisulfite	Cauvain, 2003
Sodium phosphates as water-binding agents	Potassium phosphates	Provides water binding in deli meats and hams similar to that of sodium phosphates	Ruusenen et al., 2002
Sodium phosphates and sodium citrates as emulsifying salts	Potassium citrates, potassium phosphates, calcium phosphates	Can be used as a replacement in some processed cheese products	Guinee and O'Kennedy, 2007

and the elimination of sodium-containing emulsifying salts in certain processed cheeses (Guinee and O'Kennedy, 2007). These and other changes in processing techniques may have the potential to allow significant sodium reduction, but more research is needed to further develop and implement these technologies.

FUNCTIONS OF SODIUM IN SPECIFIC FOOD CATEGORIES

Since sodium plays different roles in specific food types, it is helpful to discuss the functions of sodium in the context of food categories. This section integrates the role of sodium in preservation and physical properties with its role in taste and flavor (described in Chapter 3) to provide a more complete picture of the multifunctional roles of sodium.

For each of the nine categories described below, data are provided on the average sodium content for representative items from that category (Tables 4-5 to 4-14). These data are derived from the U.S. Food and Drug Administration (FDA) Total Diet Study, which samples approximately 280 foods that are major components of the U.S. diet from four geographic locations around the country. The foods are sampled four times per year and tested for various contaminants and nutrients, including sodium (FDA, 2007). From the Total Diet Study data, both the number of milligrams of sodium per 100 g of food and the number of milligrams of sodium per reference amount customarily consumed (RACC) have been computed (HHS/FDA, 1993).

Grains

Whole grains are naturally low in sodium. Table 4-5 lists the typical sodium content of commonly consumed grains. However, a number of products made from grains have added sodium, and these products are major contributors to sodium intake.

Ready-to-Eat Cereals

Salt is frequently added to breakfast cereals to improve flavor and texture (Brady, 2002). A survey of children's cereals from around the world found that, on average, these products are about 1 percent salt by weight. When products are reformulated to reduce sugar content, the addition of

TABLE 4-5 Typical Sodium Content of Commonly Consumed Grains

Grain	Sodium Content (mg/100 g dry weight)
Wheat	4.6
Oats	8.6
Rice	3.1–6.9
Barley	11.8
Rye	3.1

NOTE: g = gram; mg = milligram.
SOURCE: Bock, 1991.

salt may be particularly relied upon to maintain the taste of the product (Lobstein et al., 2008).

Rice and Pasta

Rice and most pastas are very low in sodium (Brady, 2002; Van der Veer, 1985); however, salt is often added for flavor during preparation. Many flavored rice and pasta products contain salt in the seasoning, with salt sometimes being used as a bulk carrier to evenly distribute flavorings used in smaller quantities.

Baked Goods

Sodium plays multiple roles in breads and other baked goods. Salt, sodium bicarbonate, and sodium salts of leavening acids are the main sources of sodium in baked goods, accounting for 95 percent of the sodium in these products (Reichenbach and Singer, 2008). In most baked goods, salt is used to improve product taste and flavor. Without salt, many baked goods have an insipid taste (Van der Veer, 1985).

Salt is also responsible for fermentation control and texture in yeast-raised breads. In the mass production of bread, salt levels are used as a tool to control yeast activity. Salt reduces yeast activity by reducing water activity and damaging the membrane of the yeast cells. If too much salt is used, doughs may rise too slowly. However, if too little is added, fermentation may proceed too quickly or "wild" fermentations may occur, resulting in doughs that are gassy and sour with poor texture (Hutton, 2002; Vetter, 1981). Fermentation that occurs too quickly can also create major problems on production lines (Hui, 2007), resulting in poor-quality products or complete loss of large production batches. Table 4-6 lists the sodium content of selected grain products. Salt can also interact with gluten, one of the major proteins in flour responsible for the texture of baked goods, to ease the handling of dough during processing. The result of this interaction reduces the stickiness of the dough (Hutton, 2002; Vetter, 1981).

Quick breads, cakes, and cookies typically rely on chemical leavening agents rather than yeast to quickly create airy textures. Some of the most popular leavening agents contain sodium, including baking soda (sodium bicarbonate) and baking powder (a combination of sodium bicarbonate and one or a combination of the following: potassium hydrogen tartrate, sodium aluminum sulfate, sodium acid pyrophosphate, and calcium acid phosphate) (Bender, 2006).

Other additives used in bread may contribute minor amounts of sodium. One of these additives is sodium stearoyl lactylate, an emulsifier used to improve the volume of breads as well as to maintain the textural

TABLE 4-6 Sodium Content of Grain Products

Grain Product	RACC (g)	Average Sodium Content (mg/RACC)	Average Sodium Content (mg/100 g)
White rice	140	1.4	1.0
Macaroni	140	0.8	0.6
Ramen noodles	140	465	332
Corn flakes	30	267	889
Crisped rice cereal	30	286	954
Granola cereal	30	65	215
Whole wheat bread	50	256	511
Bagel	55	270	490
White roll	50	262	523
Iced yellow cake	80	247	309
Cake doughnut	55	230	419
Sugar cookie	30	104	346
Butter cracker	30	240	799

NOTE: g = gram; mg = milligram; RACC = reference amount customarily consumed.
SOURCES: 21 CFR 101.12; FDA, 2007.

quality of frozen baked goods. Another sodium-containing additive is sodium metabisulfite. This acts as a dough-softening agent that can increase the extensibility of dough or be used to speed up dough development when high-speed mixing methods are not desirable (e.g., when fruit is incorporated into the dough and would be damaged by high-speed mixing) (Cauvain, 2003).

Salt also helps to control the growth of molds and the *Bacillus* species of bacteria, thus extending the shelf life of baked goods (Betts et al., 2007). The *Bacillus* species is capable of forming rope-like structures, off-flavors, and discoloration, especially in baked goods high in sugar or fats (Doyle et al., 2001). However, sugars, not salt, are the primary means of controlling water activity in many baked products; therefore many of the food preservation concerns with bakery products are not dependent on control by salt (Smith et al., 2004).

Muscle Foods

Fresh Meats

Unprocessed cuts of meat have some naturally occurring sodium, but are generally considered low in sodium. However, as described earlier, in recent years, fresh meat products increasingly have been injected with salt- and phosphate-containing brines, increasing the sodium content of fresh products.

Processed Meats

Once meat is further processed into sausages or deli meats, the sodium content increases substantially. Sodium is used in meats not only for the flavor it imparts, but also for its role as a preservative and its impact on the textural qualities of the final product. Similar to fresh meats, salt addition to processed meats can help increase water binding in the muscle tissues, leading to increased yields (more product to sell) and greater tenderness. The mechanism by which salt increases water binding is not fully understood, but it is thought to be related to the ability of salt to create repulsion between myofibrillar proteins (Desmond, 2007). At times, phosphate salts containing sodium are also used to improve water binding of muscle foods and to lengthen the time before products turn rancid (Hedrick et al., 1994).

Salt is also used in the processing of products such as sausages and restructured meats. The presence of salt can solubilize myofibrillar proteins that are insoluble in water alone. Salting, in combination with processing steps such as blending and tumbling, helps to extract these salt-soluble proteins to the surface of the meat. Solubilization of salt-soluble proteins is also important for holding pieces of meat together in batters and restructured meats. In these products, small pieces of meat are often molded and heated to form a log or loaf. Salt-soluble proteins extracted to the surface of the meat pieces are responsible for "gluing" the small pieces of meat together as they form a gel network during heating. In meat products made from batters (bologna, frankfurters, etc.), salt-soluble proteins coat fat particles, thereby keeping the fat and protein components from separating. If fat is not sufficiently emulsified in these types of products, it can melt during thermal processing and rise to form a cap of fat on the top of the product (Hedrick et al., 1994).

In cured meat products, such as hot dogs, smoked meats, bacon, and sausages, sodium can be introduced from three ingredients: salt, sodium nitrite, and the reductants sodium ascorbate and sodium erythorbate. Salt imparts flavor and plays a role in preservation by reducing water activity. The action of salt in reducing water activity is one hurdle against microbial growth in processed meats (Matthews and Strong, 2005). However, current levels of salt alone are too low to provide sufficient protection against spoilage and pathogen growth. Instead, sodium, in combination with other compounds such as sodium nitrite and with environmental conditions such as pH and storage temperature, works synergistically to create safe food products (Doyle et al., 2001; Matthews and Strong, 2005). Sodium nitrite is the ingredient responsible for the characteristic pink color of cured meats and for the preservation of meaty flavor. The color is created by the reaction of nitric oxide (formed from sodium nitrite) with myoglobin to form nitric oxide myoglobin. Once the meat is heated, this is converted to color-stable nitrosyl hemochromogen due to the denaturation of myoglobin (Hedrick et al., 1994). Sodium nitrite also has the function (in combination with salt) of inhibiting the growth of *Clostridium botulinum* (Doyle et al., 2001). If sodium nitrite and salt were not used in certain processed meat and seafood products, especially those that are vacuum or modified-atmosphere packaged, these products could no longer be produced or handled because they would pose a risk of botulism outbreaks (Betts et al., 2007; Hedrick et al., 1994; Matthews and Strong, 2005). The final sodium-containing cure ingredients are reductants. Sodium ascorbate and sodium erythorbate are commonly used reductants that play a role in increasing the rate of color formation in cured meats. Both of these compounds can convert nitrite to nitric oxide and convert iron present in myoglobin to the form needed for color formation. Although the reduction of nitrite and myoglobin iron often occurs naturally, reductants can speed up this process (Hedrick et al., 1994). The other essential role of sodium ascorbate or erythorbate is to retard the formation of *N*-nitrosamines, carcinogenic compounds that can form from residual nitrite especially during high-temperature cooking (Doyle et al., 2001). Table 4-7 lists the sodium content of select muscle foods.

Kosher Meats

Salting also plays a role in the kosher processing for meats. All blood must be removed from the tissues for a meat or poultry product to be considered kosher. To achieve this, meat is soaked and then salted. While the salt is used only on the surface of the meat, some is still able to penetrate, leading to increased salt content (Curtis, 2005).

TABLE 4-7 Sodium Content of Muscle Foods

Muscle Food	RACC (g)	Average Sodium Content (mg/RACC)	Average Sodium Content (mg/100 g)
Ground beef	85	65	77
Beef frankfurter	55	446	811
Salami	55	743	1,350
Pork roast	85	111	130
Ham luncheon meat	55	627	1,140
Roasted chicken breast	85	61	72
Chicken nuggets	85	562	661
Haddock	85	116	137
Fresh salmon	85	53	62
Fish sticks	85	377	444

NOTES: g = gram; mg = milligram; RACC = reference amount customarily consumed.
SOURCES: 21 CFR 101.12; 9 CFR 317.312; FDA, 2007.

Dairy Foods

The sodium content of selected dairy foods is listed in Table 4-8.

Milk

Cow's milk—as a source of essential nutrients for a growing mammal—naturally contains some sodium. Whole, low-fat, and skim milk all contain similar levels of sodium.

Cheese

Sodium in cheese is due to sodium naturally present in milk as well as added salt. While the characteristic salt taste of cheese is popular with consumers, salt also plays roles in the cheese making process that contribute to the texture, shelf life, and safety of the end product.

A function of salt in most cheese production is to draw water or whey out of cheese curds. Cheese curds are formed during the initial stages of cheese production when casein proteins in milk coagulate. The coagulation process also traps other milk components, such as fat, carbohydrates (lactose), minerals, and water. Often, more water is trapped in the curd than is desired in the final product. Commonly, cheese curds will be pressed prior to the ripening process to remove this excess water, but pressing alone is usually insufficient. Addition of salt by brine solution or dry rub is used to remove additional water by osmosis to reach desired moisture levels (Potter and Hotchkiss, 1995; Walstra et al., 1999).

TABLE 4-8 Sodium Content of Dairy Foods

Dairy Food	RACC Average	Average Sodium Content (mg/RACC)	Average Sodium Content (mg/100 g)
Whole milk	240 mL ≈ 240 g	94	39
Skim milk	240 mL ≈ 240 g	101	42
Yogurt	225 g	135	60
American cheese	30 g	452	1,505
Cheddar cheese	30 g	190	632
Butter	1 T ≈ 14 g	81	576
Vanilla ice cream	½ c ≈ 70 g	52	74
Chocolate pudding	½ c ≈ 113 g	349	309

NOTE: c = cup; g = gram; mg = milligrams; mL = milliliter; RACC = reference amount customarily consumed; T = tablespoon.
SOURCES: 21 CFR 101.12; FDA, 2007.

Removal of water from cheese curds helps to reduce the water available for microbial growth, reducing the likelihood of microbial spoilage and pathogen growth. For some types of cheese, salting creates a hard rind that protects the cheese during ripening and transport. In addition, the presence of salt in the resulting moisture-reduced cheese decreases the water activity of the product. Lowering water activity controls the growth of cheese starter cultures, which can influence the pH, texture, and ripening of cheese (Guinee and Fox, 2004).

Texture is also altered by the removal of excess water and by the overall sodium content of the cheese. Cheeses with lower salt content are typically soft, pasty, and adhesive, while those with higher content are harder, drier, and crumblier (Guinee and Fox, 2004). For example, ricotta and Swiss cheese have a lower sodium content than firmer cheeses, such as cheddar and gouda, which in turn have a lower sodium content than hard cheeses, such as parmesan (Van der Veer, 1985). Salt also impacts physical characteristics, such as meltability, shredding, stretching, and flow (Reddy and Marth, 1991). Texture is also altered by the activity of proteolytic enzymes, and the activity of proteolytic enzymes is altered by salt (Guinee and Fox, 2004). Processed cheeses can have additional sodium in the form of sodium phosphates and sodium citrates, which are emulsifying agents important to the formation and final texture of these products (Guinee and O'Kennedy, 2007).

Non-salty tastes are also affected by the presence of salt. Undesirable bitterness in cheese is thought to be related to insufficient salt levels (Guinee and Fox, 2004). In addition, the activity of starter cultures is impacted by salt level and time of addition. Starter cultures are responsible for the production of a number of flavor compounds in addition to acid (Doyle et al., 2001).

Butter

Salt was initially added to butter as a preservative prior to widespread use of refrigeration. Salt still plays a preservation role today, but it is less important because access to refrigeration is possible throughout the supply chain. Instead, taste and flavor development are the main drivers for common levels of salt in butter and margarine (Brady, 2002; Hutton, 2002).

Other Dairy Products

Other dairy products, such as yogurt, ice cream, and puddings, contain sodium naturally, from low levels of sodium-containing additives, such as sodium alginate and carrageenan (both thickening agents) (Goff, 1995; Lal et al., 2006), or from added flavorings.

Sauces, Gravies, Stocks, Salad Dressings, and Condiments

As shown in Table 4-9, sauces, gravies, stocks, salad dressings, and condiments are often high in sodium. Reasons for sodium use include flavor, preservation, and improving the stability of emulsions (by improving the solubility of emulsifiers). Flavor is a main reason for adding salt to these products, and saltiness is often one of the major characteristics of these items (Hutton, 2002).

In most condiments, salt also plays a role in preservation (Brady, 2002), combined with other hurdles to microbial growth. Sodium-containing additives also may be added to salad dressings, sauces, and condiments to act as emulsifiers or preservatives. For soy sauce, which is very high in sodium, salt is needed to influence the fermentation process in its production (Doyle et al., 2001).

Fruits, Vegetables, Beans, and Legumes

Fresh fruits and vegetables are generally very low in sodium, although salt may be added to fresh produce during home or foodservice preparation. Fruits that are processed further typically remain low in sodium (Van der Veer, 1985). Frozen vegetables generally do not have additional sodium unless components such as breadings or sauces are added to the product (Van der Veer, 1985). Dried pulses (beans, lentils, peas) are naturally low in sodium but they are often salted during home and foodservice cooking.

Canned vegetables are typically much higher in sodium than their fresh counterparts. In canning, a liquid medium is important for heat transfer during processing, and a salt brine is generally used because salt enhances the consistency and flavor of vegetables (Hutton, 2002; Van der Veer,

TABLE 4-9 Sodium Content of Sauces, Gravies, Stocks, Salad Dressings, and Condiments

Food Product	RACC	Average Sodium Content (mg/RACC)	Average Sodium Content (mg/100 g)
Italian dressing	30 g	443	1,478
Low-calorie buttermilk dressing	30 g	298	994
Brown gravy	¼ c ≈ 60 g	341	568
White sauce	¼ c ≈ 60 g	225	375
Mayonnaise	1 T ≈ 15 g	81	543
Mustard	1 tsp ≈ 5 g	58	1,156
Salsa	2 T ≈ 30 g	184	612

NOTE: c = cup; g = gram; mg = milligram; RACC = reference amount customarily consumed; T = tablespoon; tsp = teaspoon.
SOURCES: 21 CFR 101.12; FDA, 2007.

1985). However, salt is not essential for the canning process and no-salt-added canned vegetables are marketed. One study (Jones and Mount, 2009) that tested multiple brands of five types of popular canned beans showed that draining the beans for 2 minutes reduced sodium by 36 percent, and the draining treatment plus 10 seconds of rinsing followed by an additional 2 minutes of draining reduced sodium by 41 percent. According to one survey, draining and rinsing of canned beans is a relatively common food preparation technique (Bush Brothers and Company, 2009). Other studies have shown that treatment involving draining, rinsing, and/or soaking of various canned and packaged foods results in sodium reduction (Sinar and Mason, 1975; Vermeulen et al., 1983; Weaver et al., 1984). The sodium content of selected fruits, vegetables, beans, and legumes is shown in Table 4-10.

Pickled vegetables such as sauerkraut and cucumbers are also high in sodium because of the salt added to drive the fermentation process and to maintain a crisp texture (Brady, 2002).

Mixed Dishes

Combination foods, such as pizza, soups, stews, casseroles, and ready-to-eat meals, are usually high in sodium, as shown in Table 4-11. Sodium in these foods comes from many sources and has multiple functions; when combined into a single serving, the sodium from these varied sources can

TABLE 4-10 Sodium Content of Fruits, Vegetables, Beans, and Legumes

Fruit, Vegetable, Bean, Legume	RACC (g)	Average Sodium Content (mg/RACC)	Average Sodium Content (mg/100 g)
Banana	140	0.1	0.1
Applesauce	140	2.2	1.6
Fruit cocktail	140	4.2	3
Raisins	40	4.8	12
Frozen broccoli	85	13	15
Raw tomato	85	2.6	3
Raw cucumber	85	1.7	2
Dill pickles	30	264	879
Fresh green beans	85	0.3	0.4
Canned snap beans	130	337	259
Frozen corn	85	0.3	0.4
Canned corn	130	242	186
Baked potato	110	4.4	4
Boiled pinto beans	90	0.2	0.2

NOTE: g = gram; mg = milligram; RACC = reference amount customarily consumed.
SOURCES: 21 CFR 101.12; FDA, 2007.

TABLE 4-11 Sodium Content of Mixed Dishes

Mixed Dish	RACC (g)	Average Sodium Content (mg/RACC)	Average Sodium Content (mg/100 g)
Pepperoni pizza	140	935	668
Meatless fried rice	140	571	408
Beef burrito	140	869	621
Clam chowder	245	887	362
Chicken noodle soup	245	982	401
Frozen meal (Salisbury steak, gravy, potatoes, vegetable)	140	491	351
Quarter-pound cheeseburger	140	743	531

NOTE: g = gram; mg = milligram; RACC = reference amount customarily consumed.
SOURCES: 21 CFR 101.12; 9 CFR 317.312; FDA, 2007.

easily contribute significant levels to the total diet. Pepperoni pizza is a good example of this because each of the major ingredients contains sodium. The pepperoni has sodium for preservation, meat binding, and flavoring. Sodium in the cheese contributes to texture and preservation as well as taste and flavor. Tomato sauce is seasoned with salt in addition to other herbs and spices. Finally, the crust contains sodium to control the leavening process and dough stickiness. The combination of these ingredients leads to an average sodium content of 668 mg/100 g, according to FDA's Total Diet Study market basket data (FDA, 2007).

Soups are classic examples of complex, high-sodium foods. Some soups have high-sodium ingredients, such as cheese or sausage. However, even foods made from low-sodium ingredients, such as vegetables, are high in sodium due to the use of salt for flavoring. In soups, salt contributes not only to salt taste, but also to overall flavor, as discussed in Chapter 3 (Gillette, 1985; Rosett et al., 1997).

In chilled foods, sodium-containing compounds can play a role in preventing the growth of pathogens. Vacuum and modified-atmosphere packaging can create oxygen-free environments that favor the growth of *Clostridium botulinum*. Salt, in addition to other hurdles, can help prevent the growth of this organism. If oxygen is present, *Listeria monocytogenes* is often a concern because it can grow even at low temperatures. Salt addition can serve as one hurdle to the viability of this organism (Hutton, 2002).

Refrigerated or frozen meals often contain sauces or gravies. Besides contributing flavor, these sauces have a secondary role of preventing or masking warmed-over flavors. The fats in precooked meats have a tendency to experience lipid oxidation upon storage, resulting in rancid and "painty" odors and flavors (Hedrick et al., 1994). Using strongly flavored sauces can help to mask these flavors, and coating meats in sauces before storing can help to exclude the oxygen needed for these reactions to take place (Kuntz, 2000). Unfortunately, the sauces are often high in sodium.

Savory Snacks

Most savory snacks, including chips, nuts, pretzels, popcorn, French fries, and extruded snacks (cheese balls, shaped potato snacks, etc.), have added sodium in the form of salt. The function of salt in these foods is to contribute to salt taste and overall flavor. For many flavored snack products, salt is used to distribute minor ingredients, such as flavors and colors. Mixing minor ingredients with salt before application can help to ensure even distribution of these components over the surface of the snack (Matz, 1993). In fried products, antioxidants may also be incorporated in these mixtures to prevent the development of rancidity (Ainsworth and Plunkett, 2007). The sodium content of selected savory snacks is shown in Table 4-12.

Secondary functions of sodium in some extruded products are to modify texture and color. Extruded products have a puffy texture and the degree of expansion and airiness has been found to change with the salt concentration of the extrudate and is thought to be due to interactions between salt and starch (a main component of these snacks). Color has also been found to change with salt content, and this relationship has been proposed to be due to the ability of salt to change the water activity of the extrudate and thus change the rate of browning reactions (Ainsworth and Plunkett, 2007).

Confections

As shown in Table 4-13, hard candies are generally low in sodium, and other confections may have low levels of sodium-containing leavening or texture-modifying agents (Saulo, 2002). Dairy-based confections will contribute to sodium intake due to the sodium naturally present in milk. Chocolates may also contain small amounts of sodium to contribute to flavor and texture. Some confections are likely to contain added salt for flavoring purposes, particularly those with fillings, such as crèmes or jams

TABLE 4-12 Sodium Content of Savory Snacks

Savory Snack	RACC (g)	Average Sodium Content (mg/RACC)	Average Sodium Content (mg/100 g)
Potato chips	30	147	490
French fries	70	79	113
Buttered popcorn	30	242	808
Plain popcorn	30	0.1	0.3
Hard pretzels	30	482	1,607

NOTE: g = gram; mg = milligram; RACC = reference amount customarily consumed.
SOURCES: 21 CFR 101.12; FDA, 2007.

TABLE 4-13 Sodium Content of Confections

Confection	RACC (g)	Average Sodium Content (mg/RACC)	Average Sodium Content (mg/100 g)
Milk chocolate	40	28	71
Chocolate bar with nuts	40	84	210
Lollipop	15	7.5	50
Caramel	40	94	236

NOTE: g = gram; mg = milligram; RACC = reference amount customarily consumed.
SOURCES: 21 CFR 101.12; FDA, 2007.

(Van der Veer, 1985). Other confections that may include salt for flavoring purposes are caramels, taffy, and nut-containing candy.

Beverages

Water is relatively low in sodium, but sodium levels vary by water source and with the use of water-softening systems (Bradshaw and Powell, 2002; Pehrsson et al., 2008). Tea and coffee are also very low in sodium, although the level may increase slightly with the addition of milk and cream.

Sodium-containing preservatives are sometimes added to carbonated beverages and fruit drinks (Doyle et al., 2001). Even though these beverages contain sodium, the levels are generally low compared to those of many other solid food items.

The vegetable juice category of beverages is one in which sodium levels are traditionally quite high. Taste and flavor improvements are the reasons for addition of salt to tomato, carrot, and vegetable blend drinks. The sodium content of selected beverages is shown in Table 4-14.

Salt is often present in sports drinks for the stated purpose of rehydrating the body during or after physical activity, although the medical justification for the sodium contained in these drinks under the conditions consumed (e.g., high school sports activities) is not clearly demonstrated (Jeukendrup et al., 2009; Shirreffs et al., 2007). While no data on the sodium content of sports drinks was available from the Total Diet Study, data from USDA's National Nutrient Database[3] suggest that such drinks contain 100 mg or less per 8 oz. (240 mL) serving. It is reported that the sodium in these products is not added for taste or preservative effects (Man, 2007).

[3] Available online: http://www.nal.usda.gov/fnic/foodcomp/search/ (accessed January 27, 2010).

TABLE 4-14 Sodium Content of Beverages

Beverage	RACC (mL)	Average Sodium Content (mg/RACC)	Average Sodium Content (mg/100 g)
Bottled water	240	1.2	0.5
Orange juice	240	7.2	3
Canned fruit drink	240	41	17
Coffee	240	4.8	2
Tomato juice	240	715	298
Diet cola	240	9.6	4

NOTE: g = gram; mg = milligram; mL = milliliter; RACC = reference amount customarily consumed.
SOURCES: 21 CFR 101.12; FDA, 2007.

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5

Sodium Intake Estimates for 2003–2006 and Description of Dietary Sources

There is no question that Americans exceed the recommended levels of sodium intake by significant amounts. High intake levels are evident regardless of life stage, gender, race/ethnicity, and income. Further, estimated intake has trended upward when compared to the first National Health and Nutrition Examination Survey (NHANES) conducted in 1971–1974.

Very little sodium occurs naturally in foods, and the majority of sodium in the U.S. diet is from sodium added during food processing and by restaurants and other foodservice operations such as cafeterias and catering services. Salt is the greatest contributor of sodium to the diet, but data are inadequate to quantify with any certainty the proportions attributable to sodium chloride (i.e., salt) compared to other dietary sources of sodium such as sodium bicarbonate, sodium benzoate, and sodium ascorbate.

The 2005 *Dietary Guidelines for Americans* recommends that persons 2 or more years of age consume less than 2,300 mg of sodium per day (USDA/HHS, 2005). These recommendations further specify that many persons will benefit from further reductions in salt intake, including people with hypertension, African Americans, and middle- and older-aged adults (DGAC, 2005). The Centers for Disease Control and Prevention (CDC) recently reported that these special at-risk persons now constitute approximately 69 percent of the U.S. adult population (CDC, 2009).

The Institute of Medicine (IOM) established reference values for sodium for the first time in 2005 (IOM, 2005). An Adequate Intake[1] (AI) was established by the IOM ranging from 1,000 to 1,500 mg for persons 2 or more years of age depending on age, and is a value that reflects the recommended average daily intake level based on observed or experimentally determined approximations or estimates of nutrient intake.[2] The IOM also established a Tolerable Upper Level of Intake[3] (UL) for sodium ranging from 1,500 to 2,300 mg depending upon age, which is the highest daily intake level that is likely to pose no risk of adverse health effects to almost all individuals in the general population (IOM, 2005).

In setting the stage for the committee's deliberations, Chapter 2 provides an overview of existing information about sodium intake in relation to evaluating the effectiveness of the major national public health initiatives. This chapter presents the results of analyses[4] conducted for the committee's study using data from NHANES,[5] a large nationally representative survey conducted by CDC. Specifically, data from the 2003–2006 NHANES period were analyzed in order to specify current sodium intake. These dietary intake data are collected in the component of the NHANES known as What We Eat in America, but for the purposes of simplicity this chapter refers to them as NHANES data. The 2003–2006 NHANES data were also used to characterize current contributions to the diet based on food categories and to examine contributions to intake made by foods "from home" versus those "away from home." Issues of monitoring and surveillance of intake and related factors are also considered.

Background information on the NHANES and the methodologies used

[1] Adequate Intake: IOM reference value: the recommended average daily intake level based on observed or experimentally determined approximations of estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate (IOM, 2006).

[2] The AI of 1,500 mg for adults 19 through 50 years of age was derived based on the following rationale: a diet that provides an average of 1,500 mg/day of sodium can meet recommended intakes of other nutrients; this level exceeds the levels of sodium intake that have been associated with adverse effects on blood lipid concentrations and insulin resistance, and this level allows for excess sodium loss in sweat by unacclimitized persons who are exposed to high temperatures or who are moderately physically active (IOM, 2005). The AIs for children and adolescents 1–18 years of age (1,000 mg/day for 1–3 years of age; 1,200 mg/day for 4–8 years of age; and 1,500 mg/day for 9–18 years of age) were extrapolated down from the AI for adults using the average of median energy intake levels of the age groups for adults and for children as the basis for extrapolation. The AI for adults 51 years and older (1,300 mg/day for 51–70 years of age and 1,200 mg/day for > 70 years of age) was extrapolated from younger individuals based on energy intake (IOM, 2005).

[3] Tolerable Upper Intake Level: IOM reference value: the highest average daily nutrient intake level that is likely to pose no risk of adverse health effects to almost all individuals in the general population. As intake increases above the UL, the potential risk of adverse effects may increase.

[4] Analytical support provided by Mathematica Policy Research, Washington, DC.

[5] Available online: http://www.cdc.gov/nchs/nhanes.htm (accessed November 17, 2009).

to analyze data for this study are described in Appendix E. Information from the analyses is summarized below, and more detailed data tables can be found in Appendix F.

ESTIMATING SODIUM INTAKE

Although data based on the "disappearance" of sodium in the food supply, as described in Chapter 2, can provide some information, two general methods of assessing the population's intake of sodium are considered to provide reasonably accurate estimates: (1) dietary self-reports (interviews, food records, diaries, food frequency questionnaires of individuals) and (2) urinary sodium measures of individuals.

The more accurate and reliable method of estimating sodium intake is the analysis of urine collected during a 24-hour period, which reflects about 90 percent or more of the ingested sodium (Clark and Mossholder, 1986; Luft et al., 1982; McCullough et al., 1991; Schachter et al., 1980). However, such measures are not currently included in national surveys carried out in the United States. Therefore, available information on the U.S. population's sodium intake is based currently on national survey data derived from self-reported dietary intake of respondents. These large-scale national surveys provide representative estimates for the total population and large race/ethnic subgroups. However, NHANES data sets from 2003–2004 and 2005–2006 were combined for this study to provide larger sample sizes for subgroup analysis (see Appendix F). Clinical trials and smaller-scale studies can also provide dietary information for subgroups or special populations that cannot be gleaned from national surveys, but these cannot be relied upon to be representative.

For population-level or group intake estimates, multiple 24-hour dietary recalls are the preferred method (IOM, 2000). Other methods are feasible, but require greater respondent effort and may alter behavior (e.g., food records and diaries) or overestimate food and energy intake (e.g., food frequency questionnaires) (Thompson and Subar, 2008). The strengths of the 24-hour dietary recall include the use of a standardized protocol to quantify the types and amounts of foods consumed over the course of a day, reduced respondent burden, and the provision of valid dietary intake estimates for groups and usual nutrient intake if two or more 24-hour recalls are collected for at least a subsample of the group. Also, individual intake data permit calculation of intake distributions for groups so that the prevalence of high and low intake can be estimated. Additionally, they reflect the sodium content of foods as consumed.

The major limitation of any dietary intake method is that there is some degree of misreporting and measurement error (Thompson and Subar, 2008). For example, overweight persons may underreport intake, omitting certain foods or reducing the reported amounts; furthermore, parents may overreport their young children's intake and be unable to estimate amounts accurately (Basch et al., 1990; Briefel et al., 1997; Devaney et al., 2004). Twenty-four hour recalls are also labor intensive to collect, and at least two non-consecutive days of data are needed to estimate usual intake.

Over the years, improvements in methodologies have been made as part of the National Nutrition Monitoring and Related Research Program (Woteki, 2003), and the quality and validity of data from 24-hour recalls have been improved. Efforts have focused on training dietary interviewers to use standardized probes to elicit complete and accurate reports of intake, using appropriate measurement aids to help respondents report amounts, and developing statistical adjustments to allow better estimation of usual intake (Dwyer et al., 2003). Nonetheless, the intake estimates for sodium derived from NHANES are likely to underestimate the population's true total intake. However, despite the inherent measurement errors in dietary data collection and the underestimation of true total intake of sodium by the population, these measures provide useful and relevant information.

CURRENT SODIUM INTAKE OF THE U.S. POPULATION

For the purposes of this study, intake data from the NHANES covering 2003–2006 (i.e., combination of the 2003–2004 and 2005–2006 surveys) were used and designated as "current." For analyses related to quantitative sodium intake, estimates are provided as usual intake (see Appendix E); analyses related to food categories as well as non-food contributions to the diet are reported as 1-day means, as is sodium intake from earlier NHANES.

As shown in Table 5-1, sources of dietary sodium include foods, salt added at the table, tap water, and dietary supplements. The sodium content of foods reflects salt added in cooking and food preparation. Methodologies for estimating table salt, tap water, and dietary supplements are described in Appendix E. Information on the contribution from medications was not available for the committee's analysis. Drugs including anti-inflammatories, antacids, and laxatives can contribute to sodium intake.[6] For example, sodium bicarbonate is often used to alleviate heartburn and acid indigestion.[7,8] Although individuals with certain health conditions and their physicians may need to be concerned about the sodium content of some

[6] Available online: http://www.megaheart.com/pdf/sodiuminmedications.pdf (accessed June 3, 2009).

[7] Available online: http://www.medicinenet.com/sodium_bicarbonate-oral/article.htm (accessed November 11, 2009).

[8] For example, commercial antacid tablets have 10 mg of sodium per two tablets (ingredient is sodium polyphosphate), according to the 2008 Nutrition Dietary System for Research database.

TABLE 5-1 Mean 1-Day Sodium Intake from All Dietary Sources for Persons 2 or More Years of Age

	Dietary Source (mg/d)								Total All Sources	SE
	Food[a]	SE	Table Salt[b]	SE	Tap Water	SE	Supple-ments	SE		
All ages 2+ years	3,407	13.8	178	1.4	27	0.3	2	0.2	3,614	14.1
Children										
2–5 years	2,388	26.4	33	1.5	9	0.3	1	0.1	2,432	26.6
6–18 years[c]	3,371	23.5	89	1.1	19	0.4	1	0.2	3,481	23.7
Adults										
Men, 19+ years	4,122	29.8	226	3.0	30	0.6	2	0.6	4,380	30.2
Women, 19+ years[c]	2,874	21.0	197	2.9	30	0.6	2	0.2	3,103	21.5
Total adults, 19+ years[c]	3,491	19.4	211	2.1	30	0.4	2	0.3	3,734	19.8

NOTES: Sodium intake from food is reported as a 1-day mean rather than usual intake to be consistent with reporting method for other dietary sources; d = day; mg = milligram; SE = standard error.

[a] Includes salt added in cooking and food preparation.

[b] Salt added by the consumer at the table.

[c] Excludes pregnant and lactating women; data for these persons are shown in Appendix F, Table F-1.

SOURCE: NHANES 2003–2006.

medicines (Szarfman et al., 1995; Ubeda et al., 2009), on a population level, medications overall contribute small amounts of sodium.

The mean 1-day intake from all sources combined for persons 2 or more years of age during the 2003–2006 period is 3,614 mg/d, as shown in Table 5-1. The *Dietary Guidelines for Americans* recommends < 2,300 mg/d for this age group. Although recent data from 2009 are not available, indirect measures of estimating sodium intake (including trends in caloric intake, rates of obesity, observational studies, and the lack of consumer education) provide no indication that there is a decline in sodium intake since the 2003–2006 NHANES.

Usual mean total sodium intake from all dietary sources (foods, table salt, tap water, dietary supplements[9]) increases with age from 2–3 years

[9] Information on all prescription medicines and some over-the-counter medicines was collected in NHANES 2003–2006; however, no summary data on their sodium content were readily available for the committee's analysis.

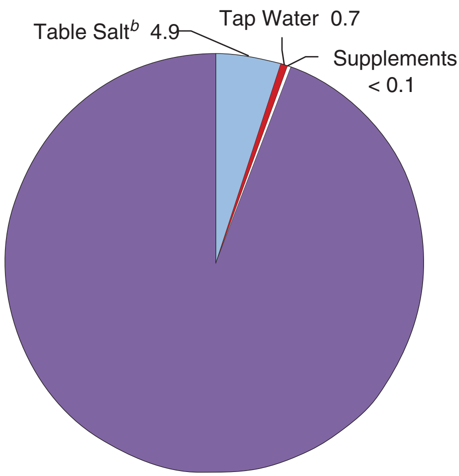

FIGURE 5-1 Percentage contribution of dietary sources to total intake of sodium for persons 2 or more years of age.

NOTES: Mean intake, 1 day, weighted 24-hour dietary recall data (*n* = 16,822); sodium intake from food is reported as a 1-day mean rather than usual intake to be consistent with the data available for other dietary sources.

[a] Includes salt added in cooking and food preparation.

[b] Salt added by the consumer at the table.

SOURCE: NHANES 2003–2006.

through childhood and early adulthood, peaks at age 19–30 years, and then declines (Appendix F, Table F-1). On average, other dietary sources beyond foods provide an additional 207 mg/d of sodium, resulting in a mean total sodium intake of 3,614 mg for the population ages 2 years and older. More detailed information on mean intake and percentile distribution for usual intake is presented in Appendix F, Tables F-1 and F-2, respectively.

Additional analyses reveal that the proportion of the population meeting the 2005 *Dietary Guidelines for Americans* recommendation of < 2,300 mg/d for sodium is only 10 percent (standard error [SE] = 0.5 percent); when only food sources are considered, 15 percent (SE = 0.6 percent) of the U.S. population ages 2 years and older meets the recommendation. Older women (71 years and older) are the most likely to meet the recommendation, but still only 36 percent (SE = 3 percent) consume < 2,300 mg/d.

Foods contribute the vast majority of dietary sodium, estimated at 3,407 mg/d for persons 2 or more years of age for 2003–2006 (Appendix F, Table F-1). As shown in Figure 5-1, sources other than food contribute less than 6 percent of dietary sodium. For this reason, intake from food is discussed first.

Intake from Foods

By Age

Usual mean daily sodium intake estimates from foods are about 2,200 mg at ages 2–3 years, peak at about 3,800 mg at ages 19–30 years, and decline slowly to about 2,600 mg above age 70 (see Figure 5-2 and Appendix F, Table F-5). Significant numbers within all age groups exceed the UL. Appendix F, Table F-3 contains more detailed information on usual intake percentile distributions for Dietary Reference Intake (DRI) age and gender subgroups.

Median intake was compared to usual mean intake and found to be slightly lower, an average of 50–150 mg lower per day, but median intake tracks closely with mean intake (see Table 5-2 and Figure 5-2). More details on median values can be found in Appendix F, Table F-3.

Usual mean sodium intake from foods exceeds the AI for all age groups, shown for children and adults in Figures 5-3 and 5-4, respectively. This indicates that there are no concerns about inadequate sodium intake in the U.S. population.

Indeed, about 88 percent of Americans ages 2 years and older have excessive sodium intake from foods, that is, intake above the UL. As shown in Figure 5-5, sodium intake for a vast majority of people in all age groups exceeds the UL. Persons over 70 years are the largest percentage with intake below the UL; about one-third have usual sodium intake below the UL.

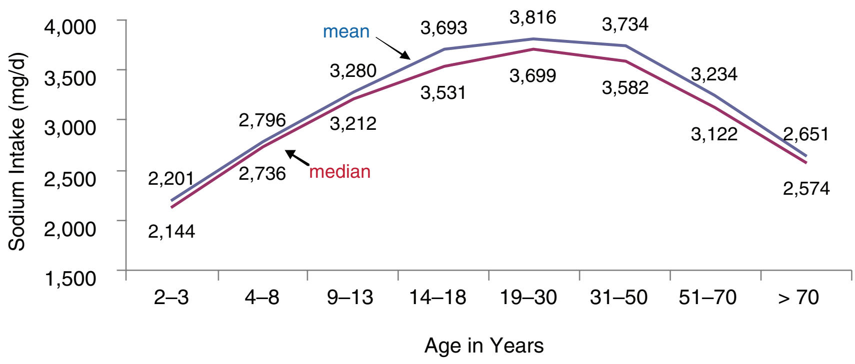

FIGURE 5-2 Usual daily mean and median sodium intake from foods for persons 2 or more years of age.
NOTE: d = day; mg = milligram.
SOURCE: NHANES 2003–2006.

TABLE 5-2 Usual Sodium Intake from Foods[a] with Percentile Distributions for Persons 2 or More Years of Age

	Usual Intake Percentiles (mg/d)								Excessive Intake	
	5th	10th	25th	Median	SE	75th	90th	95th	% > UL	SE
All ages 2+ years	1,846	2,114	2,615	3,268	9	4,044	4,879	5,454	88	1
Children										
2–5 years	1,455	1,619	1,922	2,311	16	2,767	3,250	3,579	87	2
6–18 years[a]	2,028	2,268	2,711	3,272	13	3,920	4,607	5,083	93	1
Adults										
Men, 19+ years	2,324	2,648	3,243	3,995	18	4,861	5,761	6,365	95	1
Women, 19+ years[b]	1,679	1,897	2,293	2,794	13	3,364	3,952	4,357	75	1
All adults, 19+ years[b]	1,845	2,126	2,654	3,344	13	4,166	5,048	5,652	86	1

NOTE: d = day; mg = milligram; SE = standard error; UL = Tolerable Upper Intake Level (see Appendix F, Table F-3).

[a] Includes salt added in cooking and food preparation.

[b] Excludes pregnant and lactating women; data for these persons are shown in Appendix F, Table F-3

SOURCE: NHANES 2003–2006.

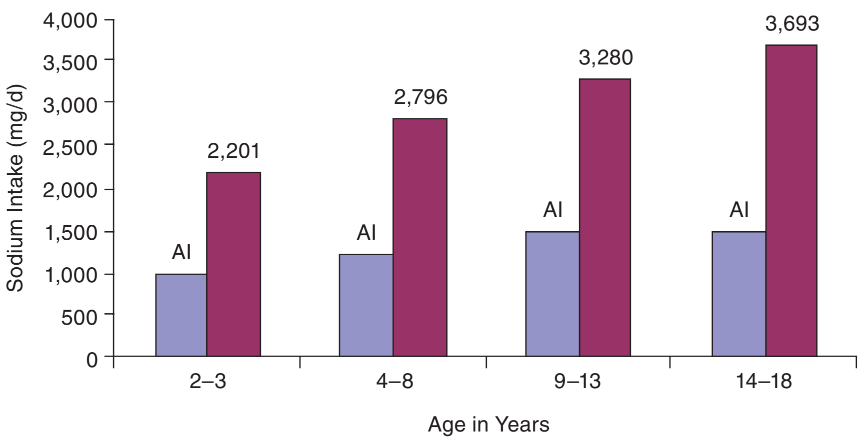

FIGURE 5-3 Usual mean sodium intake from foods versus Adequate Intake (AI) for children.
NOTE: d = day; mg = milligram.
SOURCE: NHANES 2003–2006.

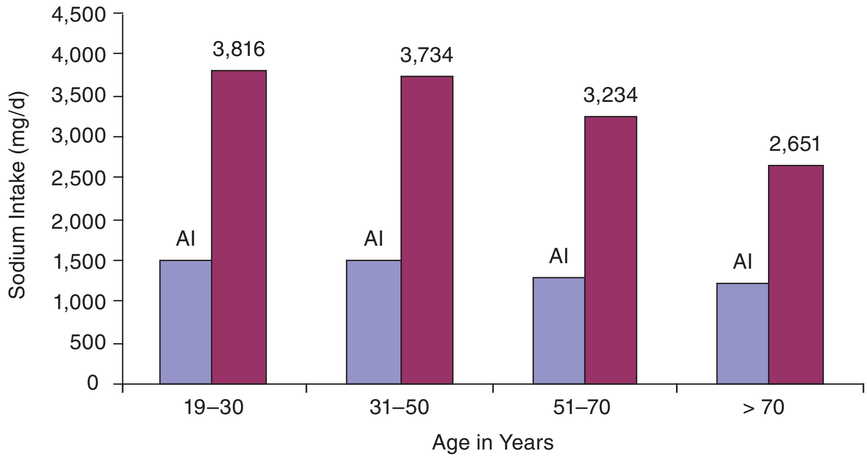

FIGURE 5-4 Usual mean sodium intake from foods versus Adequate Intake (AI) for adults.
NOTE: d = day; mg = milligram.
SOURCE: NHANES 2003–2006.

Sodium intake among children is often overlooked as a public health concern. Consistent with findings from NHANES 2003–2006, data from the Third School Nutrition and Dietary Assessment (SNDA-III) Study (Gordon and Fox, 2007), conducted in 2005 by Mathematica Policy Research and funded by the U.S. Department of Agriculture (USDA), show similar high intake estimates for school-age children. The SNDA-III data reveal a mean sodium intake from foods of 3,402 ± 46.4 mg among public school students on an average school day (Clark and Fox, 2009). Nearly 92 percent of all public school children (ages 6–18 years) were above the UL for sodium from food alone; this was highest among elementary school-age children (96 percent).

Sodium intake for children younger than 2 years is not addressed by the *Dietary Guidelines for Americans*, but data collected and analyzed by Mathematica Policy Research for the 2002 Feeding Infants and Toddlers Study (FITS) indicate that high sodium intake begins early in life (Heird et al., 2006; Ziegler et al., 2006). Mean sodium intake, as estimated by this data set, exceeds the AI for infants ages 4–5 months (mean of 188 mg/d), infants 6–11 months (mean of 493 mg/d), and toddlers 12–24 months (mean of 1,638 mg/d) (Heird et al., 2006). Among toddlers, 58 percent exceed

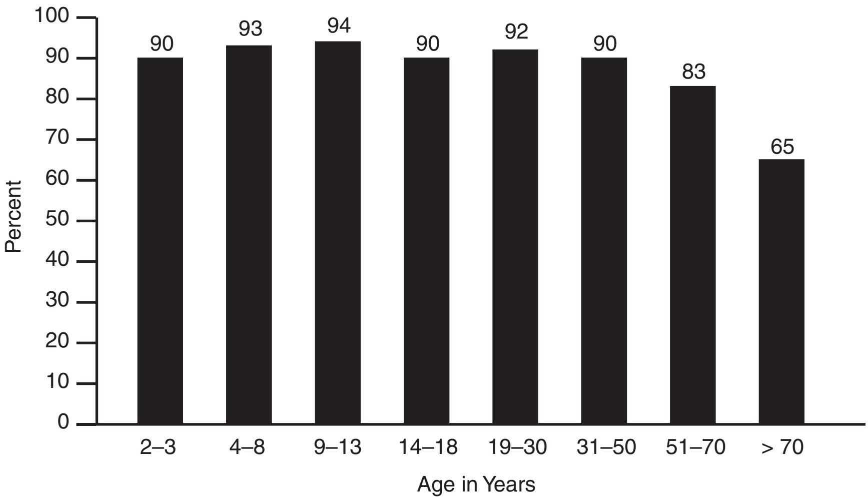

FIGURE 5-5 Percentage of persons 2 years of age or more exceeding the Tolerable Upper Intake Level (UL) for sodium from foods.
SOURCE: NHANES 2003–2006.

the UL for sodium. Preliminary findings from the 2008 FITS[10] indicate that a large proportion of toddlers and preschoolers continue to have sodium intake above the UL.

By Gender

Beginning with the school-age period, boys have higher sodium intake than girls, a pattern consistent with higher energy intake (see Figure 5-6). Among older children and adults, women over 70 years have the lowest mean sodium intake (2,398 mg/d)—only preschoolers are lower. At each age group, the higher usual sodium intake by men is associated with a greater percentage with intake above the UL compared to women. Nine out of 10 adult men have excessive sodium intake.

By Sodium Intake Density

Sodium intake increases with increased calorie intake (Loria et al., 2001). As shown in Table 5-3, analyses for age and gender groups using

[10]Nestle Nutrition Institute, presented at American Dietetic Association, Food & Nutrition Conference and Expo, Denver, CO, October 2009. Available online: http://www.foodnavigator-usa.com/Science-Nutrition/Preschoolers-diets-mimic-unhealthy-adult-eating (accessed November 9, 2009).

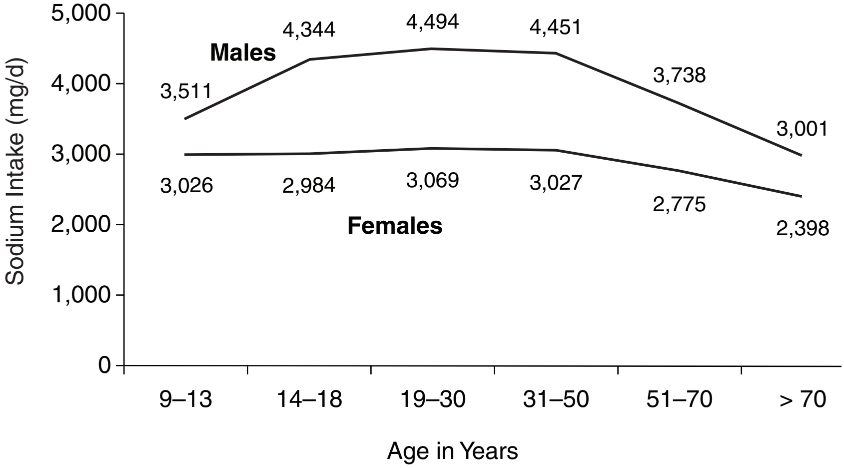

FIGURE 5-6 Usual daily mean sodium intake from foods by gender.
NOTES: d = day; mg = milligram; excludes pregnant and lactating women; data for these persons are shown in Appendix F, Table F-3.
SOURCE: NHANES 2003–2006.

NHANES 2003–2004 indicate correlation values for calories-to-sodium intake greater than 0.70 for most groups.

Expressing sodium intake per 1,000 calories—sodium intake density—allows comparison of intakes without confounding related to associations between total calorie intake and total sodium intake. Appendix F (Table F-4) gives specific information for sodium intake density measures based on NHANES 2003–2006 for the DRI age and gender groups. Overall, other than children ages 2–8 years, sodium intake density values are quite similar, suggesting that many of the differences in sodium intake are a reflection of differences in calorie intake. Both men and women ages 50–71 years show the highest sodium intake density, while among adults, women 51–70 years of age show the highest sodium intake density. As would be expected, higher energy requirements are associated with higher sodium intake. Sodium intake density is considered relative to time trends in a later section.

Intake from Foods for Subpopulations of Interest

Race/Ethnicity

As shown in Table 5-4, sodium intake levels are high among all racial/ethnic groups.

TABLE 5-3 Correlation Values for Sodium-to-Calorie Intake

	Correlation (mg to kcal)
All ages 2+ years	0.79
Children	
2–3 years	0.78
4–8 years	0.77
Males	
9–13 years	0.81
14–18 years	0.83
19–30 years	0.75
31–50 years	0.75
51–70 years	0.72
> 70 years	0.68
Females	
9–13 years	0.75
14–18 years	0.78
19–30 years	0.76
31–50 years	0.74
51–70 years	0.71
> 70 years	0.67
Pregnant and lactating women[a]	0.72
Pregnant women	0.74
Lactating women	0.63

NOTES: Based on Day 1 intake. kcal = calorie; mg = milligram.
[a] Eleven women were pregnant and lactating.
SOURCE: NHANES 2003–2006.

Non-Hispanic African American children ages 2–3 and 4–8 years have the highest mean sodium intake compared to non-Hispanic white and Mexican American children, but by ages 9–13 years there are no differences. Among adolescents and adults, non-Hispanic whites have higher mean sodium intake than non-Hispanic African Americans, and non-Hispanic whites have higher means than Mexican Americans. Since observed differences between racial/ethnic groups may be related to differences in dietary patterns (i.e., the types and amounts of foods consumed) and/or differences in accuracy of dietary reporting, these data should be interpreted with caution. Further, while parents serving as respondents for very young children may overreport intake (Devaney et al., 2004), little is known about the accuracy of parents' dietary reporting based on their race/ethnicity and socioeconomic characteristics. Further details about intake by race/ethnicity can be found in Appendix F (Table F-5).

TABLE 5-4 Usual Mean Sodium Intake from Foods by Race/Ethnicity for Persons 2 or More Years of Age

	Total		Non-Hispanic White		Non-Hispanic African American		Mexican American	
Age	Mean (mg/d)	SE	Mean (mg/d)	SE	Mean (mg/d)	SE	Mean (mg/d)	SE
Age-adjusted								
All ages 2+ years	3,506	9.0	3,589	14.0	3,315	16.0	3,342	17.0
Adults 19+ years	3,613	12.0	3,689	18.0	3,377	26.0	3,499	27.0
Not Age-adjusted								
2–3 years	2,201	19.3	2,193	36.9	2,404	39.1	2,018	31.7
4–8 years	2,796	16.0	2,811	30.8	2,874	26.6	2,672	28.5
9–13 years	3,280	16.9	3,307	34.3	3,282	29.2	3,230	30.2
14–18 years	3,693	23.6	3,806	49.8	3,479	37.2	3,486	35.6
19–30 years	3,816	23.7	3,943	36.2	3,550	45.1	3,581	47.4
31–50 years	3,734	22.9	3,830	34.0	3,499	44.4	3,620	43.5
51–70 years	3,234	20.4	3,316	27.8	2,862	39.4	2,831	50.6
> 70 years	2,651	19.0	2,692	22.4	2,362	42.4	2,236	55.9
Adults 19+ years	3,493	12.1	3,549	16.9	3,271	24.9	3,425	27.4
All ages 2+ years	3,409	8.7	3,478	14.1	3,231	15.6	3,264	16.8

NOTES: Total column includes other racial/ethnic groups not shown separately. d = day; mg = milligram; SE = standard error.
SOURCE: NHANES, 2003–2006.

Income

Distributions of usual sodium intake from foods show that sodium intake is high across all income levels in the population (see Appendix F, Table F-6). For the purposes of this report and consistent with standards for reporting nutrition and statistical data for the evaluation of nutrition assistance programs (Federation of American Societies for Experimental Biology, Life Sciences Research Office, 1995), low-income is defined as an annual household income level of 130 percent of poverty or less, the income eligibility for the Supplemental Nutrition Assistance Program (SNAP), formerly called the food stamp program; intermediate income is between 130 percent and 185 percent of the poverty line (185 being the income eligibility cut-off for free- or reduced-price school meals and the Special Supplemental Nutrition Program for Women, Infants, and Children [WIC] program); and higher-income is defined as annual household income above 185 percent of poverty. Mean sodium intake from foods is highest among low-income and higher-income adults ages 19–30 years and higher-income adults ages 31–50 years.

Special At-Risk Subpopulations Identified by the Dietary Guidelines for Americans

The 2005 *Dietary Guidelines for Americans* recommend an intake of no more than 1,500 mg/d of sodium for individuals with hypertension as well as for African Americans and middle- and older-aged adults (USDA/HHS, 2005). The NHANES 2003–2006 reports intake information on the basis of race/ethnicity and age. However, the survey classifies an individual as hypertensive if (1) measurement of systolic blood pressure is greater than or equal to 140 mm Hg, or (2) diastolic blood pressure is greater than or equal to 90 mm Hg, or (3) the person is being treated with a prescription medication (NHLBI, 2003). Therefore, the interpretation of intake values associated with this group is problematic given that it includes persons who may or may not have known they were hypertensive as well as persons receiving specific medications for hypertension.

In any case, as shown in Figure 5-7, nearly all persons in these at-risk population subgroups exceed 1,500 mg/d of sodium. More specific information on non-Hispanic African Americans and middle-aged and older subpopulations is presented earlier in this chapter. In the case of adults with hypertension, information on sodium intake percentile distributions by age and gender from NHANES 2003–2006 can be found in Appendix F (Table F-7). Usual mean intake for persons ages 19–30 years, 31–50 years,

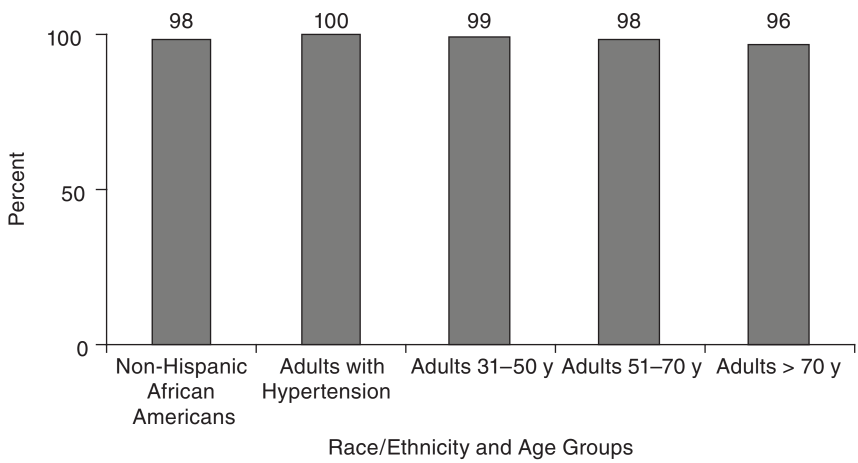

FIGURE 5-7 Percentage of at-risk populations with mean usual sodium intake from foods exceeding 1,500 mg/d.
NOTE: y = years.
SOURCE: NHANES 2003–2006.

51–70 years, and > 70 years is 4,808, 3,734, 3,179, and 2,589 mg/d, respectively.

Sodium from Dietary Sources Other Than Foods

Intake from Salt Added at the Table

Data from NHANES 2003–2006 on all sources of sodium included salt added at the table. On average, 5 percent of total sodium (178 mg of 3,614 mg) is estimated to be from salt added at the table (see Table 5-1 and Appendix F, Table F-1). The proportion of total sodium contributed by table salt is similar across age and gender groups. These data are consistent with those of Mattes and Donnelly (1991) who reported a similar estimate in 1991 using a sample of 62 adults.

Intake from Water

Approximately 1 percent (0.7 percent or 27 of 3,614 mg) of sodium intake is contributed by water, as shown in Table 5-1 and Appendix F (Table F-1). These data agree with the earlier, small study of Mattes and Donnelly (1991). Factors contributing to the sodium content of natural water include the evaporation of ocean spray particles that turn into raindrops, contamination of freshwater aquifers with seawater, road salt that is carried into water supplies by melting snow or rainwater, and the use of home water softeners (Korch, 1986). The sodium content of tap water varies by geographic location and even by source within the same locality (Azoulay, 2001). In the United States, sodium has been found to range from 0.1 to 39.1 mg/100 g in water supplies (Pehrsson et al., 2008), with an average 50 mg/L in tap water (Hoffman, 1988) and less than 10 mg/L in bottled water (according to the USDA National Nutrient Database for Standard Reference[11]).

Use of water softeners also contributes sodium to water (Bradshaw and Powell, 2002). Water softeners convert hard water characterized by a high calcium and magnesium content into softer water by an ion-exchange process that swaps sodium for these minerals. The amount of sodium added by a water softener is a function of the hardness of the water; the harder the water, the more sodium is needed to soften it. One study (Korch, 1986) found that the amount of sodium added by a water softener ranges up to 100 mg/L. Another study (Yarows et al., 1997) examined sodium concentrations in samples of softened water compared to sodium concentrations

[11] Available online: http://www.nal.usda.gov/fnic/foodcomp/search/ (accessed November 11, 2009).

of water samples from local municipal sources, finding a mean sodium concentration of 278 mg/L (similar to the mean of 269 mg/L reported in other literature) with a range of 172–1,219 mg/L. Municipal water averaged 110 mg sodium per liter, with a range of 0–253 mg/L. The authors concluded that an average daily consumption of 2.5 liters of water could provide up to an average of 695 mg sodium, or up to 3,047 mg sodium from the water with the highest concentrations. A report from the Mayo Clinic suggests that, in general, an 8-ounce glass of softened tap water contains around 12 mg of sodium.[12]

Dietary Supplements

On average, the intake of sodium due to use of dietary supplements is very low (i.e., less than 1 percent of total sodium intake in NHANES 2003–2006) (see Table 5-1 and Appendix F, Table F-1). However, although these estimates are low on a population basis, supplements can be a meaningful source of sodium for some individuals. For example, in NHANES 2003–2006, the estimated daily contribution from supplements ranged from 0.02 to 540 mg[13] among supplement users.

Measures Based on Urine Analysis

Although estimates of sodium intake based on 24-hour dietary recall methods provide important and useful estimates of intake, they likely underestimate the true total intake of sodium in the population. Mean urinary sodium excretion over a 24-hour period is generally considered to be the gold standard for accurately estimating the sodium intake of individuals. The main route of sodium disposal is through urine, with only small losses through perspiration and stool. Studies in which sodium intake and excretion were very carefully monitored showed that a 24-hour urinary sodium excretion captures about 90 percent or more of the ingested sodium (Clark and Mossholder, 1986; Luft et al., 1982; McCullough et al., 1991; Ovesen and Boeing, 2002; Reinivuo et al., 2006; Schachter et al., 1980).

Obtaining 24-hour urine collections from individuals is challenging (Elliott, 1989). It requires the willing participation of individuals who must carry a container to collect their urine for a full 24 hours. Less challenging collections include measuring urinary sodium excretion in "casual"

[12] Available online: http://www.mayoclinic.com/health/sodium/AN00317 (accessed June 3, 2009).

[13] One survey respondent reported use of a performance workout supplement containing 4,600 mg of sodium per serving dose; the next-highest reported daily amount from supplements was 540 mg.

samples, samples from the first urination in the morning, and timed overnight samples, but these have not proven satisfactory (Dyer et al., 1997). Even in the case of 24-hour urine collection, as pointed out by Dyer et al. (1997), intake changes from day to day in individuals, and there is large intra-individual variation in salt consumption thereby necessitating large sample sizes, high-quality collection and analysis, and estimates of within-person variability to ensure accurate estimates.

Due to heavy respondent burden and other logistical challenges including costs, 24-hour urine collection has not been a component of the NHANES; therefore nationally representative estimates of sodium intake based on this urinary measure are not available from the data set. However, dietary recalls are also considered to be a valid method for assessing sodium intake (Espeland et al., 2001; Reinivuo et al., 2006). Some information about the U.S. population based on urinary measures is available from two international studies and from a survey of approximately 1,000 persons ages 27–37 years. These estimates are generally consistent with findings based on dietary intake methods and confirm that sodium intake in the United States is above recommended levels.

INTERSALT

INTERSALT is the largest study, and among the most often referenced in the literature, relating electrolyte intake to blood pressure. INTERSALT conducted a single 24-hour urine collection from subjects in 32 countries during 1985–1987. Energy intake was not estimated (INTERSALT Cooperative Research Group, 1986; Loria et al., 2001). The study was carried out under the auspices of the Council on Epidemiology and Prevention of the International Society and Federation of Cardiology, with funding from the Wellcome Trust; the National Heart, Lung, and Blood Institute (NHLBI); the International Society on Hypertension; the World Health Organization (WHO); the Heart Foundations of Canada, Great Britain, Japan, and The Netherlands; the Chicago Health Research Foundation; the Belgian National Research Foundation; and Parastatal Insurance Company, Brussels. Field work began in 1984 and was completed in the mid-1980s (INTERSALT Cooperative Research Group, 1988). INTERSALT assessed more than 10,000 men and women ages 20–59 years at 52 centers in 32 countries. Observers were centrally trained, and a central laboratory was used to ensure standardization and quality control. The measures included urinary sodium, blood pressure, and several potentially confounding variables. Sodium intake was determined by a single timed 24-hour urine collection. The INTERSALT Cooperative Research Group, comprised of a number of investigators in participating centers, reported the results.

Among the four centers in the United States, urinary sodium levels (milligrams per 24 hours) ranged from 2,232 among African American men in Goodman, Mississippi, to 4,012 among African American men in Jackson, Mississippi. Measures from men in the other centers—Chicago and Hawaii—were between 3,550 and 3,650. Urinary sodium levels for women among the four centers ranged from 2,538 among African Americans in Goodman to 3,035 among Hawaiians (Loria et al., 2001). These 1985–1987 urinary estimates are consistent with the observed pattern increase in mean daily dietary sodium intake between NHANES II (1976–1980) and NHANES III (1988–1994).

INTERMAP

INTERMAP is an international cooperative study that aimed to clarify the role of multiple dietary factors in blood pressure among middle-aged and older individuals in East Asian and Western countries (Zhou et al., 2003). The investigators recognized advances in knowledge of the relationships between nutrient intake and blood pressure—furthered by INTERSALT and the Dietary Approaches to Stop Hypertension (DASH) feeding trials, for example—and used those advances as a reference point and rationale for INTERMAP's design and methods. The cross-sectional study of nearly 4,700 men and women ages 40–59 years was conducted by INTERMAP staff in China, Japan, the United States, and the United Kingdom. Research support came from NHLBI; the Chicago Health Research Foundation; and national agencies in China, Japan, and the United Kingdom. Mean daily sodium intake was determined from two timed 24-hour urine collections. INTERMAP participants were recruited from 1997 to 1999.

Urinary sodium levels (milligrams per 24 hours) were 4,202 among U.S. men and 3,272 among U.S. women (Zhou et al., 2003). These are consistent with the dietary data obtained from NHANES showing that intake is well above recommended levels and suggest somewhat greater underreporting of dietary intake among women. The available 24-hour urinary sodium measures support the NHANES time trend of increasing sodium intake between the early 1970s and the 1990s (Briefel and Johnson, 2004).

CARDIA Study

The Coronary Artery Risk Development in Young Adults (CARDIA) study, conducted in the United States, included a trio of consecutive 24-hour urinary sodium collections for a subsample of the cohort in 1990–1991 (Loria et al., 2001). Complete data were obtained for 920 participants, ages 25–37 years, half of whom were Caucasian, the other half African American. However, energy intake was not estimated. Urinary sodium levels (milligrams per 24 hours) were 4,430 for African American men, 4,550 for white men, 3,584 for African American women, and 3,612 for white women. These data complement data from national surveys and support the finding that dietary intake was well above recommended levels (Loria et al., 2001). The urinary sodium estimates are closer to the self-reported dietary estimates for men than for women in the 1988–1994 NHANES, providing additional evidence that dietary reports underestimate total sodium intake for some groups.

TRENDS IN SODIUM INTAKE: NHANES 1971–1974 THROUGH 2003–2006

This section enhances the information available on changes in sodium intake over time by adding information from NHANES 2003–2006 to existing data on time trends. Background information on the analyses and data derivation can be found in Appendix E. As described in the appendix, as is always the case with time trends data, changes in intake over time must be cautiously interpreted because of limitations in these data, particularly in older data with differences in methodologies.

Intake from Foods Over Time

While the completeness and accuracy of early NHANES data is unknown, in the four decades that sodium intake has been monitored, estimates of mean sodium intake appear to have not decreased and, in fact, have trended upward since 1971–1974 across age and gender groups. There is a less consistent upward pattern between 1988–1994 and 2003–2006 (Table 5-5).

Reasons for these changes in estimates cannot be specified with certainty. The general pattern is consistent with observed calorie increases in the population during the same period (Smiciklas-Wright et al., 2003). As discussed earlier, sodium intake is positively correlated with energy intake, so increases in energy intake are generally associated with increases in sodium. Further, different food composition databases have been used to estimate sodium intake over time, there are challenges in estimating sodium from all sources that may have changed over time, and there are likely methodological changes in assessing salt use and food composition data.

Sodium Intake Density Over Time

As described earlier, expressing sodium intake on the basis of milligrams of sodium per 1,000 calories provides another means of assessing sodium intake over time and between groups. This expression of sodium intake density can be calculated for estimates of sodium intake collected in

TABLE 5-5 Mean 1-Day Sodium Intake (mg/d; SE) from Foods[a] by Age and Gender

	NHANES I 1971–1974	NHANES II 1976–1980	NHANES III 1988–1994	NHANES 1999–2000	NHANES 2003–2006[b,c]
Both Sexes					
1–2 years	1,631 (38)	1,828 (31)	1,983 (29)	2,148 (69)	1,929 (26)
3–5 years	1,925 (32)	2,173 (27)	2,594 (47)	2,527 (84)	2,483 (34)
6–11 years	2,393 (38)	2,716 (34)	3,164 (67)	3,255 (125)	3,119 (30)
Males					
12–15 years	2,923 (75)	3,405 (85)	4,240 (158)	3,858 (171)	3,947 (69)
16–19 years	3,219 (97)	4,030 (92)	4,904 (138)	4,415 (206)	4,367 (67)
20–39 years	3,043 (64)	3,760 (59)	4,680 (68)	4,334 (103)	4,558 (58)
40–59 years	2,681(57)	3,413 (79)	4,177 (88)	4,132 (112)	4,119 (52)
60–74 years	2,318 (46)	2,934 (34)	3,513 (82)	3,557 (110)	3,487 (52)
20–74[c] years	2,780 (40)	3,486 (45)	4,288 (53)	4,127 (74)	4,300 (34)
Females					
12–15 years	2,094 (49)	2,567 (49)	3,200 (127)	3,034 (123)	2,952 (45)
16–19 years	1,812 (60)	2,336 (58)	3,160 (91)	3,048 (95)	2,995 (45)
20–39 years	1,883 (26)	2,383 (40)	3,167 (53)	3,161 (75)	3,136 (35)
40–59 years	1,754 (25)	2,256 (37)	2,852 (52)	2,978 (87)	2,932 (38)
60–74 years	1,529 (34)	2,053 (29)	2,543 (53)	2,633 (79)	2,628 (38)
20–74[c] years	1,774 (17)	2,278 (27)	2,939 (34)	3,002 (62)	3,003 (22)

NOTE: d = day; mg = milligram; NHANES = National Health and Nutrition Examination Survey; SE = standard error.

[a] Includes salt used in cooking and food preparation, but not salt added to food at the table.

[b] Estimated on basis of 1-day intake in order to be consistent with earlier surveys.

[c] Age-adjusted to the 2000 Census.

SOURCES: Briefel and Johnson (2004) for 1971–2000 data (reproduced with permission of Annual Reviews, Inc. from "Secular trends in dietary intake in the United States," Vol 24; permission conveyed through Copyright Clearance Center, Inc.); NHANES for 2003–2006 data.

NHANES beginning in 1971–1974 (see Table 5-6). More detailed information can be found on NHANES 2003–2006 in Appendix F (Table F-4).

The differences in sodium intake that are observed among children and adult men and women disappear to a large degree when expressed as measures of sodium intake density. This suggests that on a calorie-per-calorie basis, age and gender subgroups within the U.S. population are taking in equivalent amounts of sodium and larger intake among men, for example, when compared to women is primarily a function of consuming more food, not different foods. Further, the difference in measures of sodium intake density for virtually all population groups between 1971–1974 and 2003–2006 also suggest that foods, as consumed, may have had an increase in the amount of sodium on a per 1,000 calories basis during this time period. As

TABLE 5-6 Mean 1-Day Sodium Intake Density (mg/1,000 kcal) from Foods[a] by Age and Gender

	NHANES I 1971–1974	NHANES II 1976–1980	NHANES III 1988–1994[b]	NHANES 1999–2000	NHANES 2003–2006[b,c]
Both Sexes					
1–2 years	1,208	1,420	1,538	1,422	1,367
3–5 years	1,149	1,385	1,630	1,558	1,462
6–11 years	1,170	1,386	1,672	1,607	1,521
Males					
12–15 years	1,114	1,367	1,645	1,568	1,578
16–19 years	1,069	1,322	1,583	1,506	1,520
20–39 years	1,093	1,366	1,578	1,533	1,563
40–59 years	1,164	1,474	1,627	1,595	1,549
60–74 years	1,209	1,539	1,669	1,675	1,643
20–74[c] years	1,135	1,308	1,608	1,576	1,561
Females					
12–15 years	1,096	1,410	1,741	1,525	1,534
16–19 years	1,044	1,385	1,614	1,527	1,507
20–39 years	1,140	1,450	1,617	1,559	1,581
40–59 years	1,162	1,532	1,643	1,629	1,612
60–74 years	1,154	1,553	1,671	1,650	1,621
20–74[c] years	1,150	1,497	1,635	1,599	1,597

NOTE: kcal = calorie; mg = milligram; NHANES = National Health and Nutrition Examination Survey.

[a] Includes salt used in cooking and food preparation, but not salt added to food at the table; 1-day mean intake calculated using the population proportion method; weighted data from NHANES.

[b] Analyzed using 1-day mean intake data from NHANES 2003–2006 to be consistent with previous analyses.

[c] Age-adjusted to the 2000 Census.

SOURCES: Briefel and Johnson (2004) for 1971–2000 data; NHANES for 2003–2006 data.

compared to a sodium intake density of < 1,150 mg per 1,000 calories per day needed to achieve a *Dietary Guidelines for Americans* recommended daily intake of < 2,300 mg sodium, and assuming a 2,000-calorie reference diet, all groups had intakes that exceeded guideline levels, even during the earlier periods when sodium intake density appeared lower than in more recent years.

In sum, despite the confounding that may occur relative to the observed upward trend in sodium intake since 1971–1974 due to increases in calorie intake and methodological differences among surveys, it is very likely that true increases in sodium intake from foods have occurred. Consistencies across population subgroups in NHANES over five national surveys, consistencies with smaller studies and clinical trials that included urinary sodium assessments, and information on the sodium density of the food supply lend support to the upward intake trend during the past 30 to 40 years.

CHARACTERIZING SODIUM IN THE FOOD SUPPLY

Identifying Food Sources of Sodium

The ability to characterize the food sources that contribute sodium to the diet helps to clarify the nature of the food supply and to suggest those food categories that are the major contributors. The analyses reported here are based on the same 2003–2006 NHANES used to provide the estimates of sodium intake described earlier in this chapter. The description of the methods for defining and sorting food categories can be found in Appendix E. Eleven major food categories were specified. Examples of several products that demonstrate variation in sodium content among different brands for similar foods are discussed in Chapter 4.

Contribution on Basis of 11 Food Categories

Figure 5-8 shows the percentage contribution to sodium intake from 11 major food categories. Mixed dishes, which consist of foods such as sandwiches, casseroles, pasta entrées, and pizza, contribute nearly half (44 percent) of the total sodium from foods. Other major food categories include meat and meat alternates, including cheese and eggs (16 percent), grains (11 percent), and vegetables (9 percent).[14] The remaining food categories each contribute 5 percent or less of total sodium intake from foods (see Appendix F, Table F-8).

Beyond the food categories "fruit" and "fats/oils," it is difficult to comment on differences over time in these relative contributions because the major grouping schemes used to categorize foods have not remained consistent.

Further, Table 5-7 displays the top five foods that contribute sodium to the diets of persons 2 or more years of age in rank order within each of the 11 major food categories. For example, within the food category of mixed dishes—the category that is the largest contributor to dietary sodium—the main contributors (in rank order) are sandwiches (excluding burgers), pizza, hamburgers/cheeseburgers, Mexican entrées, and pasta dishes. For most food categories, the top 20 foods (see Appendix F, Table F-8) account for all or nearly all of the sodium contributed by that food category.

[14] Raw vegetables and fresh-cooked vegetables without salt or other sodium-containing seasonings or added sauces provide little naturally occurring sodium.

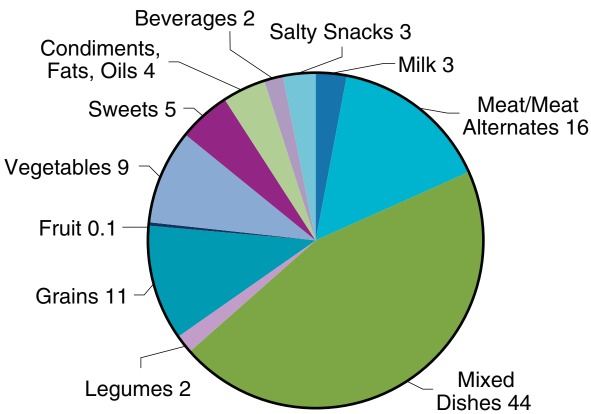

FIGURE 5-8 Percentage contributions to sodium intake by food category for persons 2 or more years of age.
SOURCE: NHANES 2003–2006.

Further, the kinds of foods that are the major contributors to sodium intake are similar across age and gender groups, as shown in Appendix F (Table F-9).

Finally, Table 5-8 provides an example to illustrate that relative to the food category that is the primary contributor to sodium intake—mixed dishes—the sodium in the mixed dish is derived from an array of items added to the dish as part of its preparation.

Contribution on Basis of Prepared Away from Home versus Prepared at Home

The definitions of foods eaten at home and those eaten away from home are given in Appendix E. As shown in Figure 5-9, in 2003–2006 about 37 percent of sodium came from food away from home. By comparison, the contribution of away-from-home foods to sodium intake is reported to have increased from 27 to 34 percent from 1987 to 1995 (Lin et al., 1999). Currently, for foods obtained at the store (and eaten at home), the main source of sodium is sandwiches, followed by pasta dishes, cereal, bread, and cheese. At restaurants, the main source is also sandwiches and then pizza, hamburgers, chicken, Mexican entrées, and salads (see Appendix F, Table F-10).

Because of the confounding effect of calories on estimates of sodium intake—persons consuming more calories have higher sodium intakes—

TABLE 5-7 Top Five Food Contributors to Sodium Intake Within Food Categories for Persons 2 or More Years of Age

Food Group	Food Item	Percentage of Sodium Contributed in Food Group[a]
Mixed dishes = 44% of total daily sodium	Sandwiches (excluding burgers)	35.3
	Pizza with meat	12.2
	Hamburgers/cheeseburgers	8.5
	Mexican entrées	6.9
	Pasta dishes, Italian style	6.5
	Sum	*69.4*
Meat, meat alternates = 15.5% of total	Chicken	25.0
	Cheese	15.3
	Eggs	12.1
	Bacon/sausage	10.6
	Beef	7.7
	Sum	*70.7*
Grains = 11.4% of total	Bread	21.5
	Cold cereal	18.5
	Rice	10.9
	Pancakes, waffles, French toast	9.6
	Crackers	9.0
	Sum	*69.5*
Vegetables = 9.3% of total	Salad (greens)[b]	30.0
	Cooked potatoes, not fried	16.7
	Cooked potatoes, fried	15.2
	Cooked tomatoes	9.2
	Cooked green beans	4.3
	Sum	*75.4*
Sweets = 5.0% of total	Cookies	22.0
	Cake/cupcakes	21.6
	Ice cream	10.5
	Pies/cobblers	9.3
	Doughnuts	7.8
	Sum	*71.2*
Condiments, oils, fats = 4.3% of total	Catsup, mustard, relish, soy sauce	39.9
	Gravy	12.3
	Salad dressing	11.7
	Garnishes such as pickles or olives	10.6
	Margarine	7.4
	Sum	*81.9*
Salty snacks = 3.4% of total	Corn-based salty snacks	32.1
	Popcorn	25.9
	Potato chips	23.0
	Pretzels/party mix	19.1
	Sum	*100.0*

TABLE 5-7 Continued

Food Group	Food Item	Percentage of Sodium Contributed in Food Group[a]
Milk = 2.9% of total	Unflavored 2% milk	28.8
	Unflavored whole milk	19.2
	Unflavored skim milk	12.9
	Unflavored 1% milk	9.9
	Yogurt	5.8
	Sum	*76.6*
Beverages = 2.2% of total	Noncarbonated sweetened drink	28.0
	Regular soda	25.2
	Sugar-free soda	12.8
	Coffee	11.7
	Beer	7.3
	Sum	*85.0*
Beans, nuts, and seeds = 2.1% of total	Baked or refried beans	37.6
	Nuts	18.7
	Beans	16.8
	Protein or meal enhancement	12.4
	Peanut or almond butter	6.9
	Sum	*92.4*
Fruit = 0.1% of total	Citrus juice	25.8
	Non-citrus juice	24.5
	Avocado, guacamole	13.8
	Fresh melon	12.4
	Other fresh fruit	4.5
	Sum	*81.0*

[a] Percentage shown within each major category reflects the percentage of sodium contributed by that food item within the food category (e.g., sandwiches provide 35% of the sodium in the mixed dish category).
[b] Includes additions to salads such as salad dressing, cheese, meat, croutons, and other condiments.
SOURCE: NHANES 2003–2006.

comparisons of relative intake from different food supply sources are best expressed on the basis of sodium intake density, specifically as milligrams per 1,000 calories consumed. Currently, as shown in Table 5-9, mean sodium intake density is lowest for foods consumed at home (obtained at the store and prepared or consumed at home) and highest for foods consumed away from home, notably from restaurants and fast food establishments (as defined by NHANES).

As discussed in Chapter 2, data collected between 1987 and 1995 (Lin et al., 1999) reveal sodium intake density measures for foods consumed at home to be similar to those from away-from-home sources (see Figure 2-4).

TABLE 5-8 Sources of Sodium in Sandwiches and Hamburgers/Cheeseburgers by Percentage of Item for Persons 2 or More Years of Age

Sandwiches (Excluding Burgers) Contribution to Total Sodium in Sandwich (%)		Hamburgers/Cheeseburgers Contribution to Total Sodium in Hamburger (%)	
Cold cuts	23.9	Ground beef	36.7
Bread	19.2	Rolls	19.6
Cheese	11.2	Cheese	18.8
Hot dogs	9.2	Catsup, mustard, relish, etc.	8.1
Rolls	7.3	Garnishes such as pickles, olives	6.4
Bacon/sausage	4.1	Bread	4.9
Catsup, mustard, relish, etc.	2.7	Mayonnaise	1.8
Chicken	2.4	Bacon/sausage	1.7
Fish	2.3	Cooked tomatoes	0.5
Ham	1.8	Salad dressing	0.4

SOURCE: NHANES 2003–2006.

Likewise, foods eaten at fast food restaurants and schools for that period show sodium densities similar to those classified as eaten at home, suggesting generally similar salt additions to foods in most food preparation and manufacturing locations, or similar food coding rules. The more recent data from NHANES 2003–2006 (see Table 5-9 and also Figure 2-4) reveal greater differences in the sodium intake density of foods obtained from the store (and prepared or eaten at home) versus all away-from-home sources. This suggests that within the U.S. food supply, away-from-home food sources are richer in sodium than foods consumed at home. Further, in the past two decades, the sodium intake density increased the most for fast food restaurants (see Figure 2-4).

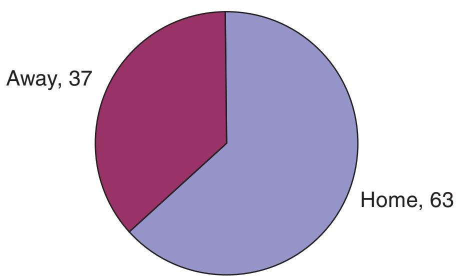

FIGURE 5-9 Percentage of sodium intake from home and away-from-home foods.
SOURCE: NHANES 2003–2006.

TABLE 5-9 Sodium Density for Foods from Home and Away for Persons 2 or More Years of Age

Source of Food	Sodium Density (mg/1,000 kcal)
Home	1,422
Away (total)	1,825
Restaurants	1,925
Fast food/pizza restaurants	1,805
School	1,629
Other	1,466

NOTE: "Home" includes foods purchased at the store and prepared at home; "restaurants" includes those with waiters/waitresses and bar/tavern/lounge restaurants; and "other" includes foods from child or adult care centers, soup kitchens, Meals on Wheels, community food programs, vending machines, food gifts, mail order purchases, street vendors, etc. kcal = calorie; mg = milligram.
SOURCE: NHANES 2003–2006.

Other Approaches to Characterizing the Sodium Content of the Food Supply

Other approaches can be used to describe the sodium content of the food supply beyond examining the main contributors of sodium to the diet on the bases of food category and types of eating establishments. However, as a general matter, the food supply as a whole has not been systematically tracked or monitored through surveys designed for this purpose. Alternatively, the sodium content of the food supply can be described using salt disappearance data (which can also be used to derive gross estimates of sodium intake). So-called "market basket" studies, such as the survey conducted by the Food and Drug Administration (FDA), could also be useful, although currently it is designed primarily for other purposes. The national databases related to food composition—which include sodium content and are maintained by USDA—cannot themselves characterize the sodium content of the food supply, but are instead a key component of the process of estimating sodium intake based on dietary recalls from a nationally representative sample of the U.S. population. However, selective comparisons of changes in food composition over time within these databases could provide some useful trend data on changes in sodium in the food supply. The only available study of this type did not include information on sodium (Ahuja et al., 2006).

Salt Disappearance Data

Monitoring intake from disappearance data allows for a reasonably accurate estimate of time trend patterns because common methods of collecting and accounting for use have remained similar over time. Salt disappearance data can be used to estimate time trend patterns in the availability of sodium for human consumption, with the understanding that there are losses and wastage that cannot be accounted for. As described in Chapter 2, the annual per capita salt disappearance data show a steady increase in per capita availability between 1983 and 1998. While this does not definitively indicate that there has been an increase in the overall sodium content of the food supply, it is suggestive. More recently, values appear to be leveling off or decreasing slightly. The peak levels in 1998 indicate that approximately 5,700 mg of sodium were available per person per day. Although the pattern of use over time suggests that early educational and program initiatives (such as in the early 1980s) were associated with a reduction in salt use, subsequent programs, including the implementation of a mandatory declaration of sodium content on all food labels in 1993 and multiple calls for food processors and food service operators to reduce the sodium content of foods since 1969, appear to have had little or no impact on salt availability for human use.

Market Basket Study: FDA's Total Diet Study

The Total Diet Study (TDS) is an ongoing FDA program that determines levels of various contaminants and nutrients in foods.[15] From this information, dietary intake of those substances by the U.S. population can be estimated. Since its inception in 1961 as a program to monitor radioactive contamination of foods, the TDS has expanded to include pesticide residues, industrial chemicals, and toxic and nutrient elements.

The TDS involves purchasing samples of food throughout the United States, preparing the foods as they would be consumed (table-ready), and analyzing the foods to measure the levels of select contaminants and nutrients. Dietary intake of these substances by the U.S. population is then calculated by multiplying the levels found in TDS foods by the average consumption amounts for each food. The outcomes for sodium are reported as milligrams per kilogram of food. The number of different foods sampled in the TDS has increased from 82 food items when the study was initiated in the early 1960s to about 280 foods in the current program.

Sample collections (also referred to as market baskets) are generally conducted four times each year, once in each of four geographic regions of the country (West, North Central, South, and Northeast). Food samples are purchased by FDA personnel from supermarkets, grocery stores, and fast food restaurants in three cities in each region and are shipped to a central FDA laboratory.

[15] Available online: http://www.fda.gov/Food/FoodSafety/FoodContaminantsAdulteration/TotalDietStudy/default.htm (accessed November 18, 2009).

The TDS analyzes sodium on composites, reports these as milligrams per kilogram of food, and does not convert the results for composites back to representative diets, thereby limiting the utility of the data on sodium relative to the food supply. Further, it is unclear whether the sampling scheme, food preparation, and documentation of product samples are sufficient or appropriate for sodium. For example, issues related to the proportioning of the sampling of vegetables among fresh, frozen, and canned may require a different approach for sodium (which should be based on how consumers consume them), given that the current focus is on contaminants and pesticides.

National Food Composition Databases

In theory, national food composition databases offer the opportunity to monitor changes in the sodium content of the food supply, but interpretation of such data is problematic. There can be a confounding effect due to improvements in the food composition data and changes in the approaches used to determine the listings for the sodium values of foods. Currently, about 70 percent of the sodium values in the food composition database used to code and assess sodium in NHANES 2003–2006 are analytical values, 5 percent are from food labels, 11 percent from manufacturers, and 15 percent imputed. Moreover, during the time dietary trends have been measured, the food composition database has been updated and expanded to include more brand names and fast food items as well as a few other restaurant foods.[16] Maintaining an up-to-date database on the sodium content of foods is a challenging but essential task.

Ahuja et al. (2006) examined the effect of improved food composition data on intake estimates in the United States through a reanalysis of data using multiyear versions of the tables of food composition. Sodium was not included in their analysis, but for the more than 25 nutrients and food components examined, results showed minor but statistically significant differences in mean intake estimates for most nutrients.

MONITORING

Monitoring intake of sodium and describing the nature of sodium sources in the food supply is fundamental to implementing and sustaining strategies to reduce sodium intake. While estimates of sodium intake based on dietary recall methodologies are useful and readily reveal the high intake levels among the U.S. population, more accurate methods for estimating intake are available, including the 24-hour urine sample.

[16] Personal communication, J. Holden, USDA, Washington, DC, September 11, 2009.

The collection of 24-hour urine specimens to assess sodium intake reflects the gold standard for estimating sodium intake, however this method has not been included in the NHANES because of the complexity and cost of such collections. NHANES has collected "casual" urine specimens to assess environmental analytes, determine the possibility of pregnancy, and measure kidney function and iodine status.[17] However, these have not been analyzed for sodium, and it is recognized that casual specimens are not likely to provide a desirable level of accuracy for the purposes of estimating intake. Nonetheless, because surplus collections of these samples have been stored since NHANES became a continuous survey in 1999, these samples offer the opportunity to carry out pilot studies relative to comparisons, given that NHANES plans to collect a second urine specimen as part of the recently initiated 2009–2010 survey.

All of the usual improvements frequently called for relative to estimating intake through dietary recall methods also apply to sodium. These include advances in recall methods and probing techniques, enhancement of food composition tables for sodium content of foods, and timely, user-friendly releases of data. More frequent analysis and reporting of distributions of usual sodium intake (and energy for calculations of sodium density) and food sources of sodium are warranted to better monitor sodium intake and initiatives to reduce sodium. Of particular importance in the case of sodium for food composition tables is the ability to incorporate into such tables the sodium content of menu items offered by the major chain restaurant/foodservice operations.

Finally, there is considerable utility to be gained through the implementation of appropriate market basket studies and innovative approaches to characterizing the sodium content of the food supply. The committee considered these in more depth as described in Chapter 8.

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6

The Food Environment: Key to Formulating Strategies for Change in Sodium Intake

As often pointed out, the United States has one of the most diverse and plentiful food supplies in the world. On balance, food is relatively inexpensive and readily available. However, the food supply is also characterized by high levels of sodium. Very little of the sodium in foods is naturally occurring; most of it is added by the food industry in the form of sodium chloride, but other sodium-containing compounds make a contribution. Further, as described in Chapter 5, the amount of salt added to foods at the table and during cooking currently contributes only minor amounts to the overall diet of Americans.

An important consideration for this report is not only that the food supply contains high levels of sodium, but also that increasing amounts of the food consumed by Americans are formulated by entities outside the home (see Chapter 5). These range from single items typically regarded as processed foods, such as canned soups and baked goods, to entire meals and sometimes entire diets. This is mirrored in the steady growth of the processed food industry, the high consumer demand for convenience and ready-to-serve products, and changes in the types of stores selling foods (Martinez, 2007).

The food environment framework reflects an interaction of multiple components: manufacturers, retailers, restaurant/foodservice operations, consumers, regulation/policy, and communication/advertising (Glanz et al., 2005). This chapter outlines the nature of the first four components. It begins with an overview of U.S. food manufacturing and retailing industries, then continues with an overview of restaurant/foodservice operations. Large-scale government programs that provide foods to individuals and households are also discussed. The chapter concludes with a discussion of consumer interactions with the food environment, looking specifically at how the food environment influences consumer choice and at current understanding of consumer behavior change models.

MANUFACTURING AND RETAILING OF PROCESSED FOODS WITHIN THE FOOD ENVIRONMENT

Since the late 1800s, the U.S. food environment has experienced tremendous growth and changes in the food manufacturing and retailing sectors, which continue to evolve (Beckley et al., 2007). Today, the majority of food undergoes some type of processing before reaching consumers. Some processing is so extensive that little or no preparation of the food is needed before consumption. As discussed in Chapter 5, processed foods are major contributors to sodium intake, making the food manufacturing and retailing sectors of key interest to the committee. This section provides an overview of food manufacturing and retailing in the United States, information on how food products are developed, and examples of efforts taken by the food industry to reduce sodium intake and the levels of sodium in the foods it produces.

Characteristics of the Processed Food Industry

Processed food represents one of the largest sectors of the U.S. manufacturing industry, accounting for 10 percent of manufacturing shipments and valued at $538 billion in 2006. The U.S. Department of Commerce defines food manufacturing as an industry that "transforms livestock and agricultural products into products for intermediate or final consumption."[1] Although the definition of processing may include minimal manipulation, such as cutting meat or slicing fresh produce, the term "processed foods" is most closely associated with more complex products, such as baked goods, canned soups, and frozen meals. Restaurant foods and food served by commercial foodservice operations are considered in the following sections.

Table 6-1 shows the wholesale value of shipments for various food categories. To produce these goods, the food manufacturing industry employed 1,476,300 people as of September 2009.[2] There are approximately 31,000 food and beverage processing plants in the United States; however, most of the output of the processed food industry is derived from a relatively

[1] Available online: http://www.trade.gov/td/ocg/report08_processedfoods.pdf (accessed July 20, 2009).

[2] Available online: http://www.bls.gov/iag/tgs/iag311.htm#workforce (accessed October 12, 2009).

TABLE 6-1 Value of Shipments by the U.S. Food Manufacturing Industry in 2006

Type of Shipment	Value (billions of U.S. dollars)
Meat	145
Dairy	69
Other food	71
Grain and oilseed milling	52
Fruit, vegetable, and specialty food	54
Bakeries and tortilla	49
Sugar and confectionery	28
Seafood	10

SOURCE: U.S. Department of Commerce Processed Food Outlook, 2008. Available online: http://www.trade.gov/td/ocg/report08_processedfoods.pdf (accessed July 20, 2009).

small number of large manufacturing plants. Large plants (100 or more employees) comprised only 12 percent of all processing plants in 2005, yet produced 77 percent of products by value. Small plants (1–19 employees) comprised 69 percent of all plants in 2005, while producing only 4 percent of products by value.[3] Further, the size of the domestic manufacturing system does not provide a complete picture because substantial amounts of the food sold for consumption in the United States are processed overseas. In 2007, more than $60 billion in consumer-ready processed foods were imported, an increase from approximately $30 billion in 1998. Canada, the European Union, Mexico, and China were the top four exporters of these products (Brooks et al., 2009). In addition, many ingredients for foods processed in the United States are imported.[4]

Table 6-2 lists the top 20 food processors in the United States and Canada on the basis of food sales in 2008. The top food manufacturers in the United States are multinationals that create and sell a variety of products under numerous national brand names. National brands are typically those that are well known and advertised, and most have strong customer loyalty.[5] In addition to large multinationals, thousands of small- and medium-sized companies make products that are sold nationally or regionally. For example, it is estimated that the average supermarket stocks products from more than 16,000 food processing companies (Harris et al., 2002), many of which produce far fewer products than large multinationals. Both large

[3] Available online: http://ers.usda.gov/Briefing/FoodMarketingSystem/processing.htm (accessed August 1, 2009).

[4] Available online: http://www.foodprocessing.com/articles/2008/037.html (accessed November 11, 2009).

[5] Available online: http://www.fmi.org/glossary/index.cfm (accessed October 12, 2009).

TABLE 6-2 Top Food Processors in the United States and Canada

Company Name	2008 Food Sales (millions of U.S. dollars)
Nestlé	26,477
Tyson Foods Inc.	26,325
PepsiCo Inc.	25,346
Kraft Foods Inc.	23,956
Anheuser-Busch InBev	15,571
Dean Foods Co.	12,455
General Mills Inc.	12,100
Smithfield Foods Inc.	10,726
Kellogg Co.	8,457
Coca-Cola Co.	8,205
ConAgra Foods Inc.	8,031
Pilgrim's Pride Corp.	8,025
JBS USA	8,000
Dole Food Co. Inc.	7,620
Mars Inc.	7,000
Sara Lee Corp.	6,828
Hormel Foods Corp.	6,755
Unilever North America	6,647
Saputo Inc.	5,793
Dr Pepper Snapple Group	5,710

SOURCE: Food Processing, 2009.

and small manufacturers produce private label products for retailers and products for the restaurant/foodservice sector in addition to well-known brand name products.

Private label products are those sold under retailer brands.[6] On average, private label goods account for 16 percent of supermarket sales (Leader and Cuthill, 2008), but the dominance of such products varies greatly by food category. Although still less prevalent than brand name products, private label products are an important component of the processed food supply, especially given their current rate of growth, which is higher than that of national brand name products (Martinez, 2007).

Overall, the U.S. food manufacturing sector can be characterized as having a multitude of players of varied sizes. The sector ranges from large multinationals selling brand name and private label products in a range of food categories to small processing plants with only a few employees to produce a single regional brand or product. As discussed later, this land-

[6] Available online: http://www.plmainternational.com/en/private_label_en3.htm (accessed July 31, 2009).

scape creates both challenges and opportunities for reducing the sodium content of the U.S. food supply.

Characteristics of the Food Retailing Industry

Food retailers are increasingly important in the food environment, not only because of their longstanding role as key distributors for and promoters of processed foods, but also because their increasing concentration and data-gathering technologies have given them the ability to influence the types of products developed by manufacturers. Over the past decade, the food retail sector has seen dramatic changes driven by the growth of non-traditional food retailers such as big box supercenters (Martinez, 2007) and changes in technology that have revolutionized sales tracking (Leader and Cuthill, 2008). Supercenters (e.g., Wal-Mart, Super Target) and warehouse clubs (e.g., Costco, BJ's) increased their shares of food-at-home expenditures from 4 percent in 1994 to 17 percent in 2005 at the expense of traditional food retailers (Martinez, 2007). Wal-Mart alone increased its number of supercenters from 672 U.S. stores in 1995 to 2,349 in 2005 (Martinez, 2007). Table 6-3 shows the share of food-at-home expenditures in 2005 by outlet type, and a list of the top 10 food retailers in the United States and Canada and their 2008 sales is provided in Table 6-4.[7]

Supermarkets commonly carry 30,000 to 40,000 stock keeping units (or distinguishable products) (Leader and Cuthill, 2008) but space remains limited, even in the largest of retailers. Convenience stores, drugstores, and dollar stores are also important parts of the food retailing industry. These retailers have more limited offerings than supermarkets, but have expanded their food offerings in recent years (Martinez, 2007).

Because of their purchasing power, large retailers gained the ability to influence the types of products produced by food manufacturers by determining which products will reach the limited space on retail shelves (Martinez, 2007). The introduction of checkout scanners and automated inventory control has given retailers powerful tools for determining which items sell best and, in turn, helped retailers determine which products they are willing to sell. With thousands of food products introduced to the market each year, products must compete for limited space on retail shelves, and manufacturers must develop products that will generate high profits for retailers in order to stay in the marketplace (Leader and Cuthill, 2008). To convince retailers that a new product should be carried, manufacturers often give them detailed sales pitches, including information on expected

[7] Available online: http://supermarketnews.com/profiles/top75/2009-top-75/ (accessed July 31, 2009).

TABLE 6-3 Share of Food-at-Home Expenditures by Type of Outlet, 2005

Type of Outlet	Percentage
Traditional Grocery Retailers	
Supermarkets	58.2
Convenience stores	2.9
Other grocery stores	3.6
Specialty food stores	2.7
Nontraditional Grocery Retailers	
Supercenters (e.g., Wal-Mart, Super Target, Super Kmart, Meijer, Fred Meyer) and warehouse clubs (e.g., Costco, Sam's Club, BJ's)	17.1
Mass merchandisers (e.g., traditional Wal-Mart, Target, and Kmart stores)	1.8
Other stores (e.g., Walgreens, Dollar General)	8.7
Home-delivered and mail order	4.0

SOURCE: Martinez, 2007.

TABLE 6-4 Top 10 Retailers in the United States and Canada

Company Name	2008 Sales (billions of U.S. dollars)
Wal-Mart Stores	258.5
Kroger Co.	77.2
Costco Wholesale Corp.	72.5
Supervalu	45.0
Safeway	44.8
Loblaw Cos.	31.5
Publix Super Markets	24.0
Ahold USA	21.8
Delhaize America	19.2
C&S Wholesale Grocers	19.0

NOTE: Sales volume includes revenues from both food and non-food merchandise in North America.
SOURCE: Supermarket News, 2009. Available online: http://supermarketnews.com/profiles/top75/2009-top-75/ (accessed July 31, 2009).

sales, marketing plans, and consumer research on the product category (FTC, 2003).

Retailers also often control what products are sold and where they are placed on retail shelves by creating slotting fees. Slotting fees are one-time payments made by food processors to retailers in exchange for placement of new products on store shelves (FTC, 2003). Some manufacturers are charged as much as $40,000 per store to stock a new food item (Desiraju, 2001).

Some retailers have also created programs to pressure manufacturers into making changes in the product characteristics of the items they sell. A recent example is Wal-Mart's work to encourage suppliers to improve the sustainability of product packaging.[8] Although not from the United States, another example is the requirement that ASDA supermarkets (which are owned by Wal-Mart) in the United Kingdom placed on their private label manufacturers to meet certain standards for fat, saturated fat, sugar, and salt in their products and to remove artificial colors and flavors (Hattersley, 2009).

Because a relatively small number of retailers are responsible for a large volume of processed foods sales, they can be the gatekeeper to new product success. If manufacturers are unable to convince major retailers that a new or reformulated product will appeal to consumers or if the company cannot safely take the risk of paying high slotting fees, its product has little chance of succeeding in the marketplace. These factors have become a major consideration in the development and reformulation of processed foods.

Product Development Process

In 2005, 18,722 new food and beverage products were introduced by food manufacturers (Martinez, 2007). The breakdown of these products by type is provided in Table 6-5.

To create new products, the largest processed food manufacturers have

[8] Available online: http://walmartstores.com/Sustainability/9125.aspx (accessed October 12, 2009).

TABLE 6-5 New Product Introductions in 2005

Type of Product	Percentage of Total
Candy, gum, snacks	27.7
Beverages	25.1
Condiments	10.2
Dairy	7.2
Baking ingredients	6.0
Processed meat	5.0
Meals and entrées	4.7
Bakery foods	4.1
Fruit and vegetables	3.4
Pasta and rice	2.2
Soups	1.6
Cereals	1.4
Desserts	0.8

SOURCE: Martinez, 2007.

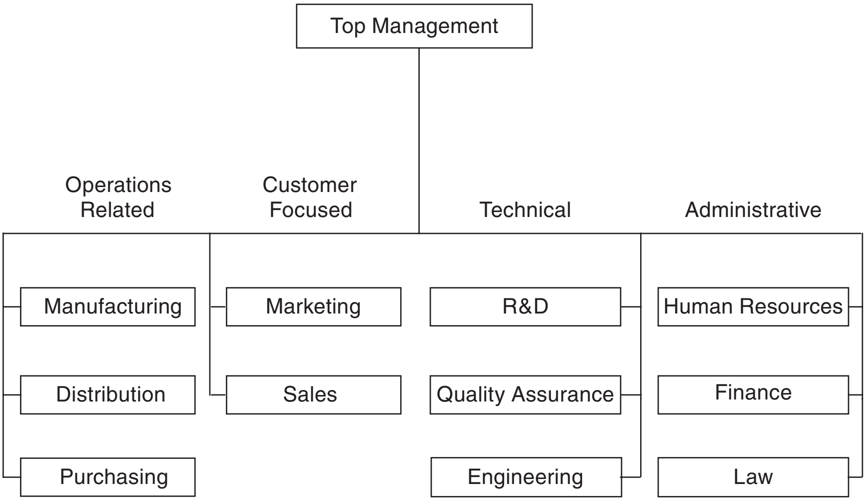

FIGURE 6-1 Business groups involved with product development.
SOURCE: Adapted from Beck, 2002. In *Organizing human resources: By project? By discipline? As a matrix?* Copyright © 2002 Iowa State Press. Reproduced with permission of John Wiley & Sons, Inc.

large groups of employees with a range of skills. As shown in Figure 6-1, these groups include employees with operations, customer, technical, and administrative expertise, including market researchers, food scientists, nutritionists, engineers, chemists, and microbiologists. Research and development teams within these companies are involved in both developing new products and reformulating existing products. Multinational manufacturers may conduct some of their research and development activities at international research centers (Nestle, 2007).

In smaller companies, research and development staff may be limited (Beck, 2002). For these manufacturers, a single scientist may be responsible for multiple functions.

All sizes of food manufacturers are relying more on ingredient suppliers, external contract developers, and consultants to be part of the product development process (Beckley et al., 2007; Thomas, 2007). These groups are useful in providing expertise that may otherwise be lacking in the company or conducting research at a lower cost than the company could do in-house (Beckley et al., 2007; Fuller, 2005). Consultants may be from private companies or from universities that see consulting as a useful way to apply their research and to generate revenues (Fuller, 2005). State Cooperative Extension Services also provide expertise, particularly to small food processors and entrepreneurs.[9]

The reasons companies undergo the costly and time-consuming process of new product development include the following (Fuller, 2005):[10]

- New or reformulated products are needed for manufacturers to maintain and expand their business as products end their life cycle and suffer from reduced sales;
- New market demands arise (e.g., more demand for healthful products);
- New technologies may make possible the creation of new products that were not feasible in the past;
- Changes in government regulations and policies may make it necessary to reformulate existing products or create incentives for new product development and reformulation (e.g., to meet requirements for health or content claims); and
- New or reformulated products are needed to respond to new or improved competitive products.

Steps to Develop New Products and Reformulate Existing Products

The product development process generally involves a series of steps that are depicted in Figure 6-2, although the ordering of initial steps may vary from project to project.

Valdovinos (2009) more simply categorized this process into four steps: (1) idea generation; (2) concept development; (3) plan and design; and (4) launch and produce. A more detailed description of these steps is provided below.

Idea generation Ideas for new products come from a variety of internal and external sources. Examples of these sources are provided in Box 6-1. Large companies have marketing teams devoted to searching consumer data and gathering information on the existing food market. This work is intended to produce insights into how to fill consumer needs and, in the process, generate successful products (Straus, 2009). Marketing, business, and research and development personnel work to brainstorm ideas and determine which ideas are promising (Straus, 2009; Thomas, 2007; Topp, 2007).

Several considerations are needed in screening ideas. Questions asked

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[9] Available online: http://www.uga.edu/nchfp/business/starting_business.html#ceslinks and http://www.ces.ncsu.edu/index.php?page=foodsafetyprocessing (accessed October 15, 2009).

[10] Personal communication, J. Ruff, Kraft Foods (retired), October 2009.

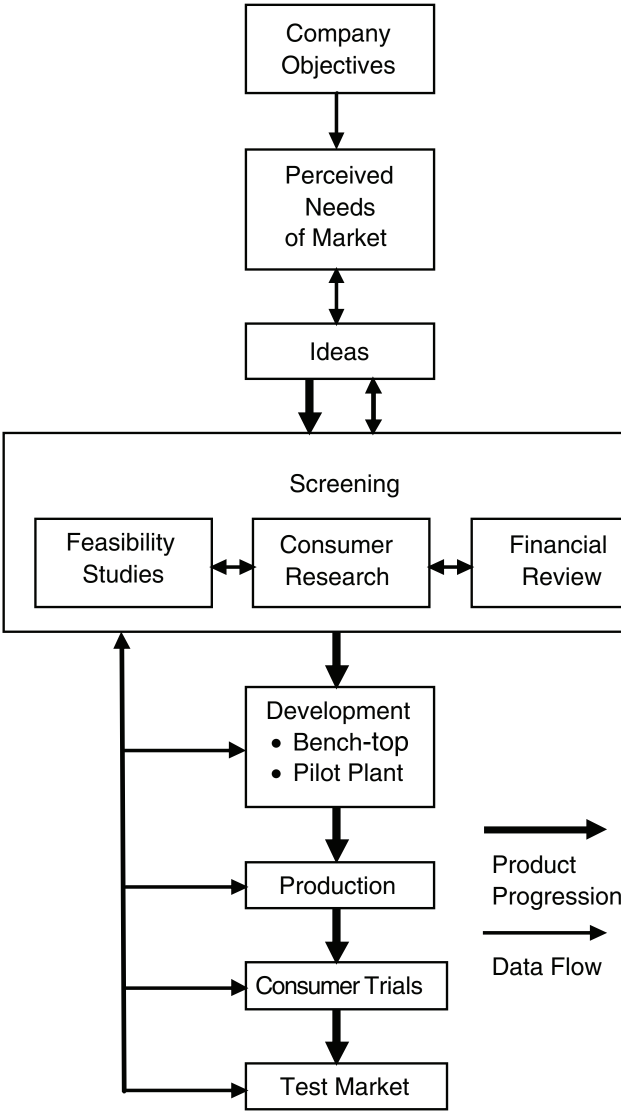

FIGURE 6-2 Phases of new product development.
SOURCE: Fuller, 2005. Reproduced with permission of Taylor and Francis Group LLC from "New food product development: From concept to marketplace," 2nd edition; permission conveyed through Copyright Clearance Center, Inc.

BOX 6-1
Sources of Product Ideas

Internal Sources
- Business and marketing teams
- Research and development teams
- Sales personnel
- Packaging teams
- Regulatory affairs departments

External Sources
- Competitors
- Suppliers
- Consumers
- Retailers

SOURCES: Straus, 2009; Topp, 2007.

include the following (Heyhoe, 2002; Moskowitz et al., 2009; Straus, 2009):

- How closely does the new product idea fit with the corporation's strength in the market (i.e., does the company have closely related products that are successful)?
- How technically feasible is the project?
- How well can the product idea be protected from competition (i.e., can patents or commercial secrets ensure that competitors will be unable to easily copy the product)?
- What capital expenditures will be needed?
- What is the expected life of the product (1 year, 3–5 years, etc.)?
- What is the spinoff potential of the product for line extensions and related products?
- How well do consumers rate the product compared to products with known success?

Another consideration that has emerged with greater importance in recent years is determining what will influence a retailer to stock the product. Retailers are the first customers and their acceptance is needed (Topp, 2007) because their willingness to stock a new product will be a major factor in its success (van Boekel, 2009).

With the above questions in mind, business teams can estimate the costs of production and the potential profit the product might generate and then decide which product ideas are most likely to be successful in moving forward. When project ideas are abandoned, it is usually due to low projected profit margins (Topp, 2007).

Concept development Once a product concept is chosen for further development, benchtop product development begins. Benchtop work includes creating prototypes and making initial plans for processing parameters (Kramer, 2002). Knowledge of food science, engineering, chemistry, microbiology, and packaging is used to create prototypes that can meet the product concept within the constraints of modern food processing and without exceeding the intended cost of the product. As prototypes are developed, the most promising formulations may be tested for mass production using pilot plants.

Sensory scientists and marketing groups are employed to determine how the prototypes are received by consumers, using both focus groups to test how well consumers receive the product concept and sensory panel testing to determine how well consumers like the taste and appearance of the product (Cox and Delaney, 2009; Moskowitz, 2009). Based on focus group and sensory study feedback, prototypes may be adjusted to meet consumer desires (Kramer, 2002). Shelf life studies are also conducted to ensure product quality and safety (Saguy and Peleg, 2009).

Plan and design As prototypes are finalized, plans are made for large-scale manufacturing. Company engineers and business units determine what facilities are needed and whether the product should be produced by company-owned plants or contracted co-packers (Weinstein, 2002). Purchasing units within the company work to procure the needed ingredients and packaging materials (Fuller, 2005). Business and sales groups make plans for the product launch, including plans for advertising and target markets (de la Huerga and Topp, 2007). In addition, sales staff often meet with retailers to pitch new products,[11] and regulatory teams ensure that the product and its packaging comply with government standards (Fuller, 2005). If a new product meets the definition of an acidified food or low-acid canned food, federal regulations require processors to file their processes with the Food and Drug Administration (FDA) for each product, product style, container size and type, and processing method.[12] Replacement process forms must be filed if a processor makes changes to a process, the container size that will be used for a product, or factors critical to the adequacy of the process

[11] Personal communication, J. Ruff, Kraft Foods (retired), October 2009.
[12] 21 CFR 108.

(such as temperature changes or product formulation).[13] Such requirements are an important step in helping to ensure the safety of such foods.

Launch and produce The final launch and production step may seem as though it is the final step in product development; however, most companies continue to test products after an initial launch and may make additional changes. To reduce the risk of large product failures in the marketplace, some firms choose to initially launch the product in a test market. The degree of success in the test market may lead to a larger rollout or may identify problems in the product that need further research and development (Fuller, 2005).

Further, companies are constantly working to reformulate products for a variety of purposes, including the following (Fuller, 2005):[14]

- to improve sensory or nutritional characteristics (including the removal of ingredients seen by consumers as undesirable due to media coverage and new health information);
- to overcome problems with ingredient availability;
- to reduce ingredient or production costs;
- to incorporate new technologies;
- to create a new market niche for the product;
- to maintain the legal marketability of products when the legal status of an ingredient is changed; and
- to meet nutritional health claim or other criteria to allow for front-of-package labeling (Webster, 2009).

Today, the primary driver of continued industry profitability is competition with others in the market on price, and reducing processing and ingredient costs is the primary means of staying competitive (Watzke and German, 2009). To reformulate existing products, issues similar to those that factor into new product development must be considered. In addition, companies test products to ensure that the reformulated product is considered by consumers to be of equal or better quality than the original version so as not to lose market share, according to a participant in the public information-gathering workshop held by the committee (March 30, 2009).

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[13] Available online: http://www.fda.gov/Food/FoodSafety/Product-SpecificInformation/AcidifiedLow-AcidCannedFoods/EstablishmentRegistrationThermalProcessFiling/Instructions/ucm125810.htm (accessed January 21, 2010).

[14] Personal communication, J. Ruff, Kraft Foods (retired), October 2009.

Differences in the Product Development Process for Smaller Companies and Private Label Foods

It is important to note that the product development process for smaller companies may be different from the processes used by large manufacturers. Smaller companies generally have limited resources for new product idea generation and testing and may have limited expertise and budgets for cutting-edge scientific research. In addition, advertising budgets may be non-existent, and product sales may be limited to smaller retailers due to the prohibitive expense of slotting fees to sell products in larger retailers (Fuller, 2005).

Product development for private label products also differs from the product development carried out for large national brands. Most private label foods are produced by contracted manufacturers or retailer co-ops, although a few retailers own their manufacturing plants (Leader and Cuthill, 2008). At times, processors of brand name products will also make private label products to utilize excess plant capacity (Ward et al., 2002). Typically, private label products aim to copy product concepts that were developed initially by brand name manufacturers. This allows the products to be produced with fewer research and development costs and allows retailers to sell items for which the product concept has already been tested as successful in the marketplace (Leader and Cuthill, 2008). This marketing strategy, along with the absence of slotting fees and lower sales force and advertising costs, allows private label products to be sold at lower prices than brand name products. On average, retailers generate 25–30 percent more profits on sales of private label products than brand name products (Private eyes, 2007).

Challenges to Introducing New or Reformulated Products with Reduced Sodium

There are a number of challenges to reducing the sodium content of processed foods. As mentioned in the description of the role of sodium in foods (Chapters 3 and 4), product taste, shelf life and safety, and other physical attributes of foods can change and become unacceptable if too much sodium is removed and not replaced with other functional ingredients. In addition, costs of reformulation are seen as prohibitive for some products. Further, certain types of products, such as organic products, may be limited in the types of sodium replacements that are allowed for use.[15] Of these challenges, food industry participants in the committee's public information-gathering workshop (March 30, 2009) cited concerns about

[15] 7 CFR § 205.600-606.

product taste and reformulation expenses as the main reasons for the lack of product reformulation.

Research has found that many consumers cite taste above other concerns, such as price and healthfulness, when making food choices (IFIC, 2008). Therefore, according to food industry representatives at the public information-gathering workshop held by the committee (March 30, 2009), manufacturers want to ensure that their products taste better than those of their competitors and that reformulated products maintain their likability so that market share is not lost to competitors who have not made similar changes.

Food industry representatives at the public workshop also said manufacturers fear that sodium reductions that create changes in product taste will result in a loss of market share to competitors' more flavorful products. In addition, manufacturers have experienced product failures in past efforts to market foods with claims of lowered sodium content. These products may have failed for a number of reasons, including the unwillingness of consumers to make the trade-off between the taste of these reformulated products and health, given the lack of immediate health results from consuming these foods (Wolf, 2009).

Cost of reformulation is another obstacle. While reformulation is a common event, it is usually done to reduce the cost of producing foods, and the savings derived from production cost reductions pay for the costs of research and development to make the reformulation possible (Kramer, 2002). Salt is a relatively inexpensive ingredient, so there may be few profits derived from reformulation. Further, if simple salt removal is insufficient, salt substitutes and other alternative ingredients may be needed, resulting in high reformulation costs, since these ingredients are usually more expensive than salt.[16] The same may be true for other sodium-containing compounds and reduction technologies (Ball et al., 2002; Cauvain, 2003). These factors create little financial incentive for manufacturers to take on the time-consuming and costly process of reformulation unless there are other market-driven reasons, such as demand from consumers or other market or social forces. New product development with lower sodium at baseline, however, may be less costly than reformulating existing products with established consumer taste expectations.

The Industry's Efforts to Reduce Sodium in Foods

The processed food and retailing industries have taken steps toward encouraging reductions in sodium intake. Other than complying with label-

[16] Available online: http://www.culinologyonline.com/articles/healthy-r-d-perspectives.html (accessed October 15, 2009).

ing regulations, which are described further in Chapter 7, such efforts have been voluntary and not adopted by all. Types of efforts include:

- marketing lower-sodium foods with label claims;
- marketing foods that have been silently reformulated to lower their sodium content;
- funding research to discover sodium substitutes and enhancers and other new technologies for lowering sodium in foods;
- providing information on sodium and healthy diets on packaging, in brochures, in advertisements, and on websites; and
- providing point-of-purchase nutrition rating information.

It is notable that the industry has used two different approaches to reduce the sodium content of the American food supply through reformulating existing products. The first approach is to make changes in the sodium content of products in order for those products to qualify for sodium content claims and then to market these items to consumers interested in reduced-sodium products. As previously discussed in Chapter 2, initial attempts to use low- and reduced-sodium claims did not see overwhelming success in the marketplace. This may be because consumers associate poor taste with low- and reduced-sodium foods (Heidolph, 2008; IFIC, 2009), which may be similar to the way that consumers demonstrated lowered expectations of the sensory properties of reduced-fat products (Kahkonen and Tuorila, 1998; Kahkonen et al., 1999; Tuorila et al., 1994.) Nonetheless, Campbell's (as described in Box 6-2) has recently used the claims approach to market a number of lower-sodium products and sees this approach as successful, according to a participant at the committee's public information-gathering workshop (March 30, 2009).

The second approach is to make gradual reductions that generally go unadvertised to the general public. Such reductions are commonly called "silent reductions" and are designed to lower sodium gradually so that regular consumers of the product will not notice the change and can slowly ratchet down their taste preferences for salt in the product (Wrick, 2009). As stated by industry representatives at the committee's public information-gathering workshop (March 30, 2009), many of the companies making silent reductions do so in hopes of avoiding losses in market share that sometimes occurred in past attempts to advertise reductions.

Given that some sodium reductions have occurred silently, it is difficult to produce a comprehensive review of the extent of sodium reductions over the past few decades. To fully catalogue all reductions that have taken place over the past 40 years, the industry would have to supply historical formulation information (especially for periods before sodium labeling was mandatory). While silent reductions have taken place for some foods, it appears that the reductions have not had a far reach across the food supply. The Center for Science in the Public Interest (CSPI), a consumer advocacy group, revealed that its tracking survey carried out since 1983 demonstrates only a 5 percent decrease in the sodium content of the foods tracked for the period 1983–2004 (CSPI, 2008).

In contrast to information about sodium content reduction, more information is available for the number of foods that have been marketed with a sodium content claim. As discussed in Chapter 2, the percentage of products with sodium content claims fluctuated between 5 and 13 percent from the early 1990s to 2007.[17] Throughout much of the 1990s, the number of new products introduced with sodium content claims dropped (CSPI, 2005). This decrease in the number of products with such claims may have been due to industry concerns that consumers viewed foods with a reduced-sodium content claim in a negative light, but it may have also been a result of the industry turning its attention to other nutrients of concern, such as fat. There has been a slight rebound in the number of products with sodium content claims in recent years, which may be a result of increased attention to sodium intake and/or more recent food science innovations that have made further reductions possible.

With renewed attention to salt and sodium reduction around the world, food manufacturers have created sodium reduction initiatives in recent years. These initiatives have been driven primarily by pressure from international initiatives to reduce sodium, such as the work taking place in the United Kingdom, petitions to FDA to reconsider the regulatory status of salt, and, most recently, the National Salt Reduction Initiative coordinated by New York City. These initiatives are described further in Chapters 2, 7, and 8 and Appendixes B and G. Examples of industry efforts in recent years are provided in Box 6-2. This list is by no means comprehensive and reflects only publicly available information, but it does provide a sample of the types of efforts being undertaken with renewed interest in sodium.

To aid their ability to make advertised and silent reductions in the sodium content of their products, leading food manufacturers have invested in research to find new technologies. Research includes work in-house as well as funding for universities, research centers, and ingredient company projects (Nestle Ltd., 2007).[18] As described in Chapter 3 and in this chapter, a variety of technologies have been developed to reduce levels of salt and other sodium-containing ingredients. Research to find replacements for sodium has not been as successful as research to find replacements for other nutritional components of health concern. For example, the sodium-reducing

[17] Personal communication, M. Brandt, FDA, December 17, 2008.

[18] Available online: http://www.senomyx.com/collaborations/ and http://www.monell.org/ (accessed October 27, 2009).

BOX 6-2
Examples of Recent Efforts by the Processed Food Industry to Reduce Sodium Intake

Campbell's expanded the number of foods marketed as lower in sodium from 24 in 2005 to 100 in 2009. Reductions included lowering sodium by 32 percent in its original tomato soup and offering 11 varieties of Pepperidge Farm reduced- or low-sodium breads. Efforts have also included reducing sodium levels in 45 soups (Khoo, 2009) and 100 percent of the V8 beverage portfolio[a] to those required for a healthy claim (≤ 480 mg) and reducing the sodium content of existing Healthy Request soup lines from 480 to 410 mg per serving.[b]

ConAgra reduced the annual sodium usage in its products by 2.8 million pounds over a period of several years, ending in 2007.[c] More recently, ConAgra announced plans to cut its overall sodium use by 20 percent by 2015, by reducing sodium in more than 160 products.[d]

General Mills instituted a sodium reduction plan across all of its business categories and has silently reduced the sodium levels in Progresso, Hamburger Helper, and Cheerios products (Wiemer, 2009), and has six reduced-sodium soups with 450–480 mg sodium per serving.[e] In its 2010 Corporate Social Responsibility Report, General Mills pledged to further reduce sodium in more than 600 of its products by 20 percent, on average, by 2015. The sodium reduction initiative represents about 40 percent of its products and covers 10 product categories.[f]

Kraft announced in March 2010 that it plans to reduce sodium by an average of 10 percent across its North American portfolio over the next 2 years, including reductions up to 20 percent in some products. Some sodium reductions have already occurred; since 2008 two Kraft Light salad dressings were reduced by more than 30 percent and all Oscar Mayer white turkey deli meat products by at least 15 percent. The company also has more than 100 products that are low, reduced, or no sodium.[g]

Nestlé set a worldwide policy to make reductions in all products with sodium contents greater than 100 mg/100 calories. Under this initiative, plans have been made to reduce sodium by 25 percent in each of these products over a 5-year period. Thus far, more than 15 million pounds of salt have been removed from products worldwide (Fern, 2009).

technologies invented or discovered thus far are not as useful as artificial sweeteners that can be used in a wide variety of applications to completely replace sugar. The lack of similar discoveries for sodium may have slowed the progress in developing more reduced-sodium products, although sodium reductions are possible without the use of salt replacements.

Food manufacturers and retailers have also directed their efforts toward providing health information about sodium to consumers. This is usually intended to lead consumers to purchase the manufacturer's lower-sodium products, but such efforts can also be a useful means of distributing health information to consumers. Historically, information has been included in advertisements, brochures, and product packaging. In more recent years, companies such as Campbell's Soup, Kellogg's, and General Mills have added information on sodium and health to their websites or sponsored more general nutrition and wellness websites.[19] Packaged food manufacturers have also provided sodium content information on the Nutrition Facts

[19] Available online: http://www.campbellwellness.com/subcategory.aspx?subcatid=3, http://www.kelloggsnutrition.com/know-nutrition/sodium.html, and http://www.eatbetteramerica.com/diet-nutrition/heart-health/try-a-sodium-shake-down.aspx (accessed October 12, 2009).

panel for many years as required by law. Retailers have also long played a role in distributing health information to customers, such as through store magazines and product pamphlets. Health and sodium content information is intended to educate consumers and provide them with tools they can use to help them reduce their sodium intake. However, as described in Chapter 2, such knowledge and tools like the Nutrition Facts panel have remained insufficient in reducing sodium content levels to those recommended by the *Dietary Guidelines for Americans*.

In recent years, some food manufacturers and retailers have begun using front-of-package and point-of-purchase nutrition rating systems to help consumers identify more healthful foods. Rating systems, including Smart Choices, which has postponed active operations,[20] Smart Spot,[21] Heart Check Mark,[22] the Choices Stamp,[23] and Sensible Solutions,[24] have been introduced by several manufacturers. For most front-of-package systems currently on the market, products receive only a logo indicating that they are a more healthful choice because certain nutrient requirements are met. Some programs have been developed by manufacturers to help market their own products. Other systems, such as the Heart Check Mark and Smart Choices, have been developed by outside organizations that license the use of the rating system to any manufacturer if the product meets nutritional requirements and the manufacturer pays a fee for its use.

Similarly, some retailers have recently begun efforts to help their customers make more healthful food selections by using nutrition scoring systems. Two of the systems being introduced to the market are NuVal and Guiding Stars. Both of these systems score foods based on a number of nutrition criteria, including sodium, and place that product's score along with its price on the product shelf tag.[25,26] These systems are different from front-of-package rating systems in that they are intended to rate all food products sold by retailers. While the primary goal of this system is

[20] Available online: http://www.smartchoicesprogram.org/index.html (accessed January 27, 2010).

[21] Available online: http://www.pepsico.com/Purpose/Health-and-Wellness/Smart-Spot.html (accessed October 15, 2009).

[22] Available online: http://www.americanheart.org/presenter.jhtml?identifier=2115 (accessed October 12, 2009).

[23] Available online: http://www.choicesinternational.org/index.php?option=com_content&task=view&id=30&Itemid=53 (accessed October 13, 2009).

[24] Available online: http://www.kraftfoods.com/kf/healthyliving/sensiblesolution/sensiblesolution_landing.aspx (accessed October 13, 2009).

[25] Available online: http://www.nuval.com/How (accessed February 11, 2010).

[26] Available online: http://www.guidingstars.com/what-is-guiding-stars/how-it-works/ (accessed February 11, 2010).

to educate consumers, a side benefit may be efforts by manufacturers to reformulate foods in order to achieve a higher rating.[27]

Front-of-package and shelf tag scoring systems vary in their thresholds and scoring methods for the content of sodium and other nutrients, which has created debate within the nutrition community as to whether the nutrient criteria are adequate. There have also been questions about the effectiveness of these programs in helping consumers make positive dietary changes. As a result, FDA recently announced steps to address the use of front-of-package and shelf label claims concerning the nutritional quality of a food.[28]

It is clear that food manufacturers and retailers have taken some steps to help the American public reduce sodium intake; however, such efforts have been limited. Not all companies have dedicated resources to this concern, and the intensity of sodium reduction efforts appears to have fluctuated over time.

PRODUCTION AND DELIVERY OF RESTAURANT/ FOODSERVICE FOODS WITHIN THE FOOD ENVIRONMENT

Characteristics of the Restaurant/Foodservice Industry

The restaurant/foodservice industry plays a major role in providing food to the U.S. population. As described in Chapter 5, the amount of food eaten away from home has grown in recent years and now accounts for 48.5 percent of total food expenditures[29] in the United States and one-third of the calories consumed by Americans (Lin et al., 1999). Estimates from the National Restaurant Association indicate that in 2009, more than 130 million Americans per day consumed restaurant/foodservice items from 945,000 restaurant/foodservice locations throughout the country.[30]

The U.S. Department of Agriculture (USDA) defines foodservice as the dispensing of prepared meals and snacks intended for on-premise or immediate consumption (Harris et al., 2002). The committee considers this definition to include "take-out foods" that are consumed in the home or another location outside the restaurant/foodservice establishment and to

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[27] Available online: http://www.examiner.com/x-1943-Fitness-Examiner~y2009m7d13-GuidingStars?cid=exrss-Fitness-Examiner and http://www.journalgazette.net/article/20090503/NEWS10/305039938/1031/BIZ (accessed October 13, 2009).

[28] Available online: http://www.fda.gov/Food/LabelingNutrition/LabelClaims/ucm187369.htm (accessed October 27, 2009).

[29] Available online: http://www.ers.usda.gov/Briefing/CPIFoodAndExpenditures/Data/Expenditures_tables/table10.htm (accessed July 30, 2009).

[30] Available online: http://www.restaurant.org/pdfs/research/2009Factbook.pdf (accessed June 28, 2009).

BOX 6-3
Types of Restaurant/Foodservice Operations as Classified by the National Restaurant Association

Full-service restaurants
- Family dining full-service restaurants
- Casual dining full-service restaurants
- Fine dining full-service restaurants

Limited service (quick-service) restaurants
- Quick-service (fast food) restaurants
- Quick-casual restaurants

Cafeterias, grill-buffets, buffets
Social caterers
Snack and nonalcoholic beverage bars
Bars and taverns
Foodservice contractors
Mobile food services

SOURCE: Personal Communication, M. Sommers, National Restaurant Association, Washington, DC, September 22, 2009.

exclude foods purchased at supermarkets, grocery stores, and other retail establishments, except for "fresh, prepared, deli foods" purchased from retailers or foods from quick-service establishments located within retail stores.

Restaurant/foodservice operations range from those that serve foods consumed on premise to those that sell ready-prepared foods for "carry out," and from multibillion-dollar restaurant chains and contract foodservice companies to upscale dining restaurants as well as independent "mom-and-pop" eateries and mobile wagons on street corners. Box 6-3 lists restaurant/foodservice operations as classified by the National Restaurant Association.[31] Definitions of each of these restaurant/foodservice categories are provided in the glossary (Appendix A).

Restaurant/foodservice operations include both commercial and non-commercial establishments. As shown in Figure 6-3, the majority of restaurant/foodservice sales in the United States is by commercial establishments (National Restaurant Association, 2008). The leading restaurant

[31] Personal communication, M. Sommers, National Restaurant Association, September 22, 2009.

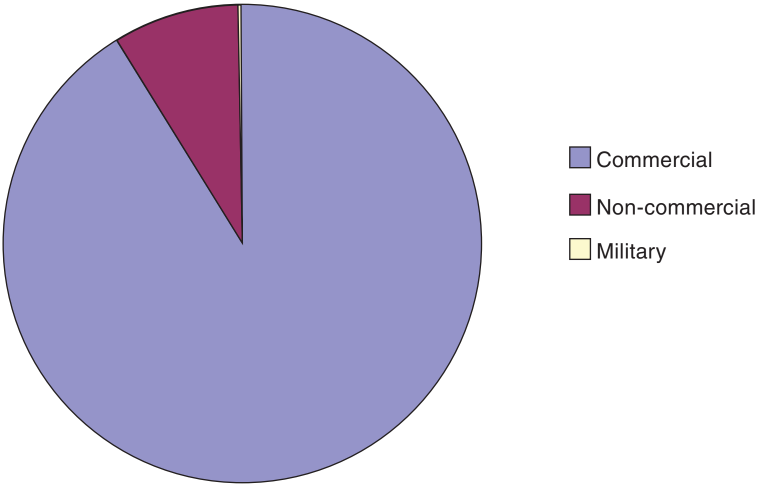

FIGURE 6-3 Restaurant/foodservice sales in 2008.
SOURCE: National Restaurant Association, 2008.

Figure 6-3.eps

TABLE 6-6 Top Restaurant/Foodservice Companies

Company Name	2005 Sales (billions of U.S. dollars)
McDonald's Corp.	26.9
Yum! Brands	17.4
Wendy's International, Inc.	8.0
Burger King	7.9
Doctor's Associates, Inc.	7.2
Starbucks Corp.	5.8
Darden Restaurants, Inc.	4.8
Allied Domecq	4.5
Applebee's International, Inc.	4.2
Brinker International	4.2

SOURCE: Martinez, 2007.

companies, as reported by Martinez (2007) on the basis of sales, are shown in Table 6-6, with the top companies reflecting fast food operations. According to USDA estimates, full-service and fast food restaurants account for more than 77 percent of away-from-home food sales.[32]

Commercial operations are open to the public such as fast food and fine dining restaurants. Commercial operations can be further classified as in-

[32] Available online: http://ers.usda.gov/Briefing/FoodMarketingSystem/foodservice.htm (accessed August 1, 2009).

dependent or chain establishments (Walker, 2009). Independent operations are not associated with a national or regional brand or name, the owners usually play a role in the day-to-day operations of the facility, and they may have greater flexibility in the types of foods served than do chain restaurants. A company or individual may own multiple independent restaurants, but because each location operates with a different menu or concept for the dining experience, these restaurants are still considered independent establishments. In contrast, chain restaurants are a group of restaurants that have the same name and marketing strategy, and menu items that are generally standardized across locations (Walker, 2009). For these reasons, consumers expect the same food and service regardless of the individual location. According to the National Restaurant Association, 206,000 of the restaurant locations around the country are part of large chains with 20 or more units.[33] With multiple locations, chains generally serve far more customers and provide more meals than independent restaurants. While the definition of "restaurants" may vary among groups that track information about the nature of such operations, data from the consumer and retail market research information company NPD Group, as reported by Bassett et al. (2008), suggest that nearly three-quarters of all restaurant "traffic" nationally is represented by fast food chain restaurants.

In contrast to commercial establishments, non-commercial establishments are typically located in or contracted by organizations that are not focused on foodservice as their primary business. These operations include corporate and school cafeterias and foodservice kitchens for health-care facilities (Walker, 2009). Military feeding operations can also be categorized as non-commercial foodservice operations. Generally, non-commercial or institutional foodservice operations provide large quantities of a limited variety of menu options, some of which are not standardized and may be rotated on a daily basis. Some institutions have their own in-house foodservice staff; however, it is increasingly common for institutions to contract with a managed services company, such as Sodexo, Compass Group, and Aramark. These companies often cater to thousands of locations with varied food needs (Walker, 2009).

The National Restaurant Association (2008) in its annual sales reports for the entire restaurant/foodservice sector provides data on the basis of more specific subcategories. These include full-service restaurants ($181 billion); limited-service (fast food) restaurants ($157 billion); cafeterias, grill-buffets, and buffets ($5 billion); social caterers ($6 billion); snack and non-alcoholic beverage bars ($20 billion); commercial foodservice contractor/managed services ($38 billion); commercial lodging restaurants

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[33]Personal communication, M. Sommers, National Restaurant Association, Washington, DC, October 30, 2009.

($27 billion); non-commercial restaurant services ($47 billion); and military foodservice ($2 billion). While these data relate to total volume of sales, they cannot be interpreted relative to the number of people consuming food at these locations or the relative contribution each makes to total sodium intake.

Menu and Menu Item Development

Menu and menu item development is part of the operations of any restaurant/foodservice establishment, regardless of its size. Menu development is the process of determining what types of foods will be offered at the establishment (Walker, 2009), and menu items are discrete, prepared foods that are listed on restaurant/foodservice menus with a price. Menu items may include appetizers, entrées, and desserts, as well as "combos," "sides," and beverages. A menu or menu item may also include "extras" or "options" for which an additional charge may or may not be made—for example, with multiple sandwich ingredient options or buffet options.

Developing menus and menu items is a complex task in which restaurant/foodservice operators consider multiple, competing concerns, including consumer needs and desires, staff skills, kitchen facilities' capacity, availability of ingredients, costs of ingredients and production, and nutrient content of foods (Thomas, 2007; Walker and Lundberg, 2005). These concerns and others are shown in Figure 6-4.

Menu development decisions include determining how many items to offer as well as deciding the characteristics of such items (Walker and Lundberg, 2005). For example, decisions may involve determining how many chicken, fish, and vegetarian options to offer or how many fried items to include versus (presumably) more healthful steamed items. Menu expansion to include more offerings can provide consumers with more options that may allow them to make more healthful choices, but it may also result in increased costs and management concerns for the restaurant/foodservice operation (Lattin, 2009). Menu item development is similar to processed food product development, in that it involves research to determine the best amounts and types of ingredient to use, as well as the best preparation techniques. Reformulation of existing menu items to improve nutrition or substitute an ingredient also requires research and development to ensure that the product can be prepared easily and will continue to be liked by consumers.

For independent operations, menu and menu item development decisions are typically made by owners or head chefs, and changes to the menu may occur frequently (Walker and Lundberg, 2005). New menu items can be created from scratch or from completely or partially prepared processed foods. Many menu items, for large and small operations, are assembled

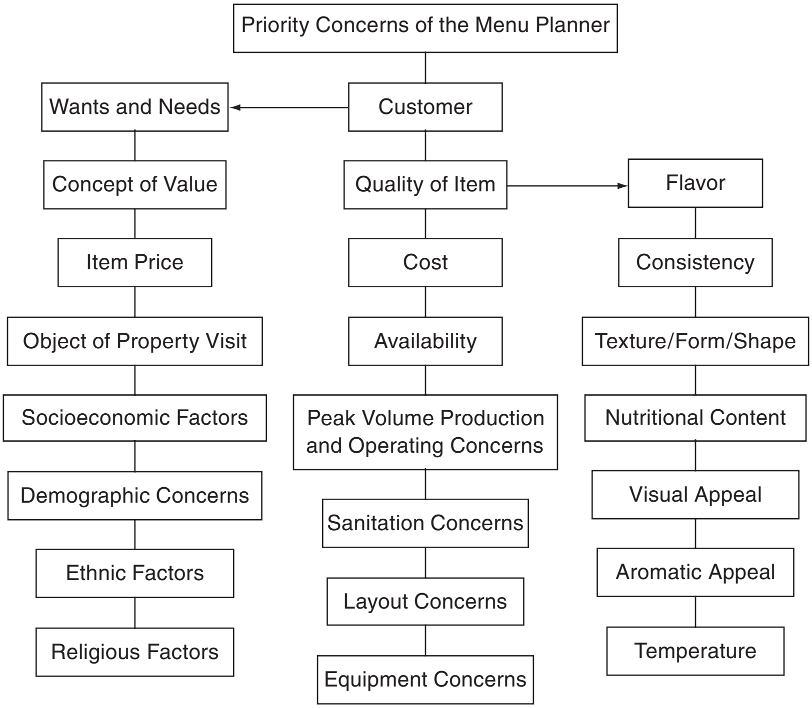

FIGURE 6-4 Priority concerns of the menu planner.
SOURCE: Lattin, 2009. Reprinted with permission.

from ingredients that have already been processed in order to facilitate quick preparation, ensure a uniform product, and reduce the need for skilled labor (Connor and Schiek, 1997). A participant at the committee's public information-gathering workshop (March 30, 2009) stated that in some cases, these items may be identical to processed foods sold to the public by retailers, but in other cases, these products are specially designed to meet the needs of restaurant/foodservice operations.

For large chains, menu and menu item development are more complex. Like large manufacturers, chains often employ marketing personnel (Lattin, 2009), corporate chefs, nutritionists, and food scientists to develop menus and menu items that will be successful and standardized across all locations (Thomas, 2007). This process often encompasses brainstorming ideas at the chain headquarters, testing the ideas with consumers, developing prototypes, and testing the new item in a limited market area before launching it across the entire chain (Walker and Lundberg, 2005). A recent survey of menu development executives at leading fast food and casual dining restaurants indicated that the top concerns when altering menus are how the changes will attract or maintain the customer base and how the changes will affect sales and profits (Glanz et al., 2007).

To develop and supply the exact ingredient or product they desire, large chains go through a product development process that is similar to that used to develop packaged foods for retail sale. In fact, large chains often establish relationships with food processors and suppliers to help develop and manufacture menu items (Connor and Schiek, 1997). For large chains, food processors may even develop proprietary recipes and produce standardized products exclusively for one company (Cobe, 2008). Because consumers expect menu items to have the same tastes, textures, nutrient content, and portion sizes regardless of the location at which they are purchased, chain restaurants work with their contracted manufacturers to create ingredient and preparation specifications to ensure a standard product (Walker and Lundberg, 2005).

Challenges to Introducing New or Reformulated Menu Items with Reduced Sodium

Introducing or changing menu items may be a challenging and time-consuming process regardless of the size of the restaurant/foodservice operation. Changes require efforts to ensure a sufficient supply of ingredients, revisions to printed menus or menu boards, and training for many food preparers with varied education and skill levels. Because of the costs of changing menus and menu items, restaurant/foodservice operations are unlikely to make changes to reduce the sodium content of their offerings unless such items are expected to generate profits (Glanz et al., 2007).

Some menu planners may believe that lower-sodium foods will be unsuccessful. A survey of more than 400 chefs found that only 39 percent believed that foods would taste good if they were designed to meet *Dietary Guidelines for Americans* recommendations (Reichler and Dalton, 1998). Along the same lines, a survey of menu developers from chains showed that these personnel believe that most customers are seeking an indulgent experience when they consume foods away from home and that the demand for more healthful foods is low. Even for menu planners who are interested in creating more healthful options, fat, calorie, and fruit and vegetable content are more top-of-mind issues than sodium content (Glanz et al., 2007). While redesigning menus and menu items to lower calories or include more fruits and vegetables may have the added benefit of reducing sodium content, this may not be the case for all items. In some cases, sodium content may not be reduced to the same extent or may even increase in the absence of menu planners who are concerned and knowledgeable about its health implications.

A related concern is the widely held reputation of salt among chefs and other food preparers as the preeminent ingredient for enhancing savory flavors (Dornenburg and Page, 2008) and flavors of foods (Nachay, 2008). Food preparers may lack knowledge of health concerns related to sodium (thinking, as many of their customers do, that sodium is a health issue only for certain individuals and therefore best handled on a special request or special menu selection basis) and may lack the skills to reduce sodium using a variety of preparation techniques or alternative flavor strategies.

Education may be useful at all levels of restaurant/foodservice operations to raise awareness of these issues. Trade groups, industry associations, culinary colleges and schools, and public health agencies are seen by menu planners as potentially valuable partners in providing information and tools to improve the health of their offerings (Glanz et al., 2007).

Another challenge for restaurant/foodservice operators related to reducing sodium may be the limited availability of lower-sodium ingredient options. As mentioned earlier, restaurant/foodservice operations use processed foods to reduce both preparation time and the need to train food preparers. Therefore, substantial amounts of sodium may be coming from sources outside of the direct control of the restaurant/foodservice operator. Restaurant/foodservice operations typically purchase foods from foodservice distributors. The foodservice distribution sector is dominated by a few multibillion-dollar companies (e.g., Sysco and U.S. Foodservice).[34] Such a concentrated supplier market could limit the restaurant's ability to procure lower-sodium options if they are not carried by distributors; however, it also offers the ability to target suppliers with education and outreach on the importance of carrying lower-sodium products. For large chains, another challenge is the time delay related to introducing new items. When a new product is introduced by a large number of chain outlets, there can be a spike in demand for ingredients (Connor and Schiek, 1997), and a lag time may be needed for suppliers to produce sufficient quantities to meet this new demand.

Yet another challenge for the restaurant/foodservice industry is the regular practice of aggregating high-sodium, high-flavor ingredients to create memorable taste and flavor experiences for its patrons. Examples are numerous and include such popular sandwiches as the double-bacon cheeseburger and breakfast specials that combine multiple meats and cheeses. Like the supersizing of portions, which is associated with increases in sodium intake, this marketing and menu development strategy will be harder to unwind than to create. Finally, the extent to which the restaurant/foodservice

[34] Available online: http://www.hoovers.com/company/SYSCO_Corporation/rrctyi-1.html and http://www.hoovers.com/company/US_Foodservice_Inc/cfthci-1.html (accessed November 20, 2009).

industry offers "customized" menu options to its patrons, even in so-called standardized menus of chain restaurants, creates something of a moving target, making it difficult to know exactly what sodium levels patrons are choosing and how to adjust accordingly. Some restaurant/foodservice businesses, such as buffet restaurants or "build-your-own" burrito, sandwich, or salad operations, are nearly completely about options, with just a few suggested combinations to help guide the customer.

The Industry's Efforts to Reduce Sodium in Foods

The abovementioned challenges are obstacles to reducing sodium in menu items and are likely reasons why the committee was unable to find much evidence that reducing sodium in foods has been a major initiative of the restaurant/foodservice industry in the past. This is not to say that individual restaurant/foodservice companies have not made efforts to lower sodium across their menus or to provide lower-sodium options.

More recently, there have been movements to give health concerns increased consideration during research and development—shifting the paradigm that taste, flavor, and consumers' desires are the sole drivers to research and development (Scarpa, 2009). A few specific examples of recent industry efforts, although not a comprehensive list, are provided in Box 6-4.

As consumer interest in more healthful foods grows, corporate chefs and other menu decision makers are adding more whole grains, fruits and vegetables, and other more healthful fare to their menus (Berta, 2006; Maes, 2008; Ram, 2009; Weisberg, 2006). Conferences such as Worlds of Healthy Flavors, sponsored by the Culinary Institute of America and the Harvard School of Public Health, have helped support such actions by educating restaurant/foodservice leaders about diet concerns and techniques for improving the nutritional quality of menus and menu items (Hayden, 2004).

To improve awareness and encourage more restaurant/foodservice companies to reduce the sodium content of their offerings, the National Restaurant Association held a conference for industry leaders in 2008.[35] Trade magazine articles report that chefs are experimenting with altering ingredients and preparation steps to enhance the flavors of menu items so that less salt can be used (Berry, 2009; Ram, 2008).[36]

There have also been efforts to provide consumers with more infor-

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[35] National Restaurant Association, 2008. Available online: http://www.restaurant.org/pressroom/pressrelease.cfm?ID=1635 (accessed December 12, 2008).

[36] Restaurants and Institutions, 2009. Available online: http://www.rimag.com/article/CA6704106.html (accessed February 11, 2010).

BOX 6-4
Examples of Recent Efforts by the Restaurant/ Foodservice Industry to Reduce Sodium Intake

Aramark has introduced a menu icon system to inform consumers of menu items that are considered more healthful choices. For a menu item to receive a *Heart Healthy* icon, it must contain 480 mg of sodium or less.[a] Aramark offers lower-sodium foods in elementary school cafeterias[b] and has committed to meet the Institute of Medicine's (IOM's) sodium standards through a 5 percent annual reduction over the next 10 years as part of a White House initiative on childhood obesity.[c]

Burger King has introduced several reduced-sodium items and meals in recent months, including reformulated chicken tenders, chicken sandwiches, and multiple kids' meals with 600 mg of sodium or less.[d]

Chartwells School Dining Services, as part of a White House initiative on childhood obesity, plans to meet IOM's sodium standards over the next 10 years by pursuing discussions with suppliers to develop products that meet the standards.[e]

Compass Group has a menu icon system to inform consumers that certain menu items are more healthful choices. Two of the icons have requirements for sodium: the *Fit* icon (600 mg of sodium or less) and the *Reduced Sodium* icon (servings must have 25 percent less sodium than the original version).[f] In order to use the icon system, chefs and managers must complete a 10-hour web-based nutrition program and answer test questions with 100 percent accuracy, and chefs must complete a day-long, hands-on training that includes reduced-sodium production techniques, which they then teach to others in their units.[g]

ConAgra announced in January 2008 that it would offer all of its Chef Boyardee foodservice products with lower sodium content. The new line of canned pasta products contain fewer than 820 mg of sodium per serving.[h]

Denny's recently made 20–25 percent reductions in the sodium content of its hash browns, shrimp skewers, and cheese sauce and has plans to make additional modifications to items it provides as part of its "Better for You" and children's menus (Scarpa, 2009).

Jason's Deli reduced the sodium in kids' meals by more than 20 percent in 2009.[i]

mation about the nutrient content of restaurant/foodservice items. Chain restaurants often provide nutrition information, including sodium content, on brochures, menus, websites, or tray liners. Some restaurants are also experimenting with adding nutrition information on purchased items to customer receipts.[37]

[37] Available online: http://www.chainleader.com/article/CA6694989.html?q=menu+labeling (accessed November 16, 2009).

McCain, a food manufacturer that produces foodservice items, recently introduced reduced-sodium oven-roasted potatoes and Smiles fries for kids.[j]

McDonald's provides information on small changes in ordering that can reduce sodium and has a list of foods that are lower in sodium on the company website.[k]

Sodexo introduced Your Health Your Way meals in mid-2009. These meals must contain less than 800 mg of sodium.[l] Sodexo and its U.S. industry partners also recently committed to working toward meeting the IOM's sodium standards through a 5 percent annual reduction over the next 10 years as part of a White House initiative on childhood obesity.[m]

Souplantation/Sweet Tomatoes began testing lower-sodium versions of some soups in 2008 (Cobe, 2008).

Subway provides tips on reducing sodium intake on the company website.[n]

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[a] http://www.diningstyle.com/just4u.htm (accessed July 21, 2009).
[b] http://www.rimag.com/article/CA6704106.html (accessed November 16, 2009).
[c] http://www.aramark.com/PressRoom/PressReleases/Michelle-Obama-Childhood-Obesity.aspx (accessed March 23, 2010).
[d] http://investor.bk.com/phoenix.zhtml?c=87140&p=irol-newsArticle&ID=1292656&highlight= (accessed October 24, 2009).
[e] http://www.csrwire.com/press/press_release/28857-Chartwells-Joins-White-House-Campaign-to-Eradicate-Childhood-Obesity (accessed March 23, 2010).
[f] http://www.cgnad.com/default.asp?action=article&ID=308 (accessed July 22, 2009).
[g] http://www.cgnad.com/default.asp?action=article&ID=323 (accessed February 11, 2010).
[h] http://www.conagrafoodservice.com/NPRList.do?nprId=2 (accessed October 24, 2009).
[i] http://www.rimag.com/article/371966-Consumers_Favorite_Sandwich_Spots.php (accessed February 11, 2010).
[j] http://www.monkeydish.com/2008100125393/buying-stories/potatoes-spud-story.html (accessed November 16, 2009).
[k] http://mcdonalds.com/usa/eat/nutrition_info/simplesteps.RowPar.85506.ContentPar.26817.ColumnPar.62251.File4.tmp/finsimpstepsodium2.pdf (accessed October 24, 2009).
[l] http://www.yourhealthyourwayonline.com/about_frameset.htm (accessed October 24, 2009).
[m] http://www.sodexo.com/group_en/press/news/our-activities/100209-obama-fight-childhood-obesity.asp (accessed March 23, 2010).
[n] http://www.rimag.com/article/CA6706578.html?industryid=48493 (accessed November 16, 2009).

In general, it appears that efforts to help Americans reduce sodium intake have been less prominent in the restaurant/foodservice industry than in the food processing industry. This may be due to a lack of consumer pressure on restaurant/foodservice companies in past initiatives to reduce the sodium content of foods, in part because of the relatively limited nutritional information readily available to the public in these venues, and it may also be closely tied to the notion that it is a special occasion to consume meals at restaurants. Sodium reduction has been perceived by the industry as less of a priority than *trans* fat elimination, saturated fat reduction, the addition of whole grains, the use of more fresh fruit and vegetables, and perhaps even other challenges, such as portion sizes and the perceived overreliance on sales of soda and other sugary beverages.[38]

LARGE-SCALE GOVERNMENT FOOD PROCUREMENT AND FOOD ASSISTANCE PROGRAMS

Federal government agencies as well as state and local governments are providers of food and should not be overlooked as part of the food environment. Various government programs procure food for their own restaurant/foodservice operations or provide assistance to allow others to do so. These programs range from food purchases for military operations to foods sold in vending machines in city parks. Because of the large scale of such operations, they warrant consideration in regard to strategies to reduce sodium intake.

As shown in Table 6-7, there are a number of federal programs that use government funds for the purchase of food (GAO, 2000).

The committee focused on four programs that reflect the spectrum of possibilities: a reimbursement program (the National School Lunch Program and School Breakfast Program), two assistance programs (the Supplemental Nutrition Assistance Program [SNAP] and the Special Supplemental Nutrition Program for Women, Infants, and Children [WIC]), and one direct procurement program (the military). Each federal program may have different abilities to institute sodium reduction efforts, given its purpose, operating constraints, and reach. It is notable that sodium intake has been a concern for some federal programs, and, as described below, limited efforts have been taken to reduce sodium in some programs.

National School Lunch Program and School Breakfast Program

Operating under the aegis of the Food and Nutrition Service of USDA, the National School Lunch Program and the School Breakfast Program provide meals for the nation's children. The National School Lunch Program offers nutritious lunches in 99 percent of U.S. public schools and in 83 percent of private and public schools combined (Fox et al., 2004). The School Breakfast Program offers breakfasts in approximately 85 percent of public schools that offer the National School Lunch Program (Gordon and Fox, 2007). In fiscal year (FY) 2009, an average of 31.2 million schoolchildren participated in the National School Lunch Program on each school day,

[38]Personal communication, G. Drescher, Culinary Institute of America, St. Helena, CA, November 2009.

TABLE 6-7 Federal Agencies and Programs That Directly Purchase, Use, or Set Standards for Food Purchases

Agency	Program
Department of Agriculture	National School Lunch Program School Breakfast Program Supplemental Nutrition Assistance Program (SNAP) Summer Food Service Program Child and Adult Care Food Program Commodity Supplemental Food Program Food Distribution Program on Indian Reservations Nutrition Program for the Elderly The Emergency Food Assistance Program Food Assistance for Disaster Relief Fresh Fruit and Vegetable Program Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) Nutrition Services Incentive Program
Department of Defense	Regular feeding of troops Fresh Fruit and Vegetable Program Defense Supply Center Philadelphia's Subsistence Directorate (link between the Armed Forces and the food industry, provides subsistence for military personnel and federal agencies worldwide)
Department of Justice (Bureau of Prisons)	Subsistence program purchases food for prisons
Department of Veterans Affairs	Food purchases for Veterans Affairs facilities
Department of Labor	Job Corps Center (provides training and employment for severely disadvantaged youths, generally in a residential setting)

SOURCES: Defense Logistics Agency (2009), http://www.dscp.dla.mil/ (accessed November 18, 2009); FNS (2009), http://www.fns.usda.gov/fns/ (accessed November 18, 2009); GAO, 2000.

and an average of 11 million children participated in the School Breakfast Program each school day (ERS, 2010). In FY 2008, participating schools served about 5.2 billion lunches at a cost to USDA of approximately $9.3 billion and about 1.8 billion breakfasts at a cost of $2.3 billion (IOM, 2009).[39] Schools receive per-meal cash reimbursements for the meals they serve to low-income students who meet certain qualifications. In addition, schools receive food from USDA's Commodity Distribution Program, which is intended to both supplement the per-meal cash reimbursements and support the agricultural economy during times of overproduction. Nationwide,

[39] Available online: http://www.fns.usda.gov/pd/annual.htm (accessed November 18, 2009).

about 1.9 billion pounds of food is distributed through the Commodity Distribution Program on a yearly basis.[40]

Currently, schools must offer meals consistent with the *National School Lunch* and *Child Nutrition Act Amendments*.[41] These regulations require that school meals provide a minimum percentage of the Recommended Dietary Allowance for calories, protein, iron, and vitamins A and C, while ensuring that total fat and saturated fat comprise less than 30 and 10 percent of calories, respectively. Under current regulations, it is recommended that schools work to decrease the level of sodium in the meals they serve, but no specific sodium levels are established (USDA/FNS, 1995). A recent IOM (2009) report focused on updating the nutrition standards to be more consistent with the *Dietary Guidelines for Americans*. The report recommends a gradual stepwise approach for reducing sodium in school meals in hopes of making changes indiscernible to participants and feasible for restaurant/foodservice operators and suppliers.

To help schools reduce the sodium content of meals, they are offered lower-sodium foods through the USDA's Commodity Distribution Program. In the past, the Commodity Distribution Program's Commodity Improvement Council conducted a review to identify potential reductions in fat, sodium, and/or sugar levels of products. Sodium modifications were adopted for 10 products. Significantly, however, other products were excluded from further change due to the belief that recipients would find additional modifications unacceptable (USDA, 1995). More recently, USDA has been looking to further decrease the sodium content of some of these products as well as various cheeses.[42]

USDA also encourages elementary schools to improve the nutritional content of the foods provided to children through the HealthierUS School Challenge. Started in 2004, the program encourages and recognizes changes in the school nutrition environment, including providing lower-sodium foods to school-age children and youth. The criteria reflect the 2005 *Dietary Guidelines for Americans* and require foods to contain < 480 mg of sodium per non-entrée or < 600 mg of sodium per entrée to receive recognition. A gold award of distinction, the highest level of recognition, is awarded if non-entrées contain < 200 mg of sodium and entrées contain < 480 mg.[43] So far, 275 schools have earned lower levels of recognition. However, only

[40] Available online: http://www.fns.usda.gov/cga/FactSheets/Commodity_Foods.pdf (accessed November 24, 2009).

[41] Public Law 94-105, 1975.

[42] Personal communication, R. Orbeta, USDA Food and Nutrition Service, November 10, 2008.

[43] Available online: http://www.fns.usda.gov/TN/HealthierUS/all_chart.pdf (accessed November 16, 2009).

one school has received the gold award of distinction, demonstrating the difficulty in reaching stricter sodium levels.[44]

Supplemental Nutrition Assistance Program

SNAP (formerly known as Food Stamps) is overseen by USDA. This program is designed to supplement the purchasing power of low-income families in hopes of helping them maintain a nutritious diet (GAO, 2008). On average, more than 33 million people participated in the program in 2009 and received approximately $50.4 billion in food benefits.[45]

Qualification for benefits is based on income—one's gross household income must not exceed 130 percent of the federal poverty level, and net income cannot exceed 100 percent of the federal poverty level. Program recipients receive an Electronic Benefit Transfer (EBT) in the form of a card that operates like a debit card. Participants are provided a monthly EBT allotment, which is allocated by state agencies and can be used at the approximately 165,000 retailers that accept these benefits (GAO, 2008). SNAP has only a few limitations on items that can be purchased using its benefits, such as food products that contain alcohol or tobacco, vitamins and supplements, and foods sold hot at the point of sale are not eligible.[46]

Recently, there has been more interest in encouraging more healthful food purchases using SNAP funds, and it has been recognized that the size of SNAP offers an impressive opportunity to promote dietary change. The 2008 Farm Bill provided $20 million in mandatory funding for a project to test point-of-purchase incentives for healthful foods in SNAP and authorized appropriations for similar projects.[47] In addition, the Government Accountability Office (GAO, 2008) reviewed what is known about the effectiveness of financial incentives for purchasing healthful foods and provided a discussion of options available to implement financial incentives in SNAP. The committee is not aware of any efforts to include sodium in such initiatives, but it may be possible to do so.

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[44] Available online: http://www.fns.usda.gov/TN/HealthierUS/silvergoldtn.html (accessed November 24, 2009).

[45] Available online: http://www.fns.usda.gov/pd/SNAPsummary.htm (accessed October 15, 2009).

[46] Available online: http://www.fns.usda.gov/FSP/retailers/pdfs/eligibile_foods.pdf (accessed October 15, 2009).

[47] Available online: http://www.fns.usda.gov/FSP/rules/Legislation/about.htm (accessed October 15, 2009).

Women, Infants, and Children Feeding Program

USDA's WIC program is designed to provide nutritious foods to supplement the diets of low-income pregnant, postpartum, and breastfeeding women and children ages 5 years or under.[48] In 2009, more than 9.1 million Americans received WIC benefits, and more than $4.6 billion in food purchases were made by the program.[49]

Unlike SNAP, which, with few exceptions, provides funds for the purchase of most foods, the WIC program allocates funds for certain kinds of foods. WIC benefits are generally provided as monthly checks or vouchers that are distributed through state agencies. These checks and vouchers can be used to purchase designated foods at retailers. A few state agencies also provide foods to participants directly through WIC warehouses and home distribution.[50] To receive benefits, WIC participants must have incomes less than 185 percent of the federal poverty guidelines and be determined to be at "nutritional risk."[51]

Currently, foods that qualify for purchase with WIC dollars are high in one or more of the following nutrients: protein, calcium, iron, and vitamins A and C. These requirements were established because populations that qualify for WIC often have deficiencies of these nutrients.[52] The WIC program has instituted limited requirements in an effort to promote healthful dietary choices with respect to sodium. In some, but not all, food categories, food must not exceed certain sodium levels or not have added sodium to qualify as a product that can be purchased with WIC vouchers (USDA/FNS, 2007).

Military

There are more than 1.4 million people on active duty in the U.S. military.[53] To feed military personnel, the U.S. military purchases more than $800 million in food (GAO, 2000).

The Defense Logistics Agency's Defense Supply Center in Philadelphia

[48] Available online: http://www.fns.usda.gov/wic/WIC-Fact-Sheet.pdf (accessed October 15, 2009).

[49] Available online: http://www.fns.usda.gov/pd/wisummary.htm (accessed October 15, 2009).

[50] Available online: http://www.fns.usda.gov/wic/WIC-Fact-Sheet.pdf (accessed October 15, 2009).

[51] Available online: http://www.fns.usda.gov/wic/WIC-Fact-Sheet.pdf (accessed October 15, 2009).

[52] Available online: http://www.fns.usda.gov/wic/FAQs/FAQ.HTM (accessed October 15, 2009).

[53] Available online: http://siadapp.dmdc.osd.mil/personnel/MILITARY/history/hst0903.pdf (accessed October 15, 2009).

is the central controller of military food procurement (Grasso, 2008). Procurement is currently handled by a prime vendor program in which a single vendor supplies all of the food products needed by military operations in a specified geographic region.[54] Prime vendors are often foodservice wholesalers that are contracted for 1 year with options to extend for additional years (ERS, 1998).

The military sets its own nutrition standards for active-duty personnel that are different from those developed for the general public, and it sets menu standards to help servicemen and servicewomen meet these nutritional requirements (Departments of the Army, Navy, and Air Force Headquarters, 2001). Since 1981, the Armed Forces Recipe Service has worked to ensure that the development of all new and revised recipes includes consideration of *Dietary Guidelines for Americans* recommendations. Throughout the 1980s and 1990s, a concerted effort was made to reduce both the salt and fat content of all military food recipes. Significant reductions in salt use were made for many recipes by modifying preparations, using different ingredients, or using smaller amounts of high-sodium ingredients. The degree of sodium reduction was determined by consumer testing, and changes were not incorporated unless adequate hedonic ratings could be maintained (Wollmeringer, year unknown). Attention to the salt content of military meals continues today. The Department of Defense Combat Feeding Program continues efforts to improve the healthfulness of new and revised recipes.[55]

STATE AND LOCAL GOVERNMENTS

Beyond federal programs, state and local governments are often relatively large purchasers of food. Local and state governments purchase foods or contract with restaurant/foodservice operators to supply the foods sold in employee cafeterias, correctional facilities, schools and child care centers, public hospitals, senior centers, parks, and numerous other facilities.

By instituting nutrition standards that include sodium criteria for all foods purchased with government dollars, local and state authorities can reduce the amount of salt consumed by their residents across a variety of environments, model more healthful eating, and potentially drive reformulation as companies respond to new product specifications. In September 2008, New York City put in place formal nutrition standards for all foods purchased or served by the city. These standards apply to the more than

[54] Available online: http://www.dscp.dla.mil/subs/pv/pvguide.pdf (accessed September 2, 2009).

[55] Available online: http://www.natick.army.mil/about/pao/pubs/warrior/02/novdec/healthy.htm (accessed October 15, 2009).

225 million snacks and meals served each year (New York City Department of Health and Mental Hygiene, 2008). They include restrictions on sodium through specifications of maximum levels allowed per serving for all products purchased and maximum sodium content levels allowed in meals served. The standards also make provisions for those locations providing for populations with specific nutritional needs, such as seniors and patients under therapeutic care. The standards are designed to be reviewed and revised regularly, taking into account updated nutritional guidelines and changes in food availability.[56]

Local and state governments have also been involved in establishing nutritional policies that apply only to select settings under their authority, such as schools, workplaces, and parks. A recent report surveying state school nutrition policies for foods outside of federally funded and regulated school meals identified only five states with policies in place restricting sodium for at least some grade levels (CSPI, 2007).

The introduction of nutrition standards for snacks and drinks sold in vending machines located on government-owned or government-operated property, most commonly schools and hospital systems, is another area of recent local government engagement. When nutrition standards (including sodium criteria) for foods sold in machines are incorporated into vending machine contracts, government further supports normalizing the consumption of lower-sodium foods.

Local and state governments can have considerable influence over a number of diverse food purchase and distribution locations. The introduction of nutrition standards, including sodium specifications, is an area of increasing activity and opportunity to influence population intake.

THE CONSUMER

Given the acknowledged failures to change sodium intake by setting strategies aimed largely at the consumer, it would be helpful if these outcomes could be better understood, set in context, and used to inform future efforts to better engage consumers in the role they must play in the future. Unfortunately, the lack of specific data in this regard relative to sodium intake is noteworthy. In discussions below regarding the consumer and the food environment, paradigms from related fields of study—including economic theory and health behavior theory—are highlighted as useful and can be applied to future work on sodium reduction targeted to consumers. But a specific analysis of reasons for the past experiences and outcomes relative to the interface between consumers and sodium intake reduction is

[56] Available online: http://www.cspinet.org/new/pdf/nyc_agency_food_standards.pdf (accessed November 18, 2009).

challenged by limited data. Conjecture and reaching beyond the data should be avoided, but several hypotheses can be outlined.

The consumer message that sodium is linked with hypertension has been consistent throughout the years. However, messages on who should reduce sodium, and best methods for reducing intake have shifted. Initially, messages most strongly encouraged higher-risk groups (e.g., African Americans and older adults) to reduce sodium, and use of salt at the table and during cooking was emphasized. As in most areas of emerging scientific research, as evidence became stronger that sodium should be a concern throughout the lifespan and as new data emerged on major sources of intake, messages were adjusted to include the entire population, and to encourage consumers to consume processed and restaurant/foodservice foods that were lower in sodium. It is reasonable to expect some consumers to be confused by—or even dismissive of—the slight change in messaging or to never adopt the revised message. This may have limited some consumer interest in reducing intake or in seeking information about how to best accomplish reductions.

Motivation may have also been a challenge. Some consumers may see hypertension as a commonplace, treatable condition in our society, and not recognize the serious ramifications of excess sodium intake. The low levels at which consumers recognize the potential for sodium intake to influence risk of heart disease, speak to this point. The channels used for dispersing sodium messages may have also been insufficient. In addition, it is possible that a portion of the population may simply be uninterested in health messages, and no amount of consumer messaging will motivate behavior change.

Sustainability of consumer interest and concern is another obvious problem. Although early public health initiatives increased awareness, concern levels, and intentions to alter sodium intake, these levels of awareness and concern subsequently declined. Competing messages in the food environment about the importance of a range of nutrients are likely to impact the sustainability of consumer interest and concern over sodium. The problem of public health messages competing for consumer attention is not unique to sodium.

The above mentioned factors cannot be documented and are largely hypotheses, but it seems apparent that even those personally concerned about sodium were also unable to reduce intake. The food supply undoubtedly played a key role in challenging such consumers, but it is also likely that consumer skills for interpreting the sodium content of their diet may have been lacking. Further, while the food industry did make a number of efforts to introduce lower sodium foods during the long history of sodium initiatives, many low-sodium products failed in the marketplace. Likely reasons for these failures were detailed further and include the lack of satisfactory sodium replacements and the possibility that the reductions needed to make label claims were relatively large and may have challenged manufacturers' abilities to make palatable products for consumers who generally have taste preferences tuned for saltier foods. As a result, consumers that did make an effort to try these products found them unacceptable and producers shied away from using such claims. In addition, there are those who would hypothesize that reformulation efforts to reduce other emerging nutrients of concern like fat and calories may have drawn the industry's focus away from sodium reduction. In fact, such efforts may have even discouraged active efforts to reduce sodium because salt is a useful ingredient for improving the taste and flavor attributes of reduced-fat and reduced-calorie products.

It would now be useful to carefully examine the factors that are important to motivating consumer change in the area of sodium reduction which, when coupled with the overarching effort to reduce the sodium content of the food supply, inform the activities needed to assist consumers in selecting diets more in line with overall sodium intake reduction. Understanding and working with the interface between consumers and the food environment is critical to the success of such efforts.

THE CONSUMER WITHIN THE FOOD ENVIRONMENT

Previous chapters of this report include discussions on the lack of success in motivating consumers to make dietary changes that result in meaningful sodium intake reduction. Such reductions could be perceived as requiring consumers to accept relatively unpalatable foods or make special dietary changes, such as increasing intake of fruits and vegetables or decreasing calories. To achieve even the highest recommended limit of sodium intake of 2,300 mg/d, the average adult would have to cut daily salt intake by at least one-third. In the current food environment, this would require complex and sustained behavior changes, such as tracking and adding the sodium content of all foods eaten over the course of a day and making other special dietary changes. Past initiatives placed considerable, if not the primary, burden on the consumer to act to reduce sodium intake. Going forward, the possibility has been raised that gradual changes in the food supply are likely to help consumers become acclimated to foods lower in sodium, especially if these reductions occur across a broad range of foods and thus significantly assist in lowering sodium intake. Even with a focus on changes in the food supply, it must nonetheless be recognized that consumers would still have a role to play in decreasing sodium intake, and efforts to promote changes in consumer behavior would be worthwhile.

Not surprisingly, a variety of factors influence consumers' food choices and actions to decrease their sodium intake. Studies of food choice behavior have identified both individual and environmental factors that shape the complex process of decision making (Bisogni et al., 2002; Booth et al., 2001; Devine, 2005; Drewnowski, 1997; Galef, 1996; Lutz et al., 1995; Nestle et al., 1998; Raine, 2005; Shepherd, 2005; Wetter et al., 2001). The social ecological model provides a useful framework for exploring these interacting influences across multiple levels—from the individual level of knowledge and attitudes, to social factors, to organizational and institutional factors, to macro-level factors such as the policies that influence the food supply (McLeroy et al., 1988; Story et al., 2008). This report focuses particularly on the pivotal role of the environment in consumer dietary patterns, with the food supply playing an obvious central role. The environment includes locations at which food is consumed, accessibility of foods (Burger et al., 1999), cultural traditions (Willows, 2005), and pricing (Hanson et al., 1994), as well as the information environment—for example, point-of-purchase labeling in restaurants or grocery stores. At the interpersonal or social level, food choices may be influenced by social networks, perceived norms, social support, and related social factors. At the individual level, when consumers are asked what is most important when choosing food, taste is the most likely response (Drewnowski, 1997). A variety of other individual factors also influence consumer food choices, including motivations, attitudes, and beliefs, as well as personal characteristics such as age, gender, education, and race/ethnicity (Bisogni et al., 2002; Booth et al., 2001; Devine, 2005; Drewnowski, 1997; Galef, 1996; Honkanen et al., 2005; Lutz et al., 1995; Nestle et al., 1998).

This section describes key considerations relevant to better understanding approaches to motivating consumers even within the context of changes in the food supply. To understand the multi-tiered food environment and the complex ways in which consumers interact with this environment, the committee applied the diverse disciplinary lenses of economic and behavioral theories, each of which frames discussions about consumer behaviors and food choices. These theories also guide considerations of two possible strategies for influencing consumer behaviors—warning labels (also referred to in this report as "special labeling/disclosure statements") and health communication campaigns—in the context of reducing sodium in the food supply. These theoretical perspectives provide further justification for an incremental approach to sodium reduction.

Applying Economic Theory to Sodium Intake Reduction

Economic theory provides a conceptual framework for how individuals and households make choices regarding food purchases, and ultimately food consumption, and the resulting implications for sodium reduction efforts. Consumers choose foods based on foods' characteristics (including salt taste) within the limitations of their budgets. Consumers must understand the importance of sodium reduction through education efforts so that this information can influence the level of satisfaction they obtain from consumption of foods. Furthermore, it would be helpful to reduce sodium using an incremental approach to assist consumers in adjusting their preferences for salt taste in foods. The price of foods with lower sodium content influences consumer choices and thus is also a factor affecting sodium reduction strategies. When considering consumers as part of households, changes in the way households allocate their time for food preparation have implications for sodium consumption because households are increasingly relying on processed and prepared foods from grocery stores and foods from restaurants and other foodservice operations. These changes in household time allocation make it more difficult for households to understand and control the sodium content of their diets and thus imply a need to change the sodium content of the food supply.

Consumer "Value" Associated with Food

The field of consumer theory suggests that consumers derive utility from the properties or characteristics of goods purchased and consumed. The term "utility" in this case means the satisfaction obtained from consuming a product, and the term "goods" would include foods. In the context of food choices, consumers derive utility from consuming individual foods depending on characteristics such as taste, nutrient content, calories, and sensory characteristics. Because the taste of some foods is derived from the presence of salt and because salt improves other flavors, salt taste and the presence of salt can be among the many characteristics of food from which consumers derive utility. Furthermore, goods consumed in combination possess characteristics different from those of the individual goods (Lancaster, 1966). Thus, foods may be combined or prepared in a way that alters the joint set of characteristics. In other words, a consumer may add salt to foods to alter their taste or may combine ingredients with varying levels of salt.

As with all types of goods, consumers faced with a set of food choices will choose a set of foods to maximize utility within the limitations of their budgets (Lancaster, 1966). Consumers consider the combinations of characteristics of different foods while making purchasing decisions. Thus, if consumers have optimized their food choices based on the existing set of characteristics, a noticeable change in the characteristics of foods might reduce their utility if there is no other type of compensating change. In the context of sodium content, a noticeable reduction in the salt taste of a food might decrease consumer utility unless there is a corresponding change in how consumers derive utility from consumption of foods. One possible method in which consumer utility functions may be altered is through consumer education efforts regarding the health effects of sodium consumption. This means, in essence, that an initially less palatable food may be accepted if the consumer wishes or is motivated to act on a health education message about the benefits of lower-sodium food. This may not, however, be necessary if the change in taste is minor or not readily perceived. It is important to note that in a recent consumer survey, when Americans were asked about the impact that convenience, healthfulness, price, and taste had on their decision to buy foods and beverages, taste was the highest ranked, the top choice by more than 80 percent of those surveyed (IFIC, 2008).

The value of each characteristic of a food can be estimated using a hedonic price function. Salt taste, as one characteristic, has an implicit value associated with it. Many analyses have estimated hedonic price functions for foods (Shi and Price, 1998), but they have not specifically addressed salt taste, a potentially positive attribute, or sodium content, a potentially negative attribute, in the analyses. Although specific values associated with salt taste and sodium content are not available in the literature, consumer theory suggests some considerations. Specifically, it will be essential for consumers to understand the importance of reducing sodium intake through education efforts that alter their utility functions. Furthermore, because consumers may understand the importance of reducing sodium intake but still have a preference for high salt content based on taste, existing consumer theory would support an incremental approach to adjusting taste preferences if possible. However, an inevitable unknown is specifically to what extent and at what speed salt taste preferences can be changed. This, in turn, suggests that efforts to encourage consumers to avoid certain practices, such as combining foods to enhance salt taste or automatically salting foods without tasting first, may be beneficial.

In addition to preferences for the characteristics of foods, food prices also influence consumer purchases. In general, most foods have inelastic price elasticities of demand (see, for example, Huang and Lin, 2000), which means that consumers are not very sensitive to changes in the prices of foods; they will reduce their purchases by only a small amount if the price increases. Low-income households tend to be more price sensitive than high-income households, but the differences are quite small (Lin and Guthrie, 2007). However, if prices of foods with lower sodium content are sufficiently higher than those with higher sodium content, consumer purchases of these foods can be substantially reduced even with relatively inelastic price elasticities of demand. Reduced-fat and reduced-sodium products often cost more than their regular counterparts (Frazao and Allshouse, 1996; Liese et al., 2007). A 1993 survey of 37 food categories found that nutritionally improved versions of foods in 81 percent of the surveyed food categories cost more than regular versions (Frazao and Allshouse, 1996).

From 2001 to 2004, between 24 and 34 percent of Americans cited the cost of healthful foods as a major reason for not eating as healthful a diet as they should (Food Marketing Institute, 2005). Data from 2004 indicate that cost is not just a concern for those with a low income; nearly 40 percent of shoppers with household incomes between $50,000 and $75,000 cite cost as a major barrier to a more healthful diet (Food Marketing Institute, 2005). Furthermore, foods naturally low in sodium often have higher prices. A survey of food prices from 1950 to 2007 found that real fruit and vegetable prices—foods that are naturally low in sodium when unprocessed—have increased since the 1950s even though general food costs have declined in recent decades (Christian and Rashad, 2009). Consumer education could play a role in informing consumers of the benefits of lower-sodium foods, thus increasing their demand for these foods (and their associated willingness to pay), and educating consumers on how to select lower-sodium foods within their budgets.

Household "Value" Associated with Food Preparation

Household production theory broadens the concept of consumer utility discussed above to address the fact that individuals within households are both utility maximizers and producing units. Households combine time and market goods to produce commodities for consumption. In this context, households maximize utility from consumption of goods, including foods, but are subject to not only the limitations of their budgets but also the limitations of their time. The full price of consumption includes the direct cost of purchasing a commodity and the indirect cost of time spent on production within the household (Becker, 1965). In the context of food, households purchase foods at various levels of preparation and apply time toward food preparation and consumption within the home or toward consuming meals away from home. Becker (1965) noted, in particular, that an increase in the value of a household member's time may induce that individual to enter the labor force and spend less time cooking by using precooked foods. Underlying the concept of production within the household is the level of human capital in the household for preparing foods (i.e., the knowledge and ability to prepare foods from raw ingredients) and also its preferences for certain goods and activities (Pollak and Wachter, 1975).

The trend over time has been for households to allocate more time toward working outside the home and less time to household production, particularly as more women have entered the workforce (Redman, 1980). As a result of this change, households purchase more prepared or convenience foods for use within the home and more away-from-home meals (Capps et al., 1985; Kinsey, 1983; McCracken and Brandt, 1987; Redman, 1980). When consuming prepared foods and food away from home, individuals have little control over the nutrient content, including the sodium content, of the foods they purchase. Although they can substitute among prepared foods and select foods with lower sodium content, they may lack the information or knowledge to do so. Prepared foods have nutrition labels stating sodium content, but the set of choices may all have relatively high levels of sodium. In addition, away-from-home meals are rarely labeled with sodium content, so individuals can only infer sodium content based on the type of food. Thus, as households have allocated less time to meal preparation in the home, they have ceded some degree of control over the foods they consume to food manufacturers and restaurant/foodservice operations.

It is also important to highlight the relationship between time allocation and changes in the food environment. As households have changed their allocation of time away from food preparation, the food environment has changed in response. Correspondingly, changes in the food environment have likely also facilitated changes in the way households allocate their time by reducing the time required to prepare foods and increasing the availability and ease of access to prepared foods and restaurant and other foodservice foods.

Between the 1970s and the 1980s the percentage of the household food dollar spent on food purchases away from home increased (Tippett et al., 1999). Total expenditures on food away from home increased within all racial/ethnic groups and at all income levels. Households with higher incomes spent more on food away from home than those with lower incomes. About one-third more Americans (57 percent total) ate away from home daily between 1994–1996 than between 1977–1978. The most likely age group to eat away from home were adolescent boys, whereas persons ages 60 years and older were the least likely. Sixty-five percent of persons with higher incomes ate away from home, while only 45 percent of those with lower incomes did so (Briefel and Johnson, 2004). Popular items consumed away from home include French-fried potatoes, sandwiches (especially burgers), lettuce salads (with salad dressings and other additions), pizza, and Mexican dishes—items that contain significant sodium. In 1994–1996 and 1998, 37 percent of adults and 42 percent of children consumed fast food. This was associated with significantly higher intake of sodium, energy, and fat, and significantly lower intake of fruits and vegetables (Paeratakul et al., 2003).

Consumption of larger portion sizes is common when foods are consumed away from home. National data from 1995 show that 34 percent of calories were consumed outside of the home, while only 27 percent of eating occasions took place away from home. This indicates that consumers either eat larger portions away from home or consume more energy-dense foods (Lin et al., 1999). Rolls (2003) found that consumers typically eat 30 to 50 percent more when offered large portions at restaurants. Continuing Survey of Food Intake by Individuals data from 1994 to 1998 show that fast food portions are often the largest compared to those prepared by full-service restaurants and those prepared in the home (Nielsen and Popkin, 2003). Zoumas-Morse et al. (2001) found that meals consumed at restaurants provided 55 percent more calories than meals from home. The larger portion sizes found at many restaurant/foodservice establishments combined with the sometimes higher sodium density of these foods may make meeting dietary recommendations for sodium intake a greater challenge for those consuming many meals away from home compared to those that have more control in the preparation of foods at home.

In summary, as households have changed the way they allocate their time for food preparation, and thus consume more foods away from home and from prepared grocery items, it has become more difficult for individuals to understand and control the nutrient content, including the sodium content, of their diets. The resulting implication is that changes in the food environment will be essential to allow individuals to purchase and consume lower-sodium foods.

Applying Health Behavior Theory to Sodium Intake Reduction

Behavioral theories provide guidance about the determinants of a given health behavior—in this case, reducing salt intake. Understanding these determinants is useful in planning strategies to promote change. There are many theories of behavioral prediction, although there is growing consensus about a limited number of variables needed for predicting behavior change (Fishbein, 2000; Glanz et al., 2008; IOM, 2002; Petraitis et al., 1995). Three prominent theories provide important guidance on these influences: social cognitive theory (Bandura, 1994); the theory of reasoned action (Ajzen and Fishbein, 1980; Fishbein et al., 1991); and the health belief model (Rosenstock et al., 1994). The committee draws from a summary of these behavioral theories presented in a prior IOM report *Speaking of Health: Assessing Health Communication Strategies for Diverse Populations* (IOM, 2002), recognizing that a wide array of resources are available that apply social and behavior theories to health behavior in general and, more specifically, to nutrition (Glanz et al., 2008; IOM, 2007; Story et al., 2008). Although the synopsis provided here simplifies the health behavior change process, it is intended to apply the guidance from social and behavioral theory specifically to salt intake.

Intention to change is a major predictor of behavior change. Generally, people are able to convey the probability that they will engage in a particular behavior, such as reducing salt intake, and their own estimate of the likelihood of behavior change is generally a leading indicator of actual change. Nonetheless, people do not always behave as they intend to behave.

The *environment* may pose unexpected barriers, although, alternatively, it may facilitate health behavior change. The lack of reduced-sodium food choices clearly constrains one's ability to limit sodium intake. Similarly, another barrier to changing health behaviors is the lack of *skills* to perform the behavior, for example, knowing how to read a nutrition label to choose lower-sodium products. If an individual has a strong intention to perform a given health behavior but is unable to perform that behavior, interventions may be focused on removing the environmental constraints or barriers and "skills training."

If individuals are not performing the behavior because of low intentions to do so, the intervention needs to focus on building intention to change. Behavioral change theories suggest that several key variables can directly influence the strength of intentions. First, *beliefs and attitudes* are important precursors to intentions to change behavior. Intentions to change behavior are strengthened when a person believes that performing the behavior will lead to positive consequences and prevent negative consequences ("outcome expectations"). In the case of sodium intake, changing attitudes may require strengthening beliefs that reducing salt intake will result in positive outcomes, such as lowering the risk of hypertension and coronary heart disease, and will not be related to certain negative outcomes, such as reducing the flavor of foods.

Second, intentions to change may be strengthened through *perceived norms*, defined as the degree to which a given behavior is seen as appropriate or normative within one's social network or society as a whole. These norms indicate the amount of social pressure one feels to perform the behavior. Family or peer social norms around sodium intake may be one important source of perceived norms. Third, intentions to change behavior may also be influenced by personal agency or *self-efficacy*, which reflects the belief that one can perform the behavior even when circumstances are not favorable.

Accordingly, effective communication interventions aim to remove or address environmental barriers to change; increase skills; and change intention, including through changing attitudes, norms, and self-efficacy. The relative importance of these variables depends both on the health behavior—here, reducing salt intake—and the intended population.

Use of Health Communication Campaigns

As noted previously in this report, prior health communication strategies have not been successful in their attempts to influence consumer salt intake, but they have made some progress in increasing awareness. In the context of recommended changes of sodium levels in the food supply, however, a coordinated effort to communicate the risks of sodium and increase consumers' motivation to reduce salt consumption may be a useful supplemental tool. The IOM report *Speaking of Health: Assessing Health Communication Strategies for Diverse Populations* (IOM, 2002), discussed above, also provides guidance on the application of social and behavioral theory to the design of health communication campaigns.

A first step in the development of a health communication campaign is to define the specific behavior targeted by the intervention—in this case, sodium intake of less than 2,300 mg/d. In the case of sodium intake, however, the committee recognizes that reduction does not rely exclusively on consumer actions, and reductions of sodium in the food supply may be the greatest contributor to overall reduction of sodium intake. Accordingly, the objectives for a health communication campaign may include increasing consumers' knowledge of the impact of sodium on health outcomes and the benefits of sodium intake reductions for all groups; building support for government actions to reduce sodium in the food supply; and building skills to make food choices in line with reductions in sodium intake.

Given that reductions in sodium intake are important across the lifespan, regardless of other risk factors, it is important that a campaign be developed for a broad audience. That said, the effectiveness of health communication messages can be increased by framing the messages according to the attitudes and beliefs of different audience segments. For example, campaign planners may develop different messages and delivery strategies for school-based interventions for children and adolescents, compared to messages to be delivered through health-care providers for persons diagnosed as hypertensive. In addition to developing different messages to different age groups, tailoring messages to specific cultural groups and dispersing these messages through communication channels that are known to reach specific groups, may be beneficial as it can assist these groups in identifying the specific food preparation and consumption behaviors that are the largest contributors to their sodium intake. This area has limited data and is not well researched. Furthermore, messages evoking positive emotions, as opposed to those evoking negative emotions (such as fear), may have a greater impact with the target audience (Monahan, 1995).

In developing the messages, it is important to consider the current beliefs of the intended audience. Hornik and Woolf (1999) note that beliefs to be targeted for change should be strongly related to intention to change or the behavior to be changed and should be feasible to be changed; in addition, it is important that there be a sufficient part of the population who do not already hold the belief to warrant trying to change it. For example, as discussed in Chapter 2, one belief to be addressed in a communication campaign may be the belief that sodium intake is associated with increased risk of high blood pressure and heart disease; only 40–50 percent of consumers are aware of this relationship between sodium intake and hypertension, and the percentage who are aware of the relationship to heart disease is even lower. Focusing on the health implications of sodium reduction may contribute to raising the salience of personal efforts to reduce sodium and contribute to normative support for changes in the sodium content of the food supply. In addition, it may be important for a communication campaign to increase awareness of one's own sodium intake. About 40 percent of the U.S. population feels that action to reduce sodium is not necessary, although results from USDA's Diet, Health and Knowledge Survey reviewed in Chapter 2 indicate that the levels of sodium intake appears to be comparable regardless of personal perceptions of need for change. A health communication campaign in the context of reductions of sodium in the food supply may additionally have positive impacts on self-efficacy; consumers may feel more confident in their ability to reduce sodium intake with increased availability of good-tasting, lower-sodium food options.

Use of Special Labeling/Disclosure Statements

As a step in the behavior change process, it is important that consumers have information available to make informed choices in food selections. Special labeling/disclosure statements placed on food packages provide one such source of information. These statements can be grouped as disclosures, reminders, and education.[57]

Although it has long been established that warning messages are an important method for potentially informing and reminding consumers about harms associated with products (HHS, 1987; Mayer et al., 1991; Morris et al., 1977), it is not clear what makes a warning effective and there are many unknowns that are unique to specific messages (Lehto and Miller, 1986). This suggests that the decision to proceed with special labeling/disclosure statements for a particular situation or product requires targeted study to determine how to not only frame the message but also measure its intended as well as unintended effects.

Stewart and Martin (1994), as part of a review of the intended and unintended consequences of warning messages, conclude that warnings inform rather than convince consumers; as a result, consumers heed only some of the messages. They caution that research suggests that warning messages can be rendered ineffective by frequent use and so-called reactive behavior caused by misinterpretation of the purpose of the message. Overall, the authors conclude that there is a need for caution in the design of warning messages because of the multiple effects of such messages and variation in responses among different groups of consumers. They also suggest that the design of warning messages should be informed by empirical research,

[57]Personal communication, A. Levy, FDA, 2009.

rather than expert opinion or judgment. The available literature suggests that risk in the context of consumer products is difficult to communicate and comprehend, for both consumers and experts. There are many ways to conceptualize risk, and while many are considered appropriate and defensible, it is established that they can lead to very different behavioral outcomes (Stewart and Martin, 1994).

Available research in this area has tended to focus on surveys designed to measure attention to a warning, perceived credibility of the messages, or awareness of warning information (Kimmerling, 1985; Lehto and Miller, 1986). Such measures, although useful, are incomplete because exposure and attention do not ensure that the warnings are perceived as credible, nor do they provide insight about whether and under what circumstances consumers will alter their attitudes, decision making, or behavior in response to warnings (Stewart and Martin, 1994).

Putting It All Together: Embedding Health Behavior for Sodium Intake Reduction Within the Broader Food Environment

In the case of sodium, removal of the environmental constraints to health behavior change is a critical first step. As stated above, with their growing reliance on processed and prepared foods, consumers have diminishing control over the amount of salt they consume.

The need for a population-wide reduction strategy rests on the massive scope of the high blood pressure epidemic, documented in prior chapters, and the limited success of individual-based sodium reduction interventions. Such interventions have been notoriously difficult to implement, especially in the setting of the current food supply, which is replete with "hidden" salt. In clinical trials, intensive interventions that focused only on salt reduction were able to shift mean intake to approximately 100 mmol/d (2,300 mg/d) (see left panel of Figure 6-5). When efforts to reduce sodium intake were combined with weight loss or part of a comprehensive lifestyle intervention program, sodium reduction was more modest (see right panel of Figure 6-5), likely because of the complexity of making multiple lifestyle changes and potential trade-offs when there are multiple goals (Appel, 2008).

Thus, it is unlikely that the average consumer will be able to successfully reduce sodium intake without changes to other components of the food environment. Changes at the policy level diminish the need for individual action to reduce sodium in the diet, which is of particular importance because, as documented in Chapter 2, the benefits of sodium reduction can accrue regardless of age or risk level. This approach to reducing risk at the source of exposure has been a long-standing cornerstone of public health practice (Winslow, 1984). In the case of sodium reduction, changes in the food supply could be aimed at reducing risk at the source of possible expo-

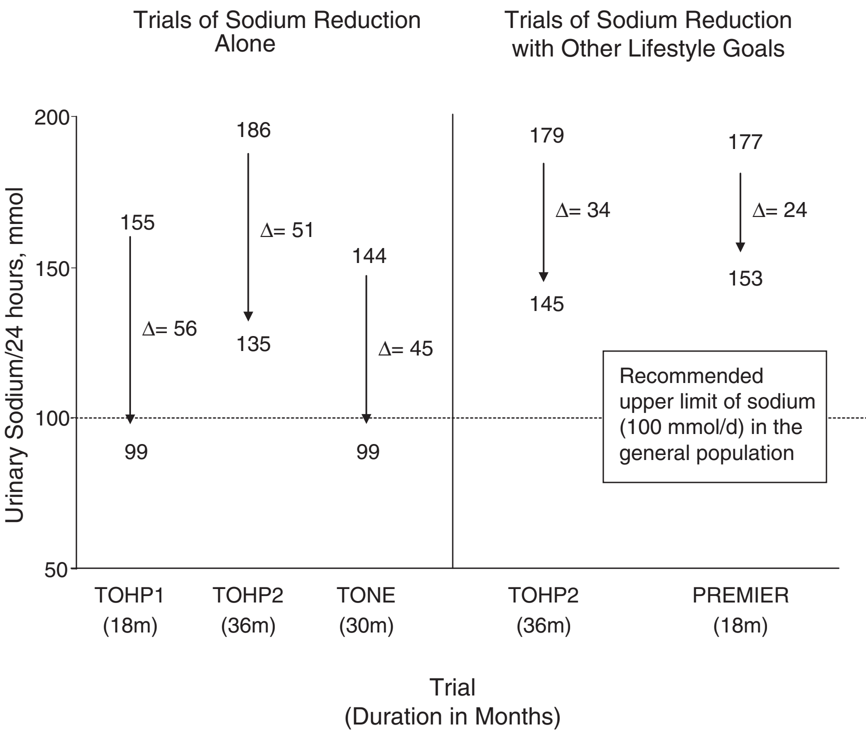

FIGURE 6-5 Mean pre- and post-levels of urinary sodium excretion in three trials (Trials of Hypertension Prevention Phase 1 and 2 [TOHP1 and TOHP2] and Trials of Nonpharmacologic Interventions in the Elderly [TONE]) that tested interventions focused only on salt reduction (*left panel*) and two trials (TOHP2 and PREMIER) that combined sodium reduction with other lifestyle interventions (*right panel*).
NOTE: d = day; mmol = millimole.
SOURCE: Appel, 2008. Copyright © 2008 *Journal of Clinical Hypertension*. Reproduced with permission from John Wiley & Sons, Inc.

sure. Policy changes to increase the content of nutrients such as folic acid and niacin have been highly effective in improving the nutritional status of the U.S. population with respect to these nutrients (Park et al., 2000; Pfeiffer et al., 2007). Monitoring and surveillance activities were critical to documenting folate's effectiveness and potential safety concerns (Lucock and Yates, 2009). However, sodium presents some unique challenges that were not encountered in these earlier policy issues, making effective monitoring and surveillance systems even more critical for implementing sodium reduction strategies. For example, sodium has taste and functional effects in foods, whereas earlier fortification policies were flavorless and had potentially less serious functional effects. Nevertheless, there is limited evidence that sodium intake reductions achieved by changes in the food supply can create meaningful changes in health status. Two decades ago, a small but significant study illustrated the potential impact on blood pressure of passive reductions of sodium in available foods. The Exeter-Andover study, conducted by Ellison and colleagues (1989), was designed to examine the extent to which reductions in the sodium content of dining hall foods would result in blood pressure reductions among students in the intervention versus control schools. Students were not instructed to change their dietary patterns or to avoid salty foods, and salt shakers were left on the tables. Sodium intake was reduced by 15–20 percent through modifications in food purchasing and preparation, and resulted in significant reductions in systolic and diastolic blood pressure over the academic year. These findings further illustrate the potential value of passive changes in the food supply, in line with changes in the macro-level environment.

Policy changes have been highly effective in influencing the intake of other nutrients. For example, food fortification was likely an important tool in eliminating pellagra in the United States (Park et al., 2000). These findings further illustrate the potential value of passive changes in the food supply, in line with changes in the macro-level environment.

By emphasizing changes in the food supply, individual consumer efforts to reduce salt intake are embedded in these broader changes. Consumers' roles in reducing salt intake will change in response to the new environment. With a broader range of food choices, consumers' control over the level of sodium in their diets is likely to increase. Additional changes of other factors in the behavior change process are supplemental.

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7

The Regulatory Framework: A Powerful and Adaptable Tool for Sodium Intake Reduction

Salt and other sodium-containing compounds—like other substances added to food—are subject to federal food safety and labeling laws. Sodium content has been a mandatory declaration in the Nutrition Facts panel on packaged foods since 1993. The manner in which these laws are used and implemented can significantly impact sodium intake by the U.S. population.

As a general matter, federal laws enacted by Congress have evolved over time to ensure the safety and adequacy of the food supply, protect public health, and require that the food industry provide information needed by consumers, including information with which to make healthful food choices. These laws are administered by various agencies of the federal government, and the "rules" or regulations needed to implement the laws are put in place commonly as part of a public rulemaking process. Details about the federal rulemaking process can be found in Appendix H.

The federal laws and regulations that relate to sodium in foods may appear complex to those unfamiliar with food law and regulations. However, once the framework is understood, it becomes evident that regulatory approaches can offer a powerful and adaptable tool for reduction of sodium intake. The options in the current regulatory framework are diverse and could be used in creative ways to facilitate a meaningful reduction of sodium intake. Further, regulations are developed through a public process, thereby enabling stakeholders to provide information on making them realistic and well matched to the reality of the world in which they will be applied.

This chapter addresses first the regulatory requirements surrounding salt and other sodium-containing compounds in the context of the safety of substances added to foods. Next, the regulatory requirements that pertain to nutrition information provided to the consumer and the requirements related to making claims about food products are outlined. In addition, the application of federal regulations to restaurant/foodservice operations is discussed.

REGULATION TO ENSURE SAFETY OF SUBSTANCES ADDED TO FOODS BY MANUFACTURERS

Protecting, enhancing, and preserving food by using "food additives" began in ancient times, undoubtedly long before documented history. The Romans added sulfites to wine as a preservative and Europeans sought spices not only to flavor but also to preserve foods. There is evidence that many cultures and geographic regions used salt as a preservative, especially for meats (Folkenberg, 1988). In the absence of a scientific understanding of the effects of such substances, it was assumed that they were safe unless they poisoned the consumer.

Today, one role of government is to ensure that the food sold to its citizens is safe to eat. The history for such authority in the United States begins with the *Food and Drugs Act* of 1906,[1] but the key provisions for the purposes of this report rest within the *Federal Food, Drug, and Cosmetic Act* of 1938.[2] This act was passed after a legally marketed elixir killed 107 people. Thus, the act was specifically intended to overhaul the public health system in the United States.[3] Among other provisions, the law authorized the government agency now housed in the U.S. Food and Drug Administration (FDA) to issue standards for foods and to demand evidence of safety for new drugs.

Concerns about the possible long-term harmful effects of food chemicals on health led Congress in 1958 to enact the *Food Additives Amendment*,[4] which became Section 409 of the 1938 act (hereafter referred to as the 1958 Amendment) to ensure the safety of substances added to foods.[5] Salt—sodium chloride—is a substance intentionally added to food by manufacturers; therefore the provisions of this amendment apply to salt as well as to any other sodium-containing compound added to foods.

As illustrated in Figure 7-1, the 1958 Amendment specified that sub-

[1] *Food and Drugs Act* of 1906, Public Law 59-384, 34 Stat 768; 21 USC § 1-15 (1934); repealed in 1938 by 21 USC § 329(a).

[2] *Federal Food, Drug, and Cosmetic Act* of 1938, Public Law 75-717; 52 Stat 1040.

[3] Food and Drug Administration (FDA), 2009. Available online: http://www.fda.gov/regulatoryinformation/legislation (accessed October 2, 2009).

[4] *Food Additives Amendment* of 1958, Public Law 85-929; 72 Stat 1784.

[5] 21 USC 348 and 342(a)(2)(C), and 21 CFR 170-179.

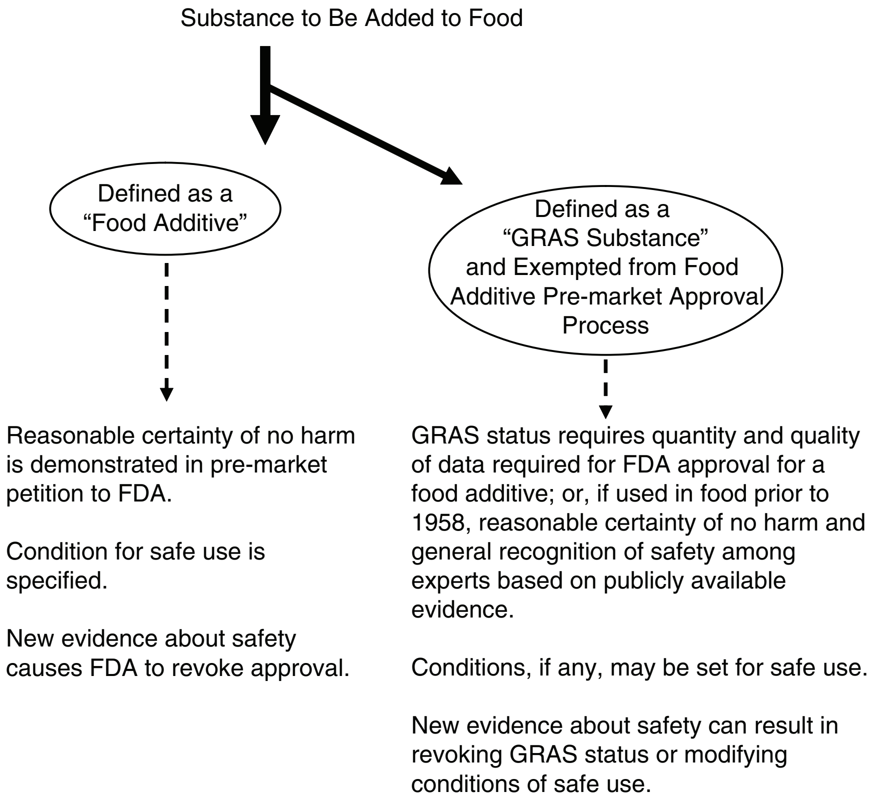

FIGURE 7-1 Pathways for a substance to gain approval for addition to food. NOTE: FDA = U.S. Food and Drug Administration; GRAS = generally recognized as safe.

stances intentionally added to food are defined as "food additives" and, in turn, that food additives must be approved by FDA before they are added to foods. The process of approval requires scientific evidence gathered by the petitioner to demonstrate that the substance—under the conditions of its intended use—meets the safety standard of a *reasonable certainty of no harm*.[6] This standard recognizes both that safety cannot be proven with absolute scientific certainty and that a substance may be safe for one use or under certain conditions, yet possibly unsafe for other uses or under other conditions.

At the same time that Congress set in place the food additives framework, it also concluded that many substances intentionally added to foods—

[6] 21 CFR 170.3.

such as vinegar, baking powder, and pepper—had a long history of use in food and were commonly accepted ingredients that should not require a formal pre-market review by FDA to ensure their safety. It made little sense for these substances to undergo review or to burden FDA with the process of doing so. Therefore, a classification of substances that were regarded as generally recognized as safe (GRAS) was excluded from the definition of food additive and is not subject to the requirement of pre-market review.

To be GRAS, the intended uses of a substance must satisfy the same "reasonable certainty of no harm" safety standard that is applicable to food additives, based on the same quantity and quality of data ("scientific procedures") required for FDA approval of a food additive, except that for substances used in food prior to 1958, the safety can be satisfied on the basis of such data or "experience based on common use in food."[7]

While a substance that is GRAS is exempted from the food additive requirement of pre-approval by FDA, it must still be safe and, with reasonable certainty, cause no harm. Further, as with a food additive, a GRAS substance is considered safe only under the conditions of use for which it is recognized as safe. Therefore, importantly, a substance may be GRAS under one condition of use and not GRAS under a different condition of use.[8] This concept of conditions of use can apply to the amounts added to food and is therefore important for the purposes of this report. Additionally, conclusions about the safety of a substance can be revised as warranted by new and evolving science. Therefore, the ability to retain GRAS status and the conditions of use associated with that status likewise can be changed as needed.

Salt as a GRAS Substance

FDA first issued a list of GRAS substances in December 1958, but the agency underscored that the list could not be considered complete and provided examples of GRAS substances only. The current GRAS list appears as Parts 182, 184, and 186 of the Code of Federal Regulations (CFR) and contains hundreds of substances, including salt.[9] Beginning in 1969, FDA worked to review the safety of the substances included within the GRAS

[7] 21 USC 321(s) and 21 CFR 170.30.

[8] 21 CFR 170.6.

[9] In 21 CFR 182.1(a), "salt" was included (in 1958) among the examples of commonly used ingredients that are considered safe, by way of explaining that it is not feasible for FDA to list every GRAS food ingredient. Salt (sodium chloride) was thus not on the original Part 182 GRAS list. It is also not listed in Part 184 as a substance whose GRAS status has been affirmed by FDA. The committee thus presumes it did not undergo the GRAS affirmation process. Many other forms of sodium did and are affirmed as GRAS in 21 CFR 184.1721-1807.

list. At that time and continuing through today, no conditions of use for salt have been incorporated into the GRAS status determination, and therefore its addition to food is not limited or prescribed.

As part of its 1969 review, FDA requested the assistance of the Life Sciences Research Office, established by the Federation of American Societies for Experimental Biology. As a result, a Select Committee on GRAS Substances (SCOGS) was designated and worked to conduct a full safety review of 235 GRAS substances during the 1970s. One of the substances was salt.

In 1979, SCOGS delivered its safety review of salt to FDA. The report (SCOGS, 1979) concluded that "the evidence on sodium chloride is insufficient to determine that the adverse effects reported are not deleterious to the public health when it is used at levels that are now current and in the manner now practiced." This conclusion raises questions about the GRAS status of added salt in light of the safety standard of "reasonable certainty of no harm" and the requirement that there be "general recognition" of safety to achieve and maintain GRAS status. Such a conclusion would typically trigger FDA action to revise or revoke the GRAS status of a substance, but the agency at that time did not begin such activities.

In early 1978, FDA was petitioned (CSPI, 2005) to reclassify salt from a GRAS substance to a food additive, which would make salt subject to pre-market approval for its use. In addition, the petitions encouraged FDA to implement other aspects of existing regulations and require a warning label on high-sodium foods and salt packets. The petitions did not request that FDA modify the conditions under which salt could be used in foods as a GRAS substance, only that salt no longer be classified as GRAS.

Based on the SCOGS report and its own analysis of regulatory options, FDA responded to the petitions by publishing a "Policy Notice" in 1982 (HHS/FDA, 1982), stating that it would not act "at this time" to revise the GRAS status of salt. The FDA called on industry to voluntarily reduce the levels of added salt in processed food based on concerns about hypertension. Furthermore, public education was emphasized, as well as a new FDA effort to expand disclosure of sodium content on product labels. FDA further stated: "The agency wishes to emphasize that if there is no substantial reduction in the sodium content of processed foods and if information [*sic*] sodium labeling is not adopted after a reasonable period, FDA will consider additional regulatory actions, including proposing a change in salt's GRAS status" (HHS/FDA, 1982, p. 26593).

In 2005, the House of Representatives' Committee on Appropriations issued a statement that encouraged the Secretary of Health and Human Services "to focus on ways—including both voluntary actions by the food industry and regulatory actions by FDA and the Department of Agriculture—to reduce salt in processed and restaurant foods."[10] A petition submitted to FDA in 2005 (CSPI, 2005) cited, among other reports, the congressional committee's statement and requested FDA to (1) revoke the GRAS status of salt, (2) amend any prior sanctions for salt, (3) require food manufacturers to reduce the amount of sodium in all processed foods, (4) require health messages on retail packages of salt (≥ 0.5 oz.), and (5) reduce the Daily Value (DV)[11] for sodium from its current level of 2,400 mg to 1,500 mg. In response to the petition, FDA held a public hearing in November 2007 to discuss the regulatory status of salt. The comment period for additional responses to the public hearing and the petition closed in August 2008 (HHS/FDA, 2008). To date, no further FDA action on this petition has taken place.

The Government Accountability Office (GAO) has also undertaken a study related to GRAS, which was released in February 2010 (GAO, 2010). The objectives of this work included determining the extent to which FDA's oversight of GRAS determinations helps ensure the safety of food ingredients and the extent to which FDA reconsiders GRAS determinations. This study found that FDA does not systematically reconsider the safety of GRAS substances as new information becomes available and that the agency has acted slowly on petitions regarding GRAS status of substances including salt due to resource constraints and other priorities. As a result, one of the recommendations of the GAO report was that FDA "develop a strategy to conduct reconsiderations of the safety of GRAS substances in a more systematic manner, including taking steps such as allocating sufficient resources to respond to citizen petitions in a timely manner, [and] developing criteria for the circumstances under which the agency will reconsider the safety of a GRAS substance."

Options for the GRAS Status of Salt on the Basis of Safety Concerns

As described above, there are two regulatory options for salt added to foods, other than maintaining the status quo of salt as a GRAS substance with no specified conditions of use. One option is to revoke the GRAS status, requiring a petition process for approval before marketing. The second is to retain salt as a GRAS substance but specify the conditions of use under which the continued addition of salt to foods can be considered safe. This would not require petitions, but food manufacturers would be required to formulate their food in such a manner that the salt levels are consistent with those recognized as safe. Uses or levels of salt in foods that could not meet the new standards could, through a petition process, be put forward as food

[10] H.R. Rept. 109-143. 109th Congress, 1st session. (June 21, 2005) at 142.

[11] The value used for nutrition labeling of packaged foods.

additive uses and have the potential for approval. This does not mean that the standard of safety is different between the GRAS approach and the food additive approach, only that there is the option, after the determination that a general recognition of safety does not exist, to permit the substance to be used as a food additive concurrent with whatever restrictions are needed to ensure its safe use.

Key Components of the Process

FDA action to either alter or revoke the GRAS status of salt would involve an established rulemaking process (see Appendix H) that would include, at a minimum, (1) public notice of proposed actions and a justification for the actions based on the available science, (2) an opportunity for public comment, and (3) a reasoned FDA response to the comments. Even prior to publishing such a proposal, FDA could publish an advanced notice of proposed rulemaking, commonly referred to as an ANPR, to outline its initial thinking and to gather information on key issues. These include but are not limited to relevant data ranging from technical processes to consumer behaviors. As part of the process, the agency could also hold public meetings, hearings, scientific consultations, or other dialogue as appropriate to resolve the GRAS status of added salt and determine the agency's regulatory and policy approaches.

In carrying out activities to alter or revoke salt's GRAS status, FDA would have to address both scientific and policy questions, including the following:

- The central question, which is predominantly scientific, is whether the current levels and uses of added salt satisfy the safety standard of "reasonable certainty of no harm" based on today's science. In addressing this question, FDA would be expected to take into account, among other sources of information and scientific findings, the recommendations of and scientific advisory documents related to the *Dietary Guidelines for Americans*, which in 2005 established a recommendation of less than 2,300 mg/d of sodium for the general population and no more than 1,500 mg/d for those with hypertension, African Americans, and people middle-aged or older as appropriate upper limits to reduce the risk of elevated blood pressure. Dietary Reference Intakes for sodium as established by the Institute of Medicine (IOM) might also be relevant. Consistent with the provisions established in law (21 USC 348[c][5][B]), the agency would use a total population "exposure" approach for determining the safety of salt or sodium.

- Further, FDA would have to consider salt's technical or functional effects in food. In any rulemaking to set standards for the level of added salt in processed food, FDA would have to solicit and analyze food industry information on the intended uses and technical effects of added salt.

Importantly for this report, FDA's authority under food additives law extends to uses of salt in foods that are under the jurisdiction of other federal agencies. For example, the use of sodium enhancement solutions intended to tenderize raw meat and poultry products that are under the jurisdiction of the U.S. Department of Agriculture (USDA) is subject to the 1958 Amendment.[12] Thus, the safety of these solutions (i.e., their risk to human health) is subject to FDA regulation. In turn, these uses of salt-containing compounds would need to be considered by FDA in reviewing the GRAS status of salt.

While FDA is charged with administering the food additives safety provisions that are applicable to meat and poultry products that are under USDA jurisdiction, USDA has its own regulatory authorities that would allow it to implement other suitable and appropriate provisions for meat and poultry products including labeling and the prohibition of deceptive uses of substances and solutions added to meat and poultry. These provisions may have sizeable impact given that USDA is responsible for food products that contain 2 percent or more by weight of meat and poultry which, in turn, constitute about 20 percent of the U.S. food supply. In 2009, USDA issued an advanced notice of proposed rulemaking related to the labeling of meat and poultry products, specifically regarding the use of the voluntary claim "natural" on such products (USDA/FSIS, 2009a). USDA specifically requested comment on whether it should approve a "natural" claim on meat and poultry products that have been enhanced with solutions that contain "natural" ingredients.

Finally, FDA would also have to address the question of so-called prior-sanctioned uses of salt. In its 1982 Policy Notice on salt (HHS/FDA, 1982), FDA noted the possibility that there may be uses of salt in processed food that had received FDA's approval prior to 1958 and thus could be deemed prior-sanctioned. These particular uses, approved before the 1958 law went into effect, were grandfathered (i.e., not made subject to the food additive law). The 1982 Notice does not identify any prior-sanctioned uses, the agency does not maintain a listing of such uses, and the Committee's search for prior-sanctioned uses of salt or sodium failed to locate such uses for salt or sodium. Nonetheless, it may be assumed some could exist for specific products. As a practical matter, prior-sanctioned uses are likely to

[12] *Food Additives Amendment* of 1958, Public Law 85-929, 72 Stat 1784.

have been granted on a case-by-case basis to specific companies for specific products, and therefore reflect a very insignificant sodium contribution to the food supply.

However, even if prior-sanctioned uses of substances are identified and are considered by legal authorities to be permanently exempted from the food additive law, they remain subject to review for safety. The authority for this is within the so-called adulterations standards specified in 21 CFR 181.1(b). As FDA itself stated in 1982 and encapsulated in the CFR,[13] the safety determinations reflected in those prior sanctions may be reviewed and modified where appropriate, when "scientific data or information . . . shows that use of a prior-sanctioned food ingredient may be injurious to health." It should be noted that such activities must meet a higher legal standard compared to those established for the food additive provisions. Moreover, for prior-sanctioned substances, the burden would likely rest on FDA to demonstrate that such regulation is needed to prevent possible harm. In any event, while prior-sanctioned uses would constitute a technical issue for the agency, its impact is expected to be insignificant in terms of sodium contribution to the food supply particularly in contrast to the levels under the GRAS provisions.

Implementation

FDA has great flexibility in adopting regulatory standards. It may determine appropriate implementation periods for new standards and take into account factors such as consumers' acclimation to changes in the salt taste of products. Other feasibility and related constraints may be considered in implementing new standards, including possible phase-in reductions to acceptable levels.

In considering implementing salt GRAS standards in a stepwise fashion, FDA will benefit from the experience gleaned from the effort to reduce, in a sequential manner over time, the allowable levels of sodium in foods bearing the implied nutrient content claim "healthy." That experience demonstrates the considerable importance of gathering information and carefully weighing options before making final decisions about an implementation process relative to sodium. It would appear that if the effort results in too rapid an implementation without sufficient regard to the need to make related changes in all food products, the outcome may not be accomplished successfully.

[13] 21 CFR 181.1(b).

Special Labeling to Ensure Safety

FDA has the option to require special labeling or disclosure statements on the foods containing added substances (whether food additives or GRAS substances) to ensure their safe use. The question of whether to require such labeling has a major policy dimension, as well as a scientific and consumer research dimension, whether the labeling is aimed at the general population or at high-risk subgroups. Such labeling could contribute to a conclusion that certain uses meet the safety standard of "reasonable certainty of no harm" that otherwise might not meet the standard. An example of such labeling that "fixes" a safety issue associated with an added substance is the required statement for aspartame: "Phenylketonurics: Contains phenyalanine." In this case, there is no safe use of the substance for the subpopulation of phenylketonurics. However, with the safety hazard disclosed by required labeling, the vulnerable subpopulation is alerted, and the rest of the population can consume the substance and benefit from its inclusion in food. FDA could use such labeling as a tool where appropriate in the development of standards for the addition of salt to foods, after the needed exploration of the appropriate nature and impact of such labeling.[14]

Chapter 6 discusses the available research regarding consumers' responses to such food label disclosures as well as the labeling associated with the *Nutrition Labeling and Education Act* (NLEA) of 1990,[15] which is discussed below. It suggests the importance of carefully researching consumer response and crafting a framework for such labeling before the provisions are put in place.

Other Sodium-Containing Compounds

The focus on regulatory approaches to reduce sodium intake has centered on salt (sodium chloride) because it is the main contributor of sodium to the American diet. However, as described in Chapter 5, there are a myriad of other compounds that contain sodium and are added to foods. Some of these uses are currently GRAS, and some have been approved as food additives.

Because sodium per se and not just sodium chloride is the concern relative to reducing the risk of elevated blood pressure, the presence of all these

[14] Further, another section of the *Federal Food, Drug, and Cosmetic Act* [Section 403(a) (codified as 21 USC 343(a)) as further defined by Section 201(n) (codified as 21 USC 321(n))] stipulates that food products cannot legally be sold if their labeling is false or "misleading." The term misleading is further defined as a failure to disclose "facts material with respect to the consequences which may result from the use" of the food. Disclosures can be required to prevent a product's label from being misleading.

[15] *Nutrition Labeling and Education Act* of 1990, Public Law 101-533, 104 Stat 2353.

compounds in foods and their total contribution to the diet would need to be factored into FDA efforts to determine safe use. Considerable data gathering will be required to incorporate these compounds into the process.

REGULATION TO REQUIRE NUTRITION INFORMATION AND TO SET STANDARDS FOR LABEL CLAIMS

Background

Nutrition labeling of foods as an activity overseen by FDA began in the 1970s and was initiated, in part, due to concern about nutrient deficiencies. It was a voluntary program unless the food contained any added vitamins, minerals, or protein or a nutritional claim had been made for the food, in which case the food had to display a nutrition label. A nutrition label gave information on calories, protein, carbohydrates, fat, and some vitamins and minerals (Lecos, 1986). Information about sodium was not required in such cases unless a claim was made about sodium content. In 1981, in response to the increasing national concern about sodium intake and elevated blood pressure, FDA began to urge the food industry to voluntarily identify the sodium content of foods on the label. In 1984, FDA issued a sodium labeling regulation (HHS/FDA, 1984), which went into effect in 1986, requiring that sodium content be included on any food that bears a nutrition label. The rule also included definitions for the label claims "sodium free," "very low sodium," "low sodium," and "reduced sodium" and described appropriate use of the terms "without added salt," "unsalted," and "no added salt" on food labels (HHS/FDA, 1984, 1985).

By the end of the 1980s, new scientific findings about diet and health were increasingly reported, and consumer interest in diet as a way to improve health was increasing. Food manufacturers were eager to market food products to take advantage of this interest. As a result, the marketplace became crowded with claims about the benefits of foods, and consumers and manufacturers expressed concern about the credibility of the food label and its potential to confuse consumers (Taylor and Wilkening, 2008a). Primarily as a result of these events, the NLEA was passed by Congress in 1990,[16] amending the existing 1938 *Federal Food, Drug, and Cosmetic Act*.

The NLEA was a broad effort not only to reduce consumer confusion, but also to provide information that consumers needed and wanted, by requiring that nutrition labeling rules be put in place by FDA. It further stipulated that declarations of the amounts of certain nutrients would be made mandatory on labels of packaged foods. It required that the government create a framework that allowed manufacturers voluntarily to use

[16] *Nutrition Labeling and Education* Act of 1990. Public Law 101-535, 104 Stat 2353.

so-called nutrient content claims and health claims on their food labels. In doing so, the NLEA gave FDA the mandate and authority to protect consumers from misleading nutrition claims and to help consumers make more healthful food choices through better access to credible nutrition information. The NLEA was also intended, in part, to establish a level playing field for nutrition information, presumably decreasing both the need and the opportunity for marketing "hype." Additionally, by providing the opportunity to make positive claims about their products, it sought to encourage manufacturers to formulate foods with improved nutrient profiles, such as foods lower in sodium or saturated fat (Taylor and Wilkening, 2008b). It strengthened FDA's authority to ensure truthful and non-misleading nutrition information on foods. The NLEA focused on information needed by the *general* population to follow *general* dietary recommendations. The result was the Nutrition Facts panel, established in 1993 and now found on most packaged foods, as well as the establishment of a framework for making nutrient-related claims and health claims.

Thus, the NLEA was directed to the labeling of foods, primarily packaged foods, regulated by FDA. In addition, FDA established a voluntary labeling program for raw fruits, vegetables, and fish.[17] However, the NLEA exempted nutrition labeling for restaurant foods as well as packaged foods products sold only to restaurant/foodservice operations.[18] Despite the exemption, and in light of the growing proportion of American meals consumed outside the home, FDA has sought to enlist the assistance and support of restaurants in addressing national obesity concerns by urging them to provide point-of-purchase nutrition information to consumers (HHS/FDA, 2004). As signed into law in March 2010, the *Patient Protection and Affordable Care Act*[19] contains provisions to address nutrition labeling of menu items. Restaurants with 20 or more outlets are required to post calories on menus, menu boards (including drive-thrus) and food display tags, with additional information (fat, saturated fat, carbohydrates, sodium, protein and fiber) available in writing upon request.

Further, the NLEA did not address advertising, which is under the authority of the Federal Trade Commission, nor did it cover foods regulated by USDA, which are primarily meat and poultry products. However, USDA voluntarily put in place nutrition labeling regulations consistent with those adopted by FDA.[20] USDA has in place guidelines for the voluntary nutrition labeling of single-ingredient, raw products and ground or chopped meat and

[17] 21 CFR 101.45.

[18] 21 CFR 101.9(j)(2)(ii),(iv).

[19] *Patient Protection and Affordable Care Act*, HR 3590, Title IV, Subtitle C, §4205; 111th Congress, 2nd session, March 2010.

[20] USDA, 1993; 9 CFR 317.300.

poultry products,[21] and it has proposed but not yet finalized regulations requiring nutrition information for these products on labels or at point of purchase (USDA/FSIS, 2009b). In order to establish comparable nutrition labeling requirements for meat and poultry products, USDA in 1993 acting under its own authorities made mandatory the nutrition labeling of meat and poultry products, other than single-ingredient, raw products. Voluntary guidelines were set in place for nutrition labeling of single-ingredient, raw meat and poultry products. In 2001, USDA proposed to make these voluntary guidelines mandatory (USDA/FSIS, 2001). This proposal was not finalized, but in December of 2009 USDA announced it would solicit further public comments on the proposed rule (USDA/FSIS, 2009b).

Sodium and the Nutrition Facts Panel

The Nutrition Facts panel, an example of which is shown in Appendix I, provides nutrient information in amounts per serving and as a percentage of the DV for certain required nutrients. Sodium is one of the required nutrients, and its declarations are expressed both as a milligram amount and as a percentage of the recommended DV, which currently is established as 2,400 mg.[22] FDA regulations provide a procedure for food producers to analyze the sodium content and determine quantitative sodium levels in their products. To be in compliance with labeling requirements, the actual nutrient content must not differ from the amounts declared in the panel by more than 20 percent.[23] For sodium, the actual amount can not be more than 20 percent above the declared value.[24]

Establishing the Daily Value for Sodium

One of the goals of the NLEA was to allow consumers to quickly and easily view and understand the nutrition information on food labels. Consumers were to be able to understand the nutrients'relative significance "in the context of the total daily diet"[25]—to tell at a glance whether the nutrients in a product represented a large or small amount of a "desirable" intake or an intake associated with better health. The DV information not only allows consumers to make choices about the foods they consume, but also it allows them to make trade-offs. By observing that a particular product may contribute, for example, 75 percent of the amount of sodium considered

[21] 9 CFR 317.345.
[22] 58 FR 2079 and 2206.
[23] 21 CFR 101.9(g)(4)(ii).
[24] 21 CFR 101.9(g)(5).
[25] *Nutrition Labeling and Education Act* of 1990. Public Law 101-535, 104 Stat 2353.

appropriate for a daily diet while only contributing perhaps 3 percent of a desirable nutrient from the consumer's perspective (for example, calcium), consumers can better balance their food choices. Moreover, the presence of this information on the packaged food label could incentivize the food industry overall to develop foods with better "nutrition profiles."

At the time of NLEA implementation, FDA explored approaches to set the quantitative nutrition information within the context of a total daily diet (Levy et al., 1996; Lewis and Yetley, 1992). No single format proved best for all tasks, but the use of a percentage of a reference intake scored the highest. So, for each nutrient to be declared within the Nutrition Facts panel, FDA developed a DV. Generally, for essential nutrients, a reference value for adequate intake is used as the basis for the DV. For non-essential nutrients, such as total fat, saturated fat, and cholesterol, a reference value related to intake above which there may be harm to health is used (Taylor and Wilkening, 2008a). The current DVs were issued through notice-and-comment rulemaking and finalized in 1993.

A challenge occurred in 1993, however, in that the National Academy of Sciences (NAS) had not provided reference values for a number of nutrients and food components that the NLEA required be listed on the food label, sodium among them. Accordingly, FDA turned to the available authoritative consensus documents and extracted from them reference intakes that could form the basis for DVs for nutrients and food components without Recommended Dietary Allowances (RDAs) from the NAS. In the case of sodium, the NAS 1989 consensus report known as *Diet and Health: Implications for Reducing Chronic Disease Risk* was used because it suggested that an intake of more than 6 g of salt (2,400 mg of sodium) per day was associated with elevated blood pressure (NRC, 1989). The value 2,400 mg became the DV used in the Nutrition Facts panel, and the levels of sodium in a serving of food have been expressed as percentage of this DV (i.e., a percentage of 2,400 mg) since that time.

Changes to the Daily Value for Sodium

Reference values for nutrients have been established beginning in the 1940s under the auspices of the National Research Council (NRC) of the NAS. In 1994, the IOM of the National Academies began a process to expand the reference values in that instead of providing a single number meant to be a recommended intake for each of the more than 25 age, gender, or life stage groups, a set of reference values is given for each nutrient for each group. The reference values are listed in Box 7-1 where it should be noted that an Adequate Intake (AI) is established when it is not possible to determine an Estimated Average Requirement (EAR) (and in turn an RDA).

BOX 7-1
Current Dietary Reference Intake (DRI) Components

Estimated Average Requirement (EAR): Reflects the estimated median requirement.

Recommended Dietary Allowance (RDA): Derived from the EAR; covers the requirements for 97 percent of the population.

Adequate Intake (AI): Used when an EAR or RDA cannot be developed; reflects an average intake level based on observed or experimental intakes or on other scientific judgments.

Tolerable Upper Intake Level (UL): Highest average intake that is likely to pose no risk.

A DRI reference value was established for sodium for the first time in 2005. The sodium reference value is now established as an AI of 1,500 mg (approximately, varying somewhat by age group) and a Tolerable Upper Intake Level (UL) of 2,300 mg (approximately, varying somewhat by age group) (IOM, 2005).[26]

FDA is in the process of preparing to update all DVs based on the 1997–2005 IOM effort to establish DRIs and has issued an Announcement of Proposed Rulemaking (HHS/FDA, 2007). In that announcement the agency asked the following question: "Should the Daily Reference Value (DRV) [note: basis for the DV for sodium] be based on the UL (2,300 mg/d) as suggested by the 2005 *Dietary Guidelines for Americans* or should it be based on the AI (1,500 mg/d using the population-coverage approach)?"

If the DV were changed to the lower AI value from the current value, which is closer to the current UL, the quantitative amount of a nutrient (500 mg, for example) per serving for a particular food would still be listed in the Nutrition Facts panel and would not change as a result of the DV change. However, the percentage of the DV as listed would change. Currently, if there were 500 mg of sodium in a serving, the label would reflect that a serving of the food contains about 20 percent of the DV, while an updated DV of 1,500 mg would result in the label indicating that a serv-

[26]Unlike AIs for other nutrients intended to reflect observed intake, the AI for sodium was set at a value that ensures that the overall diet would provide an adequate intake of important nutrients (that is, setting the reference value closer to the body's functional requirement for sodium would be too restrictive given today's food supply and preclude meeting other nutritional needs) and also covers sodium sweat losses in unacclimated individuals who are exposed to high temperatures or who become physically active (IOM, 2005).

ing of the food contains 33 percent of the DV. As outlined earlier in this discussion, the DV declarations within the Nutrition Facts panel play an important role in informing consumers about the nutritional content of the packaged foods they purchase by placing the food's nutritional contribution within the context of a total daily diet, the general target toward which consumers should strive. Therefore, the expectation is that the DV declarations will be consistent with the best thinking about the desirable composition of a daily diet.

Sodium Claims

Sodium Content Claims

As described above, the NLEA also directed FDA to establish the standards for which manufacturers could make claims on food labels. In 1993, FDA, in implementing the NLEA, made provisions for nutrient content claims, which specify how much sodium packaged foods may contain in order to bear declarations such as "sodium free," "low sodium," and "reduced sodium."[27] The thresholds for these claims are summarized in Table 7-1. Again, USDA made similar provisions for meat and meat products (USDA, 1993).

"Healthy" Claim

While the claim that a food is "healthy" is an implied nutrient content claim, it is in a slightly separate category, because the levels of certain nutrients besides sodium (specifically fat, saturated fat, fiber, cholesterol, vitamins A and C, calcium, iron, protein, and fiber) are also taken into account in determining whether a food can be labeled as "healthy." As mentioned previously, the history of "healthy" claims provides a lesson for strategies to reduce sodium intake.

The term "healthy" for label claims was defined and regulated beginning in 1994 (HHS/FDA, 1994). When the rules were first issued in 1994, foods making the claim were to contain no more than 480 mg of sodium per serving or, in the case of packaged meals and main dishes, no more than 600 mg. In response to the recognized need to allow for a stepwise reduction in sodium to foster consumer acceptance and allow time for technological adjustments, the rules stipulated that after January 1, 1998, the levels of sodium permitted for a "healthy" claim were to drop to 360 mg and 480 mg, respectively.

[27] 21 CFR 101.61.

TABLE 7-1 Definitions of Nutrient Content Claims for Sodium

Nutrient	Free	Low	Reduced or Less	Comments
Sodium (21 CFR 101.61 and 9 CFR 317.361)	Less than 5 mg per serving Contains no ingredient that is sodium chloride or generally understood to contain sodium[c] "Salt Free" must meet criterion for "Sodium Free"	140 mg or less per serving[a] (140 mg or less per 50 g if serving is small) "Very Low Sodium": 35 mg or less per serving[d] (35 mg or less per 50 g if serving is small)	At least 25% less sodium per serving than an appropriate reference food[b] Reference food may not be "Low Sodium"	"Light" (for sodium-reduced products): if food is "Low Calorie" and "Low Fat" and sodium is reduced by at least 50% "Light in Sodium": if sodium is reduced by at least 50% per serving[e] "Lightly Salted": 50% less sodium than normally added to reference food and if not "Low Sodium," so labeled on information panel

NOTES: g = gram; mg = milligram.
[a] Meals and main dishes: 140 mg or less per 100 g.
[b] For meals and main dishes: at least 25% less sodium per 100 g.
[c] Except if the ingredient listed in the ingredient statement has an asterisk that refers to a footnote clarifying that the presence of the ingredient adds only a trivial amount of the nutrient in question.
[d] For meals and main dishes: 35 mg or less per 100 g.
[e] *Nutrition Labeling and Education Act* of 1990. Public Law 101-535, 104 Stat 2353.
SOURCE: Adapted from FDA, 2008a.

This level of reduction reflects about a one-third decrease in a single step within 4 years. Yet it appears to have been problematic. In 1997, FDA was persuaded to postpone the reduction in sodium requirements based on comments that indicated technical difficulties in finding suitable alternatives for sodium and claimed that consumers would reject certain so-called "healthy" products made with lower levels of sodium or salt substitutes. The comments also voiced technological concerns with reducing sodium in food products, such as impacts on microbial safety, changes in texture and water-binding capacities, and effects on flavor characteristics of other ingredients (HHS/FDA, 1997, 2005). These comments concluded that the more stringent sodium thresholds would risk substantially eliminating existing "healthy" products from the market because of unattainable nutrient requirements or unmarketable flavor profiles. Thus, the sodium limits of 480 mg per serving and 600 mg for meals or main dishes remain in effect today, and plans to revise or reinstitute the stepwise process have not been announced.

Sodium-Related Health Claims

The provisions for health claims, as provided for by the NLEA, were intended to encourage consumption of foods with potential to improve nutrient intake and reduce the risk of chronic disease and to create standards for such claims in order to "level the playing field" for food manufacturers (Taylor and Wilkening, 2008b). Further, sodium levels in foods below a certain amount serve as one of the criteria that must be met before any health claim can be placed on the label of a food. One of the allowed health claims is that diets low in sodium are associated with a low prevalence of hypertension or high blood pressure.[28] This claim has been permitted for use since 1993. To bear this claim, foods must meet the criteria for "low sodium" nutrient content claims described above. Table 7-2 provides additional information on language requirements for this claim and model claim statements. More recently, under the *Food and Drug Administration Modernization Act*[29] a health claim was approved that states: "Diets containing foods that are good sources of potassium and low in sodium may reduce the risk of high blood pressure and stroke." Foods bearing this claim must meet all the health claim provisions as established in earlier provisions.

APPLICATION OF FEDERAL REGULATIONS TO RESTAURANT/FOODSERVICE OPERATIONS

Application of the Food Safety Provisions and GRAS Status to Restaurant/Foodservice Menu Items

The food additive provisions of the *Federal Food, Drug, and Cosmetic Act* apply to substances the intended use of which results in their becoming a *component* of any food.[30] Because the act applies to all foods that have moved in interstate commerce, FDA regulations limiting the amount of a substance in a food (in this case, salt or sodium) apply whether the substance has been added before or after the food has moved in interstate commerce.[31] In essence, the thrust of the provisions are that it is unlawful to add an unapproved food additive to food before, during, or after the food's passage in interstate commerce. Therefore, menu items are within the purview of the FDA authorities, even if they have undergone further onsite processing or are assembled onsite in restaurant/foodservice operations. This conclusion is based on the plain language of the statute, and is consis-

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[28] 21 CFR 101.74.
[29] Public Law 105-115, 105th Congress.
[30] 21 USC 321(s).
[31] 21 USC 342(a)(2)(C) and 331(a)-(c).

TABLE 7-2 Definitions of Health Claims for Sodium and Hypertension

Approved Claim	Requirements for the Food	Claim Requirements	Model Claim, Statements
Sodium and hypertension (21 CFR 101.74)	Must be "low sodium" as defined by 21 CFR 101.61	Required terms: "sodium," "high blood pressure" Includes physician statement (individuals with high blood pressure should consult their physicians) if claim defines high or normal blood pressure	Diets low in sodium may reduce the risk of high blood pressure, a disease associated with many factors

SOURCE: Adapted from FDA, 2008b.

tent with the discussions held during the committee's open public workshop (March 30, 2009). The decision to use these authorities and the manner in which they could be implemented have the potential to be controversial, but the legal authorities in the committee's opinion are clear.

On this basis, FDA may establish safe levels for the intended use of sodium in items prepared solely for restaurant/foodservice use and shipped in interstate (as commonly done by major restaurant/foodservice operations), just as it may for foods sold directly to consumers. Likewise, as is the case for packaged food, the agency could provide for disclosures or special labeling statements on such items as appropriate to assist restaurant/foodservice customers in achieving safe intake of sodium. Its implementation would require detailed preliminary analysis so as to ensure its success given the diverse and complicated nature of restaurant/foodservice operations.

Application of the *Nutrition Labeling and Education Act* to Restaurant/Foodservice Operations

Under the 1990 NLEA, the requirement for declarations about the nutritional content of a food product is limited to packaged foods, with some exceptions.[32] Thus, the mandatory use of a Nutrition Facts panel type of declaration is not currently applicable to restaurant/foodservice menu items. However, the act did not limit nutrient content and health claims to packaged foods, and therefore FDA could, under its existing misbranding and enforcement authorities, regulate the voluntary use of such claims by restaurant/foodservice operators on foods at least some component of which has moved in interstate commerce. In developing its 1993 regulations, FDA exempted menu claims from the requirements

[32] *Nutrition Labeling and Education Act* of 1990. Public Law 101-533, 104 Stat 2353.

applicable to such claims on packaged foods, but notice-and-comment rulemaking could be used to expand or adjust these regulations to include restaurant/foodservice menu items as appropriate. It is important to note that such rulemaking would relate only to the voluntarily use of such claims by restaurant/foodservice operations, as they do now to packaged foods. The advantage of such provisions is that they could be considered specifically for the unique characteristics of restaurant/foodservice operations and would offer the opportunity for a consistent approach and format across this industry.

As noted earlier, while there are no specific provisions for Nutrition Facts panel type of information on menus, FDA has sought to enlist the assistance and support of restaurants in addressing national obesity concerns by urging them to provide point-of-sale nutrition information to consumers (HHS/FDA, 2004). Further, as signed into law in March 2010, the *Patient Protection and Affordable Care Act*[33] contains provisions to address nutrition labeling of menu items. Restaurants with 20 or more outlets are required to post calories on menus, menu boards (including drive-thrus) and food display tags, with additional information (fat, saturated fat, carbohydrates, sodium, protein, and fiber) available in writing upon request. This requires national uniformity, ensuring consistency in information provided. States and localities would not be able to require additional nutrient information on menus.

STATE AND LOCAL MENU LABELING INITIATIVES

The recognition of the contribution that menu items from restaurant/foodservice operations make to the American diet, coupled with growing public health concerns about obesity and other chronic diseases, has increased the focus on point-of-purchase nutrition information within restaurant/foodservice operations. To a large extent, these initiatives are being driven by state and local public health authorities.

Before passage of the *Patient Protection and Affordable Care Act*, some states and localities considered or passed into law proposals to provide customers with sodium information at the point of purchase. Examples of these initiatives are summarized in Appendix J.

[33] *Patient Protection and Affordable Care Act*, HR 3590, Title IV, Subtitle C, § 4205; 111th Congress, 2nd session, March 2010.

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8

Committee's Considerations and Basis for Recommendations

The committee's general approach to identifying recommended strategies is illustrated in Figure 1-1 in Chapter 1. To identify recommended strategies for reducing sodium intake among the U.S. population, the committee considered the past initiatives and unique challenges described in Chapters 2 and 3. This information served as a stage-setting activity for the committee. Next, the committee considered the array of factors outlined in Chapters 4 through 7 ranging from the functional effects of sodium in foods to the food environment to regulatory options. The goal was to examine the lessons learned from past and current efforts to reduce sodium intake within the context of the available information about important factors in considering strategies to reduce sodium intake. The result provided an informed basis for identifying effective and sustainable strategies. The findings and considerations are discussed below. The recommended strategies are presented in Chapter 9.

LESSONS LEARNED FROM CONSUMER-ORIENTED PUBLIC HEALTH INITIATIVES

As described in Chapter 2, the committee reviewed campaigns and interventions initiated as early as the 1969 White House Conference on Food, Nutrition, and Health and continuing to the present. These activities are noteworthy for the number and range of organizations and initiatives that have worked to educate consumers about the importance of reducing sodium intake and impact their food choices to reduce intake. Over the past 40 years, government agencies, authoritative scientific bodies, and health professional organizations have set target goals for sodium intake and disseminated relevant information to consumers as well as health professionals and other stakeholders. The activities generally focused on informing consumers about the health consequences of high sodium intake and included attempts to motivate consumers to make changes. Efforts to put in place point-of-purchase information about the sodium content of foods and to encourage the food industry to voluntarily reduce the sodium content of foods were included as adjunct activities to assist consumers. Given that sodium intake estimates from national surveys beginning in 1971 have not shown a decline, and suggest that sodium intake has increased, the goal has not been achieved.

Despite 40 years of efforts to reduce sodium intake in the United States, intakes remain much higher than recommended levels.

The committee first considered the possibility that the failure to reduce intake was due to basic flaws or inadequate implementation of the efforts to educate and motivate consumers. Although it is likely there is room for improvement in these consumer-based initiatives, the explanation appears to rest with the nature of the public health problem itself. In the case of sodium intake reduction, at least two factors limit the success of efforts based on consumer education and motivation alone.

1. Many of the foods consumed by Americans—from breads to entire meals—are processed in ways that include the addition of salt and contribute significant amounts of sodium to the diet. Sodium is relatively ubiquitous in the food supply, and it is challenging for the average consumer to avoid consuming sodium.
2. Americans have become accustomed to high-salt taste preference. When coupled with consumer surveys indicating that taste is a primary influence on food selection and consumption, often overriding other reasons such as health motivations and even cost, this acquired taste preference warrants special attention. Further, because a high-salt diet may actually enhance the liking of salty foods, the U.S. food supply—which is high in added salt—may work against consumers' successfully lowering their taste preferences for salt and therefore handicap the acceptance of lower-sodium foods.

On balance, consumer-based initiatives without a concomitant change in the overall food supply and without considerations related to changing salt taste preference are likely to be inadequate to address the public health problem.

The need for changes in the food supply is not a conclusion unique to this committee, nor are the challenges associated with consuming a low-sodium diet, given the general nature of the food supply as experienced by the average American. Rather, as documented in Chapter 2, the major public health initiatives beginning in 1969 called on the food industry to reduce the sodium content of foods. Table 8-1 lists some examples of related comments from study authors.

Despite long-standing efforts by government, public health groups, and food industry leaders to encourage reformulation of foods to lower-sodium content and thus reduce sodium in the food supply, the U.S. food supply remains high in sodium as described in Chapter 2. Between 1984 and 2004, the sodium content of a number of McDonald's products was reduced by an average of 9 percent; the content of a number of Quaker products was reduced by an average of 23 percent; and the amount of sodium in 13 Campbell's soup products declined by an average of 10 percent (CSPI, 2005). A tracking survey of a relatively small sample of foods carried out by a public interest group beginning in 1983, indicates that of the 69 products still marketed in 2004, the average sodium content

TABLE 8-1 Examples of Comments Concerning the Need for Change in the Food Supply

Reference	Comment
Fodor et al., 2009[a]	"The DASH [Dietary Approaches to Stop Hypertension] diet was successful as long as food was provided to the study participants . . . as soon as the respondents had to take care of their diet themselves . . . the beneficial effects of this diet diminished or disappeared."
Kumanyika et al., 2005[b]	"Sodium reduction sufficient to favorably influence the population blood pressure distribution will be difficult to achieve without food supply changes."
Loria et al., 2001	"[In the context] of the overwhelming lack of adherence to dietary sodium guidelines . . . [there is a] need for a multifaceted approach. . . ."
Cleveland et al., 1993[c]	"The results [of the study] document the advantage of a change in the food supply—toward convenience foods with less sodium."

[a] Copyright © 2009 *Journal of Clinical Hypertension*. Reproduced with permission from John Wiley & Sons.

[b] Reprinted by permission from Macmillan Publishers Ltd: *Journal of Human Hypertension* 19(1):33–45, Copyright © 2005.

[c] Reprinted from *Journal of the American Dietetic Association*, 93(5), Cleveland et al., Method for identifying differences between existing food intake patterns and patterns that meet nutrition recommendations, pp. 556–560, Copyright © 1993, with permission from Elsevier.

decreased by 5 percent (from 592 to 564 mg) during the 20-year period (CSPI, 2008). However, for the more recent 10-year period (1994–2004), this survey reported an actual increase of 6 percent, suggesting that the reductions gained in the 1980s and early 1990s have been reversed. During the public information-gathering workshop convened by the committee (March 30, 2009), discussions among food industry panelists suggested that a 10–20 percent reduction in sodium for some products was a realistic estimate, but there are also reports that a few products may have achieved a 50 percent reduction in sodium while others achieved reductions smaller than 10 percent.[1] While such information is generally encouraging, the overall picture for the United States reveals little success for the industry as a whole. Even though there is evidence of efforts to reduce sodium in some food products on the part of larger food processors and a few restaurant chains, meaningful overall reductions in the food supply have not been accomplished. Specifically, Figure 2-4A indicates, on the basis of sodium density, that the amount of sodium in the overall food supply has not declined over time.

Past voluntary efforts by the processed food and restaurant/foodservice industries to reduce the sodium content of the food supply have not been successful in meeting the goal of reducing population sodium intake. Specific reasons cannot be documented but are likely due to a myriad of reasons.

A Unilever press release stated that consumers will be more likely to adapt their taste preference to lower levels of salt if the food industry as a whole reduces salt levels.[2] During the committee's public information-gathering workshop (March 30, 2009), a panel of food industry representatives discussed the issue of reducing the sodium content of the foods they sell. One representative stated:

> We also need to have a much more cohesive industry-wide approach. We have seen, to our detriment when we've tried to take a leadership role in reducing nutrients of concern unilaterally in different product areas that the consumers just move to different brands that have higher levels of those nutrients of concern at the expense of our products. And so, unless there is a consistent approach across the industry, with a baseline set so that we're all operating off a similar starting point, it will be difficult for any one company to take the lead.

[1] Personal communication, J. Ruff, Kraft Foods (retired), October 2009.

[2] Available online: http://www.unilever.com/mediacentre/pressreleases/2009/Unilevermakesacommitmenttoreducesaltacrossitsportfolio.aspx (accessed November 14, 2009).

This comment is consistent with the Food and Drug Administration (FDA) action to suspend the planned decrease in the levels of sodium per serving that a food product must have to bear the claim "healthy" (HHS/FDA, 2005).

In sum, food industry representatives report challenges associated with marketing products with substantially lower sodium—and hence a less acceptable taste profile—compared to competitors' products. It is known that food taste is an important determinant of food choice, and to alter salt taste preferences will likely require a level playing field approach in which salt reductions are made across the food supply. Luft et al. (1997) offered the following observation:

> The food industry has made a genuine effort to introduce low-salt food products; however, the public has not been willing to purchase the products and many have been withdrawn because they could not be sold (C.S. Khoo, personal communication, 1994). Pietinen et al. (1984) also observed that during their intervention (in Finland), low-salt bread, margarine, sausage, and mineral water were available. However, by the end of the study, only the mineral water and the margarine were selling well and were still available. Thus, the conclusion that compliance to a low-salt diet is difficult solely because of an uncooperative and nefarious food industry is overstated and not supported by the evidence. Public tastes continue to dictate the marketplace.

Given the need for food products to be "palatably competitive," the food industry lacks a level playing field for reduction of sodium in foods.

In view of these findings, the evidence presented in Chapter 3 regarding salt taste provides a foundation for identifying strategies to reduce sodium intake. An important consideration is that while the preference for salt taste, if not addressed, will be a barrier to success in lowering the sodium content of the food supply, salt taste preference is mutable and can be lowered. The preference for salt beyond physiological need may be due to evolutionary pressures to consume salt that have shaped an innate liking for its taste, or, alternatively and perhaps concomitantly, be due to learning, particularly early learning. Continued exposure to high levels of salt in the food supply likely reinforces the preference for a higher level of intake. Kumanyika (1991) noted that the environment promotes adaptation to a higher salt preference, even for individuals who prefer a low sodium dietary pattern, because it is difficult for them to sustain avoidance of inadvertent consumption of foods with high amounts of added salt.

Existing experience with lowering the taste preference for salt (Engstrom et al., 1997; NHLBI, 1996; public information-gathering session held by the committee on March 30, 2009), when coupled with a number of published experimental studies (see Chapter 3), suggest that salt taste preference may be most successfully decreased through a stepwise process and is likely dependent on lowering salt sources overall.

The general preference for salt taste can be changed. High levels of salt in the food supply can reinforce the preference for salt taste.

Finally, point-of-purchase information about the sodium content of foods has been the third prong of national public health initiatives. Nutrition labels have appeared on packaged foods since the 1970s and were mandated in 1993, but sodium intake has not declined. However, the availability of nutrition information for foods is a prerequisite for consumers' ability to make informed choices.

Availability to consumers of food label information about the sodium content of foods has not been accompanied by an overall reduction of sodium intake by the U.S. population.

Regarding point-of-purchase information—health claims or claims about sodium reduction in foods—intended to stimulate the food industry to reformulate foods, the promise associated with the marketability of such claims has not been realized. The ability to make claims about reduced levels of sodium in food products has not stimulated substantial or successful food reformulation or impacted the overall content of sodium in the food supply. Not surprisingly, the label surveys described in Chapter 2 revealed that claims about the sodium content of packaged foods are not widely used. As described in Chapter 6, the food industry likely is concerned that consumers associate reduced- or lower-sodium claims with poor-tasting products.

Label claims about the sodium content of food have not been widely used by manufacturers, perhaps because of concern that consumers associate such claims with poor-tasting products.

In the face of these unsuccessful national initiatives, some state and local authorities have taken on initiatives intended to reduce sodium intake. Much of this activity has centered on making point-of-purchase sodium information for restaurant/foodservice menu items available to consumers (see Appendix J). At least one current voluntary initiative in the United States addresses the sodium content of the food supply. The National Salt Reduction Initiative (NSRI), described in Appendix G, was developed initially by the New York City Health Department and has expanded into a national collaboration of state public health authorities and organizations. Based on the United Kingdom (UK) Food Standards Agency's Salt Reduction Campaign (see Appendix C), the NSRI aims to decrease sodium by setting targets that are defined as substantive and achievable and will result in gradual, measurable reductions of sodium content over time. The initiative includes two parallel components, one focusing on processed foods and the second on restaurants and the foodservice industry. The NSRI uses a food category approach to set targets for the sodium content of foods and relies on voluntary compliance on the part of the food industry.

A national collaboration of this type may be useful in encouraging the food industry to voluntarily lower the sodium content of its foods, and the reach of such efforts may extend to communities not actively participating in the initiative given the nationwide distribution of many food products. However, such initiatives are challenged by the inability to ensure that there will be compliance and they do not guarantee a level playing field for food producers. Additionally, it is likely that volunteers will drop out as reductions become more challenging over time. Further, these efforts may not be sustainable in the long term because they rely on "bully pulpit" and strong leadership approaches that can be reduced or lose political popularity with changes in state and local government administration. Additionally, other emerging public health concerns may draw focus away from the sodium initiatives.

Overall, the committee's considerations of the public health initiatives of the past 40 years directed toward lowering sodium intake by the U.S. population are outlined in Box 8-1.

INFORMATION FROM SODIUM INITIATIVES IN OTHER COUNTRIES

Appendix C contains specific information on efforts to reduce sodium intake in the United Kingdom, Canada, Finland, France, and the European Union. Components of these programs are summarized in Table 8-2, and the programs are described below.

Of the countries for which information is available, Finland has had the longest experience; initiatives were begun in the 1970s when intake was estimated to be more than 5,000 mg/d for adult males. Stroke mortality and blood pressure rates have declined. The efforts in the United Kingdom, which are relatively comprehensive, are of more recent origin with initia-

BOX 8-1
Findings from Review of Public Health Initiatives

- The lack of success in reducing sodium intake population-wide in the United States indicates that prior initiatives were not sufficient in the face of the nature of the public health problem they are meant to address.
- Without an overall reduction in the level of sodium in the food supply—that is, the level of sodium to which consumers are exposed on a daily basis—the current focus on instructing consumers and making available reduced-sodium "niche" products cannot result in lowering intakes to levels consistent with the *Dietary Guidelines for Americans*.
- Food industry efforts to voluntarily reduce the sodium content of the food supply face technological challenges, are not consistently undertaken by all, are difficult to sustain on a voluntary basis, and in the aggregate have not resulted in overall success.
- Food manufacturers and restaurant/foodservice operators face challenges in marketing lower-sodium foods in the context of the current food supply because such foods may be considered less palatable than higher-sodium competitors; it is known that food taste is a major determinant of food choice. What is lacking is a level playing field.
- A factor germane to improving the success of efforts to reduce sodium intake is that persons have become accustomed to high-salt taste, but the preference can be changed. Since a high-salt diet may actually enhance a preference for salt taste, a food supply with high levels of salt may handicap the acceptance of lower-sodium foods.
- Reductions in the preference for salt taste are likely best accomplished through gradual, stepwise reductions of sodium across the food supply.

tives beginning in 2003, following a national survey in 2000–2001 that suggested an average daily intake of more than 3,800 mg/d of sodium.

The activities in Finland focused on extensive media campaigns in the 1970s and 1980s, during which consumer awareness was the focus. These were followed by required labeling in the 1990s. The labeling is targeted to eight food categories known to be rich sources of salt in the diet: bread, sausages, cheese, butter, breakfast cereals, crisp bread, fish products, and soups, sauces, or ready-made dishes. Those foods that exceed a certain level of salt based on the percentage of salt "by fresh weight of the product" are required to bear a "high-salt" label, while those below certain percentages of fresh weight of product are allowed to bear a "low-salt" label.

In Finland, manufacturers apparently worked to reduce the sodium content of foods in these eight food categories, achieving for example a 10 percent reduction in the sodium content of sausages. Based on sodium excretion measures, the efforts in Finland coincided with a drop in sodium

TABLE 8-2 Overview of Initiatives in Other Countries

Country	Public Education	Requests to Industry for Sodium Reformulation	Food Labeling	Comments About Program
Canada	Yes	Yes	Voluntary	• Early voluntary reductions by food industry combined with public education and labeling had no impact on sodium intake from processed foods • Too early to assess
Finland	Yes	Yes	Mandatory	• Government regulation and implementation of food labeling with high-sodium-content warning • Strong media campaigns to increase public awareness • Much sodium intake under control of consumer (salt at table) • Replacement of usual salt with potassium-enriched Pansalt • Sodium intake decreased from 5,600 mg in 1972 to 3,200 mg in 2002 • Blood pressure and stroke mortality rates declined
France	Yes	Yes	Voluntary	• Efforts initiated in 2004 • Optional sodium labeling being developed • Limited public education in which sodium reduction is the main message; done through the National Nutrition and Health Program • Not much change to date except in the bakery sector, where 33% of bakers claim to have reduced sodium
Ireland	Yes	Yes	Voluntary pending	• Collaborative program between government and industry to heighten industry's awareness about salt and health • Government seeks salt reduction commitments from industry sectors; more than 70 have registered • Working on voluntary universal labeling of salt in packaged foods • No intake data available post-implementation

continued

TABLE 8-2 Continued

Country	Public Education	Requests to Industry for Sodium Reformulation	Food Labeling	Comments About Program
United Kingdom	Yes	Yes	Voluntary	• Collaborative effort with food industry for targeted sodium reduction in specific groups of foods under the oversight of the Food Standards Agency • Ongoing monitoring and evaluation of population intake • Public campaigns to increase public awareness and labeling strategy geared toward informing consumers • Sodium intake decreased from 3,800 mg in 2004 to 3,440 mg in 2008

SOURCE: Adapted from Mohan et al.

intake between 1979 and 2002 from more than 5,000 mg/d to less than 3,900 mg/d among men and from nearly 4,000 mg/d to slightly less than 3,000 mg/d for women (Laatikainen et al., 2006). However, use of salt added at home has been notably higher in Finland than in the United States, and the majority of the reported reduction in sodium intake was primarily due to a reduction of almost 50 percent in salt added by consumers at the table or in the home.

More specifically, in 1980, the average Finnish sodium intake was 5,080 mg/d, of which 30 percent was from table salt used in households. This is compared to 1997–1999 when the average intake was 4,440 mg/d, of which 21 percent was from table salt used in households. Thus, in 1980, approximately 1,520 mg/d of sodium was added by the consumer and 3,560 mg/d came from other sources, compared to 1997–1999 when approximately 930 mg/d of sodium was added by the consumer and 3,510 mg/d came from other sources (Reinivuo et al., 2006).

The UK effort at present is an entirely voluntary activity that relies on the impact of strong messaging from public health authorities, highly targeted and specific messages to the population, and highly visible efforts to enlist industry involvement and cooperation. These activities have been the focus of considerable government activity ranging from dialoguing with stakeholders to set appropriate and workable targets for reducing the salt content of key food categories to efforts to track progress toward the goal to government-sponsored awareness campaigns. Further, supermarkets and manufacturers are requested to voluntarily display front-of-package labeling of sodium and other nutrients using a traffic light color system. While a review of progress and the salt targets is planned for 2011,[3] the UK government reported reductions in sodium intake among the general population from an average of 3,800 mg/d in 2000–2001 to 3,440 mg/d in 2008 based on urine analysis of approximately 700 adults (National Centre for Social Research, 2008). The latter estimate is in line with the current U.S. dietary estimates. The 2011 review is planned to include information about the costs of the program.

In 2007, the Canadian government launched a multistakeholder working group on sodium reduction. The group intends to work in stages and should shortly be issuing a strategic framework that is slated for implementation in 2010. In 2003, Ireland began its work with a program intended to raise the food industry's awareness about the relationship between salt and health, and to work with the industry to voluntarily reduce sodium levels in foods. The Irish government reports that 72 companies have registered with the program, and reductions of approximately 20 percent in the sodium content of key foods such as breads and sausages have been reported. Similar to the situation in the United Kingdom, Irish intake estimates for sodium have been reported to be higher than U.S. estimates, but no recent national estimates subsequent to the implementation of the program are available. The French government released a report in 2002 that recommended a 20 percent reduction in sodium intake for its population and developed initiatives for consumers, the food/catering industry, and medical professions. To date, no significant changes have been reported in the salt content of processed foods or in the level of food labeling incorporated. Finally, the European Union has developed a so-called common framework approach to reducing salt intake among the populations of its member countries. The framework will focus on 12 categories of food identified as priorities.

No information on the cost effectiveness of these international strategies could be gleaned from the available data, although the United Kingdom plans to release information about the cost of its program in 2011.

Clearly, reducing sodium intake is a public health priority beyond the United States. The ability to directly relate existing reports from other countries to strategies that would be workable in the United States is somewhat difficult, given differences in food patterns, regulatory provisions, government resource capabilities, and consumers' perspectives on the food supply as well as the perceived importance of reducing sodium intake. In particular,

[3] Available online: http://www.food.gov.uk/healthiereating/salt/saltreduction (accessed November 16, 2009).

the committee expressed concern that adopting an exclusively voluntary approach in the United States may have limited success and questionable potential for long-term sustainability based on past U.S. experience. It was also noted that the regulatory structure surrounding the U.S. food supply may make regulation more feasible in the United States than in some of the other nations that have initiated sodium reduction strategies.

However, strategies carried out in other countries offer relevant themes. First, labeling initiatives are a component of all programs and are reported to be of assistance to consumers. However, labeling format and consistency has been found to be important; one UK study of the use of front-of-pack labeling found that the coexistence of a number of label formats in the market caused consumer confusion on the levels of key nutrients (British Market Research Bureau, 2009). Second, those who have worked to issue guidelines for the sodium content of foods have approached the task on the basis of food categories. The efforts undertaken by the United Kingdom in regard to food categories are particularly noteworthy and illustrative (see Appendix C). They reportedly reflect extensive dialogues with knowledgeable stakeholders and are fairly comprehensive. They have also served as the basis for the NSRI coordinated by the New York City Health Department (see Appendix G).

THE POSSIBILITY OF ECONOMIC INCENTIVES

In addition to the lessons learned from past experience, several approaches based on economic incentives have been suggested as strategies for reducing sodium intake and have an experience of use in other areas. These include agricultural subsidies for foods with lower sodium, tax incentives for production of lower-sodium foods, a salt tax on foods with higher sodium content, and a cap and trade system for salt or sodium. Although each of these possible approaches has the potential to reduce sodium intake, these may not be fine-tuned enough to reduce sodium intake or may be burdensome and costly relative to the potential reduction of sodium intake.

Agricultural Subsidies for Lower-Sodium Foods

Agricultural price supports have been provided for certain crops under periodic *Farm Act* legislation since the 1930s. The *Farm Act* legislation allows different methods of providing price and income support for agricultural commodities including direct payments, countercyclical payments, marketing assistance loans, and loan deficiency payments. Throughout the history of *Farm Act* legislation, covered commodities have included staple food commodities. Most recently, the *Food, Conservation, and Energy Act* passed in 2008 (i.e., the 2008 *Farm Act*) includes target prices for wheat, corn, grain sorghum, barley, oats, cotton, rice, peanuts, soybeans, dry peas, lentils, and chickpeas. The payment mechanism most similar to an agricultural subsidy is the countercyclical payment in which farmers receive the difference between the crop's target price and the current commodity price. It has been suggested that the list of commodities could be expanded to include fresh fruits and vegetables to encourage production of these commodities and thus reduce prices paid by consumers. The expected result is that lower prices for subsidized fruits and vegetables would encourage consumers to substitute fruits and vegetables for higher-sodium foods.

Without a great deal of further study, it is uncertain whether any reasonable level of subsidization of fruits and vegetables would cause consumers to alter their diets sufficiently to result in a lower total intake of sodium. Extension of the current *Farm Act* provisions to fruits and vegetables would involve development of a costly government infrastructure for administering the program, including determining target prices that take into account the differences in production practices across the country as well as enrolling a large number of additional farms. Also, agricultural subsidy programs can cause unfavorable market distortions and raise international trade issues. Thus, although subsidization of fruits and vegetables could potentially provide some benefit in encouraging an overall increase in consumption of fruits and vegetables, the benefits in terms of reducing sodium intake would likely not justify the costs of implementing such a strategy.

Tax Incentives for Production of Lower-Sodium Foods

Income tax incentives are, in some cases, provided by the federal or state governments to encourage production of certain products by manufacturers. For example, the *American Recovery and Reinvestment Act* of 2009 extended production tax credits and investment tax credits for the production of renewable energy (wind, solar, geothermal, and biofuels). It has been suggested that income tax incentives could be provided to food manufacturers for producing lower-sodium processed foods and to restaurant/foodservice operators for providing lower-sodium menu items. The tax credits would need to be tied to the volume of lower-sodium foods sold to ensure that products are offered for sale and consumers are purchasing the products in sufficient volume to have an appreciable effect on sodium intake. The expected result of the tax incentives is that more food manufacturers and restaurant/foodservice operators would provide lower-sodium foods and also would provide a broader range of lower-sodium foods at potentially lower prices.

Recommending tax incentives for the production of lower-sodium foods would not necessarily result in the desired outcome of lower sodium intake. Food manufacturers and restaurant/foodservice operators would weigh the benefits of the tax incentive offered for lower-sodium foods against the potentially lower revenue that might occur if many of their customers prefer higher-sodium foods because of their taste. It is unclear whether food manufacturers and restaurant/foodservice operators would consider it to their advantage to offer lower-sodium foods once they evaluate the total potential effect on their profits. Furthermore, food manufacturers and restaurant/foodservice operators that can most easily reduce the sodium content of their foods are likely to do so, with the result that this strategy might achieve reductions only in some foods offered in some locations. In other words, tax incentives may not result in broad sodium intake reduction across the population. Because of the uncertainties regarding the resulting reduction of sodium intake, the costs of implementing a tax incentive system (including the extensive reporting requirements that would be needed) would likely exceed the benefits of such a strategy.

Salt Tax on Foods with High Sodium Content

Public policy advocates have recently been making the case for instituting food taxes on certain foods that are suspected to be leading causes of obesity[4] (Brownell and Frieden, 2009; Brownell et al., 2009). These types of taxes, often referred to as "sin taxes," are typically excise (i.e., per-unit) taxes imposed on particular products that are believed to be harmful to society (Williams and Christ, 2009). By increasing the prices that consumers pay for these potentially harmful products, this theory suggests that consumers will reduce their purchases, substitute more healthful alternatives, and thus improve public health. Although these taxes are typically proposed for foods such as calorically sweetened beverages and high-fat snacks to reduce their consumption due to concerns about obesity, it has also been suggested that foods high in sodium could be taxed to reduce their consumption due to concerns about diseases associated with high sodium intake.

There is insufficient evidence to demonstrate the effectiveness of a sodium tax or to ensure that it will not result in unintended consequences. Past research has shown that consumers are not very responsive to small changes in food prices (i.e., food prices are relatively inelastic). Thus, the tax rate on high-sodium foods would have to be fairly substantial to induce a sufficiently large change in food purchases in order to have a major influence on health (Forshee, 2008; Golan et al., 2009; Waist banned, 2009). This has already been demonstrated by the fact that states that have implemented taxes on soft drinks have not seen a substantial effect

[4]Available online: http://www.sciencenews.org/view/generic/id/42598/title/Coming_Hard_tax_on_soft_drinks%3f (accessed November 16, 2009).

on sales[5] (Brownell et al., 2009). Furthermore, if consumers do alter their purchasing patterns in response to the tax, it is uncertain whether they would substitute more healthful alternatives (Williams and Christ, 2009). The issue of substitution is even more of a concern for a salt tax because sodium is an ingredient in numerous foods, some of which are otherwise nutritious. This is in contrast to a targeted tax on particular products such as sugar-sweetened beverages that have no nutritional benefits. Finally, sales taxes in general are regressive and affect lower-income households disproportionately more than higher-income households (Forshee, 2008; Williams and Christ, 2009), which could have the unintended consequence of crowding out purchases of other more healthful products and activities (Waist banned, 2009). Thus, given these concerns, other recommended strategies have the potential for a more direct reduction of sodium intake without the potential for unintended consequences on other purchase decisions by households.

Cap and Trade System for Sodium

Cap and trade systems are those in which market-based incentives are used with the intent of reducing harmful substances in the environment in an economically efficient manner. These systems have typically been applied for reducing air pollutants. For example, the 1990 *Clean Air Act Amendments* established a successful cap and trade system for sulfur dioxide emissions that drastically reduced these emissions at substantially lower cost than originally estimated.[6] Under an air pollution cap and trade system, a cap is placed on the volume of a harmful air pollutant and fixed allowances are allocated in some manner to each polluting entity. Entities that can reduce emissions at relatively low cost sell their allowances to other entities that have greater difficulty in reducing emissions. The fixed allowances can be reduced gradually so that total air pollutant emissions will diminish over time.

It has been suggested that a similar cap and trade system could be established for salt (or sodium more generally) in processed foods (Forshee, 2008). In this case, an oversight body would place a cap on the amount of sodium that could be used in the production of processed foods. Food manufacturers would have to determine how to produce foods given their allocation of sodium credits, or they would have to purchase sodium credits from those manufacturers that can more easily reduce the sodium content of their foods. Thus, a cap and trade system could lead to reformulation of existing food products; development of new, lower-sodium foods; or

[5] Ibid.

[6] Available online: http://www.edf.org/page.cfm?tagID=1085 (accessed October 12, 2009).

elimination of certain products with high sodium content. If food manufacturers elect to purchase sodium credits in order to continue producing higher-sodium foods, they may pass along the associated costs of the salt credits to consumers, thereby raising the price of these foods and potentially reducing consumer purchases. Over time, as the available sodium allocations are reduced, the price of sodium credits in the marketplace would increase, thus further inducing food manufacturers to reformulate foods or reconsider their product offerings in order to produce foods within their given allocations.

The context for processed foods is so substantially different from that for air pollutants that it is unclear whether the application of cap and trade would result in the desired outcomes without negative consequences. Whereas the goal of a cap and trade system for air pollutants is to encourage polluters that can reduce emissions at the lowest marginal cost to do so, the goal of a public health initiative on sodium is to achieve the lowest possible average level of sodium among the foods that are the largest contributors to sodium intake. A cap and trade system for sodium could conceivably result in dramatic reductions in foods that are not significant sources of intake. Also, most food manufacturers produce a range of products and could elect to apply their sodium credits toward retaining higher sodium levels in certain foods while reducing them in others. However, such a compliance strategy might potentially result in disparities in the sodium content of individual diets, and may make changes in taste preferences difficult to achieve. Arguably, cap and trade programs are best suited to pollutants whose aggregate environmental impact does not vary with their distribution. In addition, cap and trade systems were developed for cases in which the behavior of polluters largely determines the extent of an environmental harm; with sodium, individuals have control over their dietary choices and can alter the sodium content of their diets, potentially negating any benefits of a sodium cap. Setting a cap for sodium would also be difficult because the optimal quantity of sodium credits would vary over time depending on the size of the population and demographic shifts that may be difficult to predict. Thus, for all of the reasons stated above, the costs of developing, implementing, and monitoring a successful cap and trade system for sodium undercut the ability to justify uncertain reductions in the sodium content of the food supply.

TECHNOLOGICAL ADVANCES

In light of the considerable role that salt taste plays in food choice, it is likely that it will be necessary to consider approaches that result in a modification of salt taste along with the search for salt substitutes if meaningful reductions on sodium intake are to be achieved. Chapter 3 presents the possibilities for changes in salt taste preference and identifies other potential avenues for reduction of sodium in the food supply through the use of sensory approaches. In addition, more technological approaches are also relevant. The possibility of modifying the size and structure of salt particles holds some promise.

Use of sea salt to replace regular salt is an emerging interest in the food industry that could be of value to food formulators and chefs to assist in reducing the sodium content of some foods perhaps in part by enhancing overall flavor. However, since little is known about mechanisms potentially underlying this strategy and since sea salt contains large amounts of sodium, it is unclear how effective the use of sea salt might be in reducing overall sodium intake. Further consideration of sea salt as a useful adjunct to other sodium reduction strategies is indicated.

Effective and broadly useful salt substitutes have been elusive. Many sodium substitutes are more expensive than salt. Without significant consumer demand or pressure from governments and consumer and public health groups it is reasonable to expect that the food industry will not take on the expense of reformulation and added ingredient costs. Importantly, negative effects on taste reduce the appeal and general utility of sodium substitutes like potassium chloride. Although potassium chloride provides a salt taste to food, many individuals reportedly find that it imparts a bitterness to food that makes it unacceptable (Beauchamp and Stein, 2008), although the number of persons affected has not been determined. As discussed in Chapter 3, foods sometimes use up to a 50:50 ratio of potassium chloride mixed with salt (sodium chloride) to reduce bitterness, with higher ratios resulting in increased bitterness. While current dietary recommendations focus on increasing potassium in the diet of healthy Americans with normal kidney function, levels of intake above 4,700 mg/d may present risks for persons whose urinary potassium excretion is impaired, as discussed later in this chapter (DGAC, 2005).

Technological advances may lessen the need to use sodium to develop physical properties in foods or to prevent microbial growth. A number of alternatives for physical property development have already been discovered and are described in Chapter 4. For example, lower- or no-sodium alternatives to baking soda and baking powder have been developed, and the use of proteins, gums, and alginates has raised the possibility of reducing sodium in restructured meat products. Work continues to find additional ingredients that can impart these properties in foods and to explore alternative processing mechanisms. Similar advances may be possible to maintain food safety while reducing sodium. A number of researchers are searching for naturally occurring antimicrobial compounds (herbs, spices, etc.) (Doyle et al., 2001). In addition, new processing and packaging technologies such as non-thermal processing may find use as methods to improve the safety and quality of foods. It is likely that additional technologies and new ingredients or ingredient applications will be found as sodium reduction becomes a higher priority for food researchers. Further, the differences in sodium content of similar foods, as outlined in Chapter 4, suggest that there is some flexibility for the food industry in meeting safety and functional needs for sodium, although this is likely to vary depending upon product type and conditions of food manufacture. As with salt substitutes, technological advances to reducing sodium while maintaining food safety and physical properties may have an associated cost and therefore may be more responsive to policy/regulatory changes or increased consumer demand.

THE OPPORTUNITY TO LEVERAGE SODIUM REDUCTION BY USE OF FOOD PURCHASE SPECIFICATIONS AND FOOD ASSISTANCE REQUIREMENTS

There is no doubt that large-scale government food procurement and food assistance programs reach a sizable proportion of the U.S. population. The large number of citizens served by such programs makes them potentially influential. As described in Chapter 6, efforts already undertaken to reduce the sodium content of school and military foods are seen as positive attempts to reduce sodium intake as a public health measure.

However, such activities cannot realistically be expanded or sustained if the context in which they operate—the broader food supply—is not addressed. Experiences with the U.S. Department of Agriculture Commodity Distribution Program for school meal foods, as described in Chapter 6, outlines some of the challenges. The same may hold true for a supplemental feeding program such as the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) in which the foods purchased are consumed with other foods obtained from the general food supply. There are also arguments against holding Supplemental Nutrition Assistance Program recipients to the challenge of obtaining a low-cost diet with limited lower-sodium choices available for the types of food typically consumed. A recent Institute of Medicine (IOM) report recommended a reduction in the sodium content of school foods but did so in the context of a gradual stepwise approach in anticipation of lowering the sodium content in a way that was not discernible to participants (IOM, 2009) and to give school foodservice personnel and suppliers of the school meal programs time to respond and adjust their activities. This is consistent with discussions below.

While reductions of sodium levels in foods in the entire food environment appear to hold the most promise, the procurement and assistance programs can seek opportunities to obtain or require the purchase of lower-sodium foods that still maintain acceptable flavor profiles but serve to reduce sodium intake. Some reduction in intake is preferable to none at all. Furthermore, reformulations that would be required to secure large government contracts may result in increased availability of these lower-sodium products in other non-contract environments because companies may prefer not to reformulate to higher sodium levels for other contracts that lack sodium specifications. Finally, it was noted that in some cases, the existence of such programs offers the opportunity to teach participants ways to seek and use flavorful alternatives to foods with high levels of salt and sodium.

POTENTIAL FOR CHANGES IN THE REGULATORY STATUS OF SALT

Modification of the GRAS Provisions for the Addition of Salt to Food

The committee reviewed the issues surrounding the regulatory status of salt and concluded that the ability to adjust the generally recognized as safe (GRAS) status of salt is a potentially powerful and relatively adaptable regulatory tool. The potential of GRAS modification seems particularly promising given the failure of non-regulatory options to accomplish meaningful reductions in the sodium content of the food supply. In short, setting mandatory standards for the levels of salt in foods addresses many barriers to reducing overall sodium intake that have been identified as reasons for past strategy failures. GRAS modification can provide:

- Changes in the sodium content across all food categories and brands—important changes that have not been seen using voluntary approaches.
- A mechanism to reduce sodium in a gradual, consistent manner across the food supply to allow for changes in consumer taste preferences.
- A sustainable approach that will maintain sodium reductions over time.

The goal is clearly not to ban salt use or to make foods unpleasant for consumers, but rather to begin the process of reducing the excessive addition of salt to processed foods and restaurant/foodservice menu items in a way that is measured, informed, and deliberative. As such, the approach would need to be carried out gradually in a stepwise manner with extensive real-time monitoring to inform the ongoing process. A stepwise approach is consistent both with the interest in changing the overall salt taste preference by slowly reducing the levels of salt to which consumers are exposed and with information suggesting that reducing the level of sodium in foods gradually means that changes in flavor profiles are likely to go unnoticed or undetected. Rapid, major, and non-universal changes in the food supply will likely have negative impacts on the success of the program, ranging from consumers' decreased enjoyment of food to the food industry's inability to comply. While there is an inevitable tension between wanting to move quickly to protect public health and moving more gradually with informed decision making, it is evident that the only viable approach is a gradual, universal reduction if a sustained reduction consistent with achieving the goals of the *Dietary Guidelines for Americans* is to be accomplished. If initiated judiciously as part of an informed process, monitored extensively once implemented, and adjusted as needed, standards set for the levels of salt across the food supply should reduce sodium intake.

Rationale for GRAS Modification

The starting point for use of the available regulatory tools is the conclusion first voiced in 1979 that salt—given the levels at which it is currently added to the food supply—is no longer a substance for which there is a reasonable certainty of no harm. However, rather than conclude that salt's GRAS status should be revoked, the committee found that it would be possible to modify the conditions under which salt is considered to be GRAS, that is, to set standards for the addition of salt to foods. This allows salt to remain a GRAS substance, but a GRAS substance for which standards are set and conditions of use are specified so as to reduce the total levels of sodium in the food supply. In short, by taking into account current dietary recommendations for its consumption, salt is a substance for which a safe use level in foods can be set. This approach would be preferable to revoking the GRAS status of all uses of salt. Revoking GRAS status is not consistent with the notion that there is a safe level of salt use. In addition, revoking GRAS status could cause disturbances and changes in the food supply that would undermine consumer support for regulatory actions to protect their health while increasing the regulatory burden on both FDA and the food industry to potentially unacceptable levels. Further, revoking GRAS status is not consistent with the fact that sodium is an essential nutrient.

Modification of the GRAS status of salt underpins a new set of strategies that could effectively reduce sodium intake. It would address the concern that much of the sodium in the diet comes from sources largely outside consumers' direct control. Instructing consumers and providing labeling of foods, although critical, are not enough because they rely on individual behavior (Loria et al., 2001). Rather, an environmental change would not rely solely on human behaviors, which are difficult to change, and would have a faster and potentially greater effect than educational efforts aimed at increasing the consumption of lower-sodium products (Loria et al., 2001). There are some examples of the effectiveness of environmental change from the nutrition field, such as the fortification programs associated with folate and niacin. However, sodium presents some unique challenges that were not encountered in these previous fortification programs; for example, sodium has taste and functional effects in foods, whereas the folate and niacin changes to the food supply were flavorless to consumers and had potentially less serious functional effects on foods. This would indicate that monitoring and surveillance during implementation of such a change is essential. The concern may be mitigated somewhat by the likelihood that if the entire food supply were to be lower in salt, the overall taste preference for salt would be decreased, facilitating the acceptance of a reduction in the sodium content of food.

Given the ability of existing regulatory provisions to be used to set standards for the conditions of use of a substance added to foods as part of an overall long-term process that can be adjusted and modified over time based on monitoring and stakeholder input, FDA could develop mandatory standards appropriate to the conditions within the food market and the reality of current (and future) technologies. Such standard setting could also help to stimulate the development of new technologies and flavor alternatives.

Modifying the GRAS status of salt will be a complicated and challenging process for FDA. To initiate it will require considerable information gathering, detailed input from stakeholders, in-depth analysis of the food supply, use of simulation modeling of the effect of different levels of sodium content on total intake, examination of consumer eating behaviors, adjustments for food safety concerns, and studies of economic impact and potential unintended consequences. To ensure its success and responsiveness to emerging realities, extensive ongoing monitoring will be needed. All of these activities will require resources and time. However, on balance, its impact on reducing consumers' intake of sodium, its ability to provide the level playing field that has eluded the food industry when only voluntary activities are available, and its long-term sustainability are compelling arguments for recommending this effort. Further, by incorporating sodium reduction in the food supply as a regulatory activity, it ensures that relevant time lines for reductions will be established, adhered to in a systematic way, and monitored.

Stepwise Approach

Based on the available evidence related to the successful approaches for introducing lower-sodium foods to consumers as described in Chapter 3, a stepwise approach is essential.

First, the alternative to a stepwise approach—that is, a rapid, sizable, and non-universal decrease in the salt content of specific foods—would provide substantial, perhaps insurmountable, impediments to success. Although there is experimental evidence that individuals would after a time come to accept and even prefer lower-sodium foods following an abrupt decrease (see Chapter 3), consumers would likely initially reject such products as unpalatable and refuse to purchase and eat them. Unlike clinical or experimental situations in which persons are either highly motivated or compensated for continuing to adhere to such a diet, it cannot be expected that the average American consumer would find this acceptable. Testimony from the FDA hearings on the GRAS status of salt in 2007 acknowledged this problem.[7] In addition, the food industry discussion panel convened as part of a public information-gathering workshop for this committee's work (March 30, 2009) relayed this experience as common.

Second, there is support for a stepwise approach as a workable alternative to an abrupt decrease. Experimental evidence suggests that lowering sodium in the diet can be accomplished if the reductions are implemented gradually (see Chapter 3). Accordingly, if small reductions in all foods are instituted regularly and as part of a carefully monitored process that allows appropriate adjustments based on real-time data and outcomes, it would allow for meaningful reductions in the salt content of foods over the course of several years and, importantly, in a fashion that would be consistent with continued consumer enjoyment and acceptance of foods. The acquired taste preferences for high-sodium diets would be gradually reduced in conjunction with decreases in the salt content of foods across the food supply. Additional support for a stepwise approach has been provided by several food manufacturers that reported successfully using this strategy in their products at the committee's public information-gathering workshop (March 30, 2009).

Given the apparent advantages of introducing such changes in the food supply in a stepwise manner, FDA could consider its options for establishing a gradual implementation of the standards, whether through rulemaking or through other administrative procedures available under the law. Ensuring the successful implementation of standards using a stepwise approach requires that the agency and its stakeholders clearly explore a range of implementing issues including the rates and percentages of decrease in the sodium content of food that would constitute a gradual and workable step-down in sodium content. The standards could be established at the outset with the understanding that the approach is to be evaluated periodically, monitored in real-time, and adjusted as necessary to ensure both success in reaching the ultimate goal and continued support for the effort among consumers and the food industry. One such issue to monitor closely would be the acceptance of foods by consumers. A number of other unknowns would

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[7] Available online: http://www.regulations.gov/search/Regs/home.html#documentDetail?R=09000064803f8862 (accessed November 14, 2009).

need to be explored as well, including the extent to which certain types of high-salt foods could be retained in the diet and not adversely affect the modification of taste preferences toward lower sodium content.

It is important to address the suggestion that efforts to effect sodium reduction in the general food supply could be offset by the consumer's own actions to add salt back to foods. Indeed, this is part of the argument put forth in a recent paper by McCarron et al. (2009). However, there is no direct evidence to support such compensation for reduced sodium in foods. On the contrary, one study that experimentally evaluated this hypothesis failed to find substantial compensation. In this study, sodium levels in clinically prepared foods were decreased to reduce intake from an average of 3,100 mg/d to an average of 1,600 mg/d over a 13-week period, and subjects were permitted unlimited use of a salt shaker to salt their food to taste. Less than 20 percent of the overall sodium removed during food preparation was replaced by increased use of table salt—the use of which was measured without subjects' knowledge—resulting in steady maintenance of a sodium intake of about 1,800 mg/d for about 10 weeks (Beauchamp et al., 1987). These data suggest that even with consumers' additions of salt to foods at the table, significant reductions in sodium intake can be achieved.

Establishing Ongoing Evaluation to Further Inform the Stepwise Approach

An identified plan for and rigorous use of ongoing monitoring and evaluation system are central to the success of using standards for the sodium content of foods to reduce the overall intake of sodium. They will be critical to the success of the initiative. A number of unknowns cannot be elucidated fully at this time, and the activity will depend on an integration of factors and consequences that will change over time and are likely to interact in ways that cannot be anticipated. The role of evaluation in the activity of setting standards for the addition of salt to foods and adjusting their implementation as needed is illustrated in Figure 8-1. This illustration is hypothetical and is meant to only outline the process generally and is not intended to suggest any specific number of iterations or a specific timeframe.

The process for establishing standards for the addition of salt to foods would begin with the needed information gathering that precedes notice-and-comment rulemaking, and could be extensive. The rulemaking would establish both the ultimate standards for foods in the food supply (the goal or maximum final level) and the initial starting point for specific standards as well as tentative targets for the timing of stepwise reductions.

During notice-and-comment rulemaking, the comments, information, and data submitted will inform the GRAS modification process as it is initi-

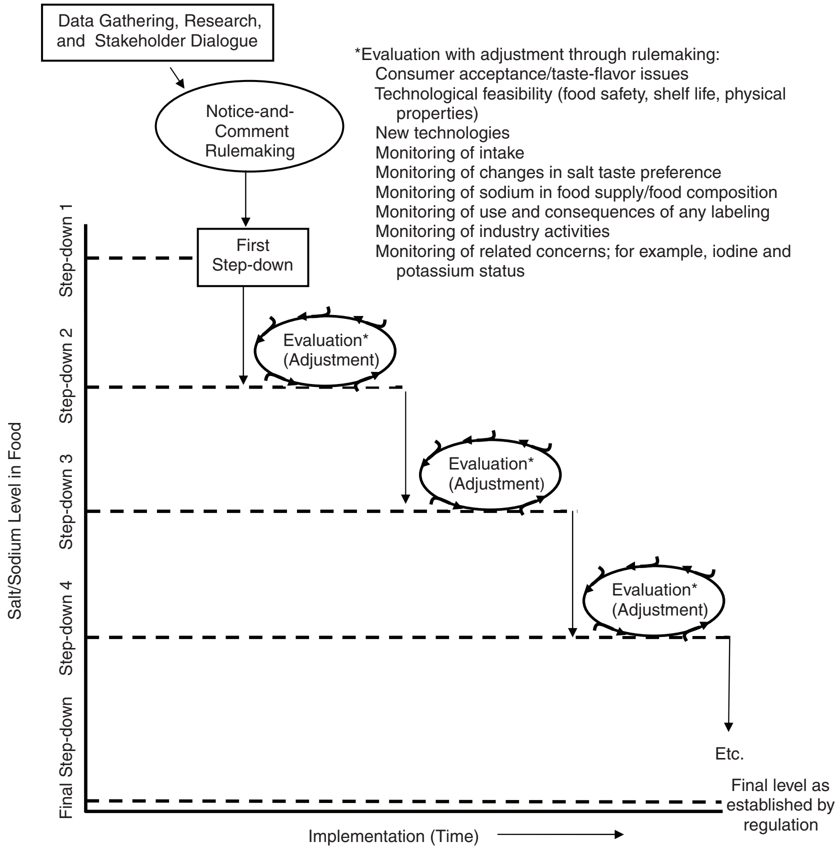

FIGURE 8-1 The path to achieving final standards for the addition of salt to foods: the need for monitoring and evaluation to inform the stepwise approach with a hypothetical number of steps.

ated. However, it is unrealistic to assume that further data will not emerge after the first implementation steps are put in place. In recognizing that experience and new research as well as monitoring could continue to inform the process as the stepwise approach continues, the committee's recommendation that the GRAS modification process be carried out in a stepwise fashion enhances the ability to ensure appropriate and effective implementation and allows for adjustments as needed throughout the process.

Moreover, the step-down process will allow time for adaptation of consumer taste preference for salt added to foods and for industry to deal with technical challenges. The number of step-downs actually needed may be food category specific (see Chapter 10) and may vary on a number of factors elucidated during notice-and-comment rulemaking. As implementation of the step-down process takes place, evaluation is conducted and adjustments are made before each step occurs. The nature of the evaluation is multifaceted. It is essential that methods be in place to monitor consumer acceptance of the changes to taste, flavor, and texture, as well as to detect any limitations that may be reached related to food category quality and product safety. Likewise, the ability to use and implement new technologies and their feasibility would benefit from monitoring. Information gathering related to changes in sodium intake, changes in salt taste preference, the consequences of any labeling used, and industry activities would also be useful. This system will also serve as an early warning of any unintended consequences such as measures related to ensuring adequate levels of iodine in the food supply and the avoidance of excessive potassium intake that may be a risk to persons using certain medications. Further, it has recently been argued (see Chapter 3) that sodium intake is physiologically regulated at levels that are well above the recommendations of the *Dietary Guidelines for Americans*. Although evidence for this is weak, a gradual stepwise reduction strategy would permit regulators to monitor for evidence of this and to modify their regulations accordingly.

Restaurants/Foodservice Operations

The evidence that restaurant/foodservice operations contribute significant amounts of sodium to the American diet (see Chapter 5) means that efforts to reduce the overall sodium content of such foods should be consistent with activities pertaining to the rest of the food supply. The provisions related to setting GRAS standards for the addition of salt to processed foods can, at a minimum, be applied to standardized/chain restaurant and foodservice operations. Such operations range from table service establishments to fast food outlets. The menu items that are offered by these standardized/chain operations are uniform and specified in ways similar to processed foods; the logistics of developing and applying standards for the addition of salt could be similar; and as discussed in Chapter 7, FDA authority does extend to such activities. The data-gathering step that precedes rulemaking would benefit from gathering relevant information on the nature of the standardization that would be appropriate for the purpose of implementing standards for the addition of salt to foods in the case of restaurant/foodservice operations.

The feasibility of extending standards to restaurant/foodservice operations that are termed independents or that do not have standardized menus (see Chapter 6) is questionable at this time. Small restaurant/foodservice operations often do not have standardized recipes and menus can change on a daily basis. This may also be the case for larger operations that service a variety of clients with highly variable menus. In addition, small operations may lack the training and resources that would be needed to ensure that their foods met sodium standards—a factor that is less likely to be an issue for chains that have corporate research staffs. These realities create challenges for implementing standards to small operations. However, the contribution of smaller-scale and more diverse operations to reduction of sodium intake by the U.S. population should not be overlooked. It is the committee's opinion that while it is most likely that highly standardized operations and larger chains—which structurally are more like a processed food industry than an independent, local restaurant—will be more capable of working with federal regulations, it is also likely that through this process ways will become clear over time for working with smaller operations that are initially exempt. Given the unfamiliar and disruptive nature of reaching into independent restaurant settings, this can only be accomplished slowly and as part of an informed experience that the committee intended in recommending a stepwise approach that will expand and grow over time.

However, strategies can be adopted to promote sodium reductions in the menus and menu items of small and non-standardized restaurant/foodservice operations. Since many of these types of operations use preprocessed foods to reduce preparation time, standards for salt addition to these foods would have an impact on the final sodium content of menu items as served. In addition, training efforts could be used to educate food preparers and operation owners on ways to reduce sodium in their menu items and develop menus with a greater number of lower-sodium options (e.g., more foods that are naturally low in sodium, reduced portion sizes). This topic is discussed further in Chapter 10 on next steps. Ensuring that restaurant/foodservice operations are given focused attention to "get on board" with sodium reduction activities is important to increasing the ability to create a level playing field for the food industry, even if the methods used for such operations are not initially based on regulated standards of sodium use.

Related Considerations

Sodium enhancement solutions The public interest surrounding the use of the existing regulatory framework has centered primarily on packaged foods under FDA jurisdiction. However, it is worthwhile to note that the statutory provisions employed by FDA extend to uses of salt when added to foods under the jurisdiction of other federal agencies. For example, the safety of sodium enhancement solutions intended to tenderize raw meat and poultry products[8] is subject to FDA oversight, even though meat and poul-

[8] Sodium enhancement solutions (see Chapter 7) are also used for raw seafood products, which are under FDA jurisdiction.

try are under the jurisdiction of the U.S. Department of Agriculture (USDA). Thus, these uses of salt-containing compounds would be encompassed by FDA considerations relative to modifying the GRAS status of salt.

Application to restaurant/foodservice operations The regulatory framework that underpins the GRAS status of salt can be applied to many foods currently offered by restaurant/foodservice operations. As discussed in Chapter 7, because the components of the finished food product served to customers will have moved in interstate commerce, the finished product itself can be subject to the *Federal Food, Drug, and Cosmetic Act* and, thus, standards can be set by FDA.

On this basis and with recognition that many implementing issues would need to be addressed, there is considerable benefit to be gained by considering restaurant/foodservice menu items, particularly for heavily standardized operations, in the establishment of GRAS standards. While it must be recognized that such activities would be challenging and will undoubtedly require considerable analysis as part of a public process carried out by FDA, the facts regarding the contribution made by foods eaten away from home to total dietary intake are concerning and point to the clear need to extend efforts to reduce the sodium content of the food supply to restaurant/foodservice operations. This expansion of requirements and standards for salt content to the domain of restaurant/foodservice operations would be assisted to some degree by the likelihood that these operations use many processed foods, and those processed foods will have had to comply with new GRAS standards for sodium content. Large foodservice operations, such as chain restaurants and fast food outlets, function with respect to product development more like processed food manufacturers than do independent, special-occasion restaurants.

Prior-sanctioned uses of salt In its 1982 Policy Notice (HHS/FDA, 1982) discussed in Chapter 7, FDA noted salt use in processed food that may have received specific approval for some manufacturers prior to 1958, primarily in FDA standards of identity. These specific uses are deemed "prior-sanctioned" (as described in Chapter 7) and are excluded from food additive regulation on that basis. In undertaking the use of its food additive authority to reduce levels of sodium in food, FDA would have to resolve which uses are prior-sanctioned and which are not. These uses are likely small in number and responsible for relatively minor contributions to the food supply. For completeness, the agency may choose to address such use through a variety of venues stipulated in the act.[9]

[9] 21 USC 342(a).

Regulatory status of other sodium-containing compounds Sodium can be added to foods in ways other than by the addition of salt. As discussed in Chapter 4, an array of sodium-containing compounds is approved for use in foods; these have a wide range of functions from processing effects to reducing pathogens. While it is clear that much of the sodium added to foods comes from the addition of salt, it is not clear how much sodium is attributable to these other compounds and whether their contribution to total sodium intake has increased. Therefore, it would be important for FDA to closely examine these other sources of sodium, take into account their conditions of use and function in food, and in turn integrate their presence in the food supply into considerations for reducing the overall sodium content of the food supply and achieving sodium intake consistent with the *Dietary Guidelines for Americans*.

Resource and Cost Issues

Undoubtedly, regulatory activities require resources and there are costs associated with development, implementation, and enforcement of such provisions. In the case of setting standards for salt and sodium in foods, there is also a considerable need for initial costs for information-gathering, research, and related resources for rulemaking. However, such costs cannot now be enumerated or characterized, and are dependent upon decisions made by policy makers.

Approaches to Modifying the GRAS Status of Salt

Determination of the quantitative levels of salt that should be considered to be GRAS and of the specifics of the appropriate implementation of GRAS changes is beyond the scope of this committee's work. Rather, it is imperative that setting such levels benefits from additional data that will be submitted in response to the anticipated FDA announcement of proposed rulemaking and collated by the agency. Based on its review and as described in Chapter 10, the committee considered implementation possibilities for modifying the GRAS status of salt. It anticipated that the overarching goal could be to specify as GRAS the uses and use levels of salt that allow persons to consume such foods as part of a normal diet with a reasonable likelihood of keeping their total daily intake of sodium consistent with the *Dietary Guidelines for Americans*.

In this context, the committee's discussions focused on (1) a food category framework for determining the allowable levels of salt in foods; (2) consideration of special labeling or disclosure statements as part of the stepwise implementation activities; (3) consideration of exemptions for a limited number of high-sodium foods; and (4) the nature of relevant notice-and-comment rulemaking (see Chapter 7).

SUPPORTING CONSUMERS TO MAKE DIETARY BEHAVIOR CHANGES

The committee considered a food supply approach to reducing sodium intake to be central to achieving meaningful reductions of sodium in the diet. Such an approach is needed because in the current food environment, it is difficult for even the most motivated consumers to assemble a diet with healthful levels of sodium. However, it was recognized that consumer-based initiatives can play an important supporting role as part of a larger public health intervention. As stated by Loria et al. (2001), "both environmental changes and increased educational efforts are required for a truly effective approach toward reducing sodium in American diets." A lack of implementation and evaluation information on past initiatives limits the ability to draw firm conclusions on how future efforts might avoid repeating past failures. However, some potentially useful approaches for creating consumer awareness and stimulating behavior change can be highlighted.

National Focus

As is often the case with consumer outreach, efforts targeted at sodium reduction will likely benefit from a coordinated effort that uses the latest science on social marketing and other health communication approaches for educating and motivating consumers. Such a coordinated effort will ensure a broad reach and consistent messages that will help to avoid consumer confusion that might arise from uncoordinated education initiatives. Given the public health mission that rests with the federal government, as well as the clear national priority to reduce sodium intake, the most logical focal point for renewed and coordinated efforts to reach consumers is the federal government. In addition to offering a national and prominent locale for efforts to spearhead reduction of sodium intake, the activities could also be linked to relevant programs related to the *Dietary Guidelines for Americans* initiative.

In turn, collaboration with a diverse set of stakeholders, coupled with the development of public-private partnerships, is also thought to be essential. State and local governments, health professionals, educators, the media, private foundations, corporations, and the food industry all have a role to play. Important goals include building on existing knowledge, obtaining new information through research, and seeking input from other fields of study in order to build a basis upon which to design effective programs to assist consumers in better navigating and supporting changes in the food environment to reduce sodium intake. Consumer initiatives should also maintain consistent overall messages that can also be tailored to most effectively reach and motivate different subpopulations (see Recommendation 4). Further, the need to evaluate ongoing and future efforts in order to measure overall success and make adjustments as activities are informed by experience is critical.

In order to realize the potential, a national campaign focused on consumers and the reduction of sodium intake is needed. Key components to ensure the success of the campaign are:

- a broad range of collaborative partners;
- incorporation of behavior change models;
- planning activities undertaken as part of a public process;
- a strong evidence base to guide campaign planning and design to ensure the best use of campaign resources;
- renewed efforts to develop effective and appropriate messages related to reducing sodium intake that include integration with broader messages about diet and health;
- clear coordination with policy initiatives targeting changes in the food supply; and
- periodic evaluation of campaign costs and effectiveness.

Several key factors are highlighted below.

Behavior Change

Consumer-based initiatives to reduce sodium intake could benefit from the incorporation of behavior change models. The socioecological model provides a useful framework exploring the interacting multiple levels of influence and underscores the need to coordinate changes in the food environment, including changes in the food supply, with health communications aimed at individuals. Theories predicting the diverse factors influencing health behaviors, such as sodium intake, need to guide the development of health communications as well as research aimed at improving the effectiveness of these strategies. While it is accepted that knowledge and attitudes as well as access to resources are important starting points for behavior change, additional factors come into play to achieve such change. The nature of these factors for sodium, especially in the face of the compelling nature of salt taste, has not been clearly elucidated. Moreover, the operationalization of a model of behavior change for sodium intake reduction that would apply population-wide in coordination with and support of changes in the food supply is desirable.

Education

In terms of education, three very basic needs are readily apparent. First, it is critical to dispel the prevalent misunderstanding that sodium intake is a concern relevant only to persons who (1) are "salt sensitive," (2) have hypertension, or (3) are middle-aged or elderly. The adverse effects of sodium occur at all stages of the lifespan, and a lower sodium intake is a public health goal for every segment of the population (see Chapter 1). Second, consumers must be more cognizant that sodium is present in a broad range of foods, not only those that taste salty or contain visible salt. In the absence of this understanding, consumers misinterpret the effectiveness of their food choices in avoiding sodium. Evidence presented in Chapter 2 reveals that in one survey approximately three-quarters of persons exceeding the recommended intake believed that their intake was "about right." This is, of course, in marked contrast to current estimates showing that virtually all persons exceed the recommended intake level. In the absence of a simple clinical measure for sodium similar to the serum measures used for cholesterol determinations, a know-your-number campaign is not possible. However, it does provide a segue into the third concern, which is developing better label-reading skills among consumers so that the sodium values of foods are understood and used to choose foods comprising a healthful diet. For example, many consumers may believe that if they avoid foods that are considered to be "salty" (i.e., potato chips, popcorn, and pretzels), they will reduce their sodium intake. In actuality, these foods only contribute about three percent of sodium to the diet, where as meats and grains contribute approximately 16 and 11 percent, respectively (NHANES 2003–2006; also see Chapter 5). This is especially important because the goal is not a diet free of sodium—as may be the case for a substance such as *trans* fat produced through partial hydration of vegetable oil—but rather that consumers avoid excessive intake while achieving a nutritionally adequate diet.

Coordinated Messages

The development of appropriate messages will require an extensive breadth of expertise and related research. Attention will be needed to ensure that messages are consistent in describing the risks of excess sodium intake and actions consumers can take to modify their sodium consumption (see Recommendation 4). The consistency of these messages will hopefully help to prevent consumer misunderstanding about whom should be concerned about sodium and the best methods for reducing intake. While messages should be consistent, tailoring messages to the behaviors and interests of specific cultural groups and dispersing these messages through communication channels that are known to reach specific groups may also be beneficial.

It is likely that the focus of coordinated messaging should extend beyond developing specific messages for sodium by integrating the issues important for sodium intake reduction into existing, broad messages about diet and health. For example, guidance related to weight control—primarily guidance on lowering calorie consumption and reducing portion sizes—could result in lower sodium intake, because sodium intake tracks with calorie intake; however, at current average dietary sodium density, calorie control alone would not generally achieve recommended sodium intake limits. Also, messages about increasing the consumption of fruits and vegetables could have beneficial impacts on sodium intake. Overall, consumers may have difficulty focusing on a multitude of different messages about diet and health, and as a result sodium messages may compete for consumer attention with other key issues such as reducing obesity and increasing fruit and vegetable consumption. However, coordinating the sodium message with existing general messages about diet and health consistent with the *Dietary Guidelines for Americans* coupled with some specific messages targeted to sodium may promote a better outcome. Research and consumer testing of health messages related to sodium have been neglected and could support the role of consumers in reducing their sodium intake.

Outreach Opportunities and Tools for Consumers

Despite the importance of reducing sodium intake as a public health priority, relatively few tools and support initiatives have been put in place. For example, MyPyramid,[10] one of USDA's major consumer initiatives for dietary change consistent with the *Dietary Guidelines for Americans*, does not currently include sodium as an area of focus. That is, sodium levels are not factored into the MyPyramid Plan or the MyPyramid Menu Planner tools. There is a footnote in the MyPyramid Menu Planner explaining that sodium cannot be calculated accurately using the tool because sodium levels vary so much within similar foods.

The National Heart, Lung, and Blood Institute (NHLBI) is probably the agency most readily recognized as a federal leader in the area of dietary sodium reduction. The primary mission of NHLBI, however, is not to produce consumer-oriented toolkits or related enabling tools, but to facilitate research on topics relevant to its mission through a system of grant awards. Nonetheless, through what might be termed "ancillary" activities, NHLBI has provided a number of enabling tools for dietary change related to sodium intake, and it would be useful to enhance research related to such materials. The National High Blood Pressure Education Program is a cooperative effort involving professional and voluntary health agencies, state health departments, and community groups. Outputs that could be developed or enhanced include fact sheets, pamphlets, and brochures dealing with lifestyle changes; planning kits, posters, and print ads; radio messages;

[10] Available online: http://www.mypyramid.gov (accessed October 27, 2009).

messages on social media networks; and working group reports. NHLBI also produces materials for physicians to help them guide patients to more healthful lifestyles, another critical area of focus (NHLBI, 2004).

Further, although there is evidence that health professionals and their associations support initiatives to reduce sodium intake, there is less evidence that physicians actively incorporate sodium intake awareness as part of primary care. Health-care professionals, including physicians, need to counsel patients about the health risks associated with high sodium intake and how to reduce sodium intake (Mohan et al., 2009). Therefore, it is necessary to incorporate sodium reduction strategies and their importance to reducing the risk of chronic disease into health professional training curricula and standards of care (WHO, 2007).

The U.S. Centers for Disease Control and Prevention (CDC) supports state efforts to enable public health changes, including efforts to address high blood pressure as a cardiovascular risk. Under the State Heart Disease and Stroke Prevention Program, CDC funds health departments in 41 states and Washington, DC, to plan, monitor, and sustain population-based interventions that address cardiovascular disease (CVD) and related risk factors.[11] The strategies focus on a specific population or geographic area. Of the broad activities that states are funded to carry out, several could incorporate sodium strategies. These programs include developing and updating state plans for CVD prevention, assessing existing population strategies for CVD prevention, emphasizing policies to create heart-healthy environments, increasing adherence to guidelines related to hypertension, increasing awareness and education about risk factors and lifestyle changes, and implementing and evaluating community interventions to promote cardiovascular health. In fact, a recent IOM committee (IOM, 2010) recommended that CDC's Division of Heart Disease and Stroke Prevention take active leadership in convening other partners in the federal, state, and local government, and industry, to advocate for and implement strategies to reduce sodium in the American diet. That committee also recommended that all state and local public health jurisdictions immediately begin to consider developing a portfolio of dietary sodium reduction strategies that make the most sense for early action in their jurisdictions. The committee report also concluded that because some evidence indicates that taste preferences develop early and excess sodium intake is a problem across the lifespan, early education may be key to reducing intake in future generations. It points out that such programs may also be critical for reaching groups, such as adolescent males, that have some of the highest sodium intakes.

Finally, the question of the role of food product advertising in a set

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[11] Available online: http://www.cdc.gov/DHDSP/state_program/index.htm (accessed October 27, 2009).

of strategies to reduce sodium intake is not readily addressed. Activities intended to sell products that have been reformulated with reduced sodium are likely to play an outreach role that could be significant, given the dollars available for food advertising compared to those likely to be available for purely educational outreach (by government and others) with respect to sodium. The nature and extent of such activities cannot easily be predicted, particularly in light of comments from industry participants during the committee's public information-gathering workshop (March 30, 2009) that past attempts to promote low-sodium food lines have been less than successful, leading some companies to refocus their efforts on "silent" (unadvertised) sodium reduction. When public attention is focused on the need for sodium reduction and industry decides to promote sodium-reduced products, the Federal Trade Commission, which is charged with protecting the public from false or misleading advertising and promotion, will need to engage to assure that explicit and implicit promotional claims are supported by science. Conversely, there is the question of bans on advertising for high-sodium products and/or mandatory disclosures. With respect to foods and beverages, Congress has been reluctant to constrain advertising, even to children (IOM, 2006), and First Amendment rights would be a consideration. However, an alternate approach might be the development of voluntary standards by the industry. The issue of advertising as it relates to high-sodium foods targeted to the general population is a topic not yet ready for exploration as a strategy.

Nutrition Labeling: Point-of-Purchase Sodium Information for Consumers

Label Reading and Interpretation

It is clear that efforts to improve the frequency of use and understanding of the Nutrition Facts panel on food labels are needed. As with all tools, some basic guidance is required to ensure that this tool is used and used properly. While there is a gap in consumer education in this regard, it is also true that the nutrition labeling provisions are now more than 15 years old. Newer information about how consumers use and interpret such information for all nutrients including sodium has been emerging since the implementation of the Nutrition Facts panel. As suggested by FDA itself (HHS/FDA, 2007), it is time for reevaluation and revision of some aspects of nutrition labeling. Further, CDC, FDA, and USDA, along with Congress, have signaled interest in exploring the utility and appropriateness of "front-of-package" nutrition labeling to assist consumers.[12] At this time the main

[12] Available online: http://www.fda.gov/Food/LabelingNutrition/LabelClaims/ucm187369.htm (accessed October 27, 2009).

focus for front-of-package labeling is often calories, but other substances including sodium are also considered candidates for such labeling. To the extent that the discussion is expanded to other nutrients, it would be appropriate to include sodium. Should research show that information about sodium can be incorporated into front-of-package labeling to the benefit of consumers, it would be worthwhile to provide this added tool to help consumers reduce their sodium intake.

Daily Value for Sodium

Another aspect of the Nutrition Facts panel worthy of attention is the Daily Value (DV) for sodium as described in Chapter 7. FDA has asked whether the DV for sodium should be updated based on a reference value of adequacy as opposed to a reference value of safety (HHS/FDA, 2007). The committee considered the following:

- The purpose of the DV declaration is to help consumers set the contribution of the nutrient in a serving of that particular food within the context of a total daily diet.
- The DV generally is:
    - based on a reference value of adequacy when the nutrient is an essential nutrient; and
    - based on a reference value of safety when the nutrient is non-essential (e.g., saturated fat and cholesterol).
- Despite the fact that sodium meets all scientific criteria as an essential nutrient, a reference value of safety instead of a reference value of adequacy was used for sodium in 1993 because there was no available reference value for adequacy at the time.
- In 2005, a reference value of adequacy was established for sodium, known as the Adequate Intake (AI).
- Use of the AI could better inform consumers of the actual contribution of sodium content to total sodium needs as an essential nutrient and avoid misleading consumers into thinking that the sodium content of foods is more favorable than is actually the case.
    - As discussed in Chapter 2, consumers think that their sodium intake is better than it actually is, and intake has not decreased in association with current nutrition labeling. This indirect evidence supports the use of the AI; however, studies that provide direct evidence are needed.

The basis for the DV for sodium should be the AI. Given a 2005 report from the Institute of Medicine that has now identified a reference value of adequacy for sodium intake (i.e., the AI) (IOM, 2005), this reference value should now be incorporated as the basis for the DV for sodium (see Recommendation 3). Its use makes the derivation of a DV for sodium consistent with the approach used for all other essential nutrients. From the perspective of technical feasibility, there are no limitations or challenges to using the Adequate Intake as the basis for the DV as the declaration within the Nutrition Facts panel is a factual statement of sodium content.

The committee considered whether lowering the DV for sodium would act as a disincentive to industry to make sodium claims, and it concluded this would be unlikely as a general matter. A change in the DV for sodium would not change the basis for "free," "reduced," "less," or "light" claims because they are based on either the absence of sodium or a comparison to sodium levels in a reference product. While the claims "low sodium" and "very low sodium" would be affected because the DV forms the quantitative basis for the claim, there are opportunities to review the basis for these claims to ensure they remain meaningful and serve their purpose.

There is also the possibility that lowering the DV for sodium will act as an incentive for most companies to reduce the sodium content of their foods. Reducing the DV would mean that labels would indicate that products contain a higher percentage of daily recommended intake than they had previously shown. Producers, wanting to appeal to concerned consumers, would have incentive to lower sodium in their products so that the Nutrition Facts panel would show the product to have a lower contribution to daily intake. Overall, such changes could have a dramatic impact on the food supply even if it would raise challenges for making "low" sodium claims on a certain number of products.

Restaurant/Foodservice Operations

Finally, the utility of point-of-purchase information for foods offered by restaurant/foodservice operations is worthy of consideration. Given that a large percentage of food consumed by the U.S. population is obtained from restaurant/foodservice operations, the absence of information similar to the Nutrition Facts panel is a concern. Eating out is no longer reserved for "special occasions," and consumers undoubtedly need such information when making selections in a restaurant just as they do when making selections in the grocery store. As a step toward providing consumers with more nutrition information when eating out, the *Patient Protection and Affordable Care Act*[13] contains provisions to address nutrition labeling of menu items. Restaurants with 20 or more outlets are required to post calories on menus, menu boards (including drive-thrus) and food display tags, with additional information (including sodium, fat, saturated fat,

[13] *Patient Protection and Affordable Care Act*, HR 3590, Title IV, Subtitle C, § 205; 111th Congress, 2nd session, March 2010.

carbohydrates, protein, and fiber) available in writing upon request. Given the challenges of labeling foods consistently across the entire universe of restaurant/foodservice operations, the Patient Protection and Affordable Care Act did not require smaller operations to use such labeling. However, voluntary labeling for smaller restaurant/foodservice operations would also be useful to consumers.

One potential obstacle to making nutrition labeling, and specifically sodium labeling, possible for all restaurant/foodservice establishments is a nutrition labeling exemption for products distributed only to restaurant/foodservice operations. Requiring nutrition information on foodservice products would both help all restaurants in providing sodium information to consumers and help establishments monitor and lower the sodium content of their menu offerings.

Nutrient-related claims are another potential aspect of restaurant/foodservice labeling that is worthy of consideration. The Nutrition Labeling and Education Act stipulates that the rules for nutrient content and health claims are germane to "labeling," and menus are characteristically considered to be labeling. As described later in this chapter in the context of providing incentives to the food industry, there are options by which provisions for sodium claims could be extended to restaurant/foodservice operations and thus provide some additional information to all consumers at the point of purchase.

Labeling of Raw Meat, Poultry, and Seafood

Under current regulations, raw meat and poultry products are exempt from nutrition labeling even when packaged for retail sale (see Chapter 7). However, such products do contain sodium enhancement solutions and therefore can be a source of sodium in the diet. This is also the case for seafood, which is subject to the use of sodium enhancement solutions as well and for which nutrition labeling is voluntary on the part of the producer. While the labeling of such non-uniform products is challenging in the same way that labeling fresh produce is challenging, it would be worthwhile to explore approaches to the use of labeling that would make the presence of sodium known to the consumer.

Nutrition Claims: Point-of-Purchase Sodium Information to Assist Consumers and Offer Incentives to the Food Industry

While the *Nutrition Labeling and Education Act* of 1990 was intended to help consumers compare and select foods that lead to healthful diets, its focus also included the food industry. The aspects of the act that relate to standards for allowing claims on the labels of packaged foods about the nutritional content of the product were viewed as offering incentives to food manufacturers as well as quickly signaling to consumers the desirable attributes of food products. During the development of *Nutrition Labeling and Education Act* (NLEA) regulations, it was assumed that food product marketability would be enhanced if products bore label statements or claims about the nutrient content of a food product or touted the ability of the nutrients present in (or absent from) the food to reduce the risk of disease. In turn, it was anticipated that manufacturers would be incentivized to reformulate foods to meet the standards for the claims.

Failure to Use Claims

It would appear that neither the call for the food industry to voluntarily reduce sodium intake nor the ability to make claims about the reduced levels of sodium in food products has seriously impacted the overall content of sodium in the food supply or the consumer's intake of sodium. The label surveys described in Chapter 2 revealed that claims about the sodium content of packaged foods are not widely used by food manufacturers. There is the parallel concern, not clearly documented but discussed during the committee's public information-gathering workshop and also highlighted in Chapter 6, that use of claims about lower-sodium content may signal to the consumer that the food will be less tasty than its non-sodium-reduced competitors. The reasons for the failure of sodium content and health claims to be used are undoubtedly complicated and not well understood, but the evidence would warrant revisiting the requirements currently established for such claims, especially those related to the extent of sodium reductions required to make a claim.

Future of Sodium-Related Claims

There is the possibility that the specifications underlying the provisions for sodium claims may be overly ambitious. They are applied equally across all food categories and may not take into account the need to decrease the salt content of foods gradually in order to assist the consumer in making taste adaptations, as well as giving manufacturers time to seek newer techniques for lowering sodium levels in foods. Of particular note are the regulations for the claim "healthy." The provisions did include a step-down approach to be implemented over time, but the step-down was deferred on the basis of arguments from the food industry that such reductions could not be achieved while providing products that could successfully compete against those containing higher levels of salt. It may be that the regulatory starting points for such claims are not appropriately set or that the nature of the anticipated step-down in the levels for such claims should be explored (see Recommendation 3). This may parallel anecdotal reports suggesting that the food industry tried to move too far too fast, giving rise to the current consumer perception that a label claim about reduced or low sodium equates with an unpalatable product. Alternatively, the industry may have been aiming for a niche market and been unsuccessful in achieving palatability at a level that could compete.

Nonetheless, claims about the sodium content of food products implemented under the NLEA provisions in principle remain a helpful signal to consumers and should be a useful adjunct to stimulate food manufacturers to reformulate their products. The Grocery Manufacturers Association (GMA, 2008) and food industry participants in the public information-gathering workshop held by the committee (March 30, 2009) have suggested that the current requirement for a minimum reduction of 25 percent for reduced-sodium claims is counterproductive to the stepwise approach. It may be useful to consider the potential benefits of permitting reduced-sodium claims for cumulative changes that would be consistent with the approach of stepwise reductions. In undertaking any revisions to these requirements, FDA and USDA will need to strike a difficult balance between providing for claims that reflect truly healthful reductions in the sodium content of food and protecting the consumer from a plethora of meaningless claims based on relatively inconsequential reductions.

Further, in the context of reaching standardized restaurant/foodservice operations in the same manner as processed foods, there is value in giving the same opportunities and incentives to restaurant/foodservice operations. In implementing the 1990 NLEA, FDA limited its regulations for claims to packaged foods; as appropriate, however, the regulations could be expanded to menu items as discussed in Chapter 7. FDA could now undertake activities to provide for sodium content claims and related health claims on menu items offered by restaurant/foodservice operations that are sufficiently standardized for implementation to be practically accomplished. It was concluded that such measures might provide greater opportunities for consumers to make informed choices while eating away from home. However, it was also recognized that there will be a need for preliminary activities to gather data and background information about restaurant/foodservice operations and to carry out stakeholder dialogues in order to develop and then implement workable regulations for sodium claims to be used by such operations.

POTENTIAL UNINTENDED CONSEQUENCES OF REDUCING SODIUM ACROSS THE U.S. POPULATION

All public health initiatives have the potential to cause unintended consequences. Efforts to anticipate how such consequences could manifest themselves and to incorporate activities to avoid them are prudent. Likewise, systems to monitor and evaluate the impact of such programs closely over time help to track the possibility of such consequences and identify those that emerge in unexpected ways. The section identifies four unintended consequences that are potentially associated with the implementation of strategies to reduce sodium intake. Awareness of such consequences among the medical and public health communities will be essential for ensuring that any such adverse events are quickly identified and mitigated.

Adverse Effects of Low Sodium Intake

Concerns have been raised that low sodium intake adversely affects plasma renin activity, sympathetic nervous system activity, blood lipids, and insulin resistance. The suggestion is that attempts to achieve the levels recommended in the *Dietary Guidelines for Americans* on a population basis would place some persons at risk.

When sodium intake is reduced, there is a physiological stimulation of counter regulatory hormone systems, specifically the renin-angiotensin system and the sympathetic nervous system (IOM, 2005). These compensatory responses are much greater with abrupt large changes in sodium intake than with gradual reductions (Sagnella et al., 1990) as currently recommended. Furthermore, in contrast to the well-accepted benefits of blood pressure reduction, the clinical relevance of modest rises in plasma renin activity as a result of sodium reduction is uncertain.

Other studies have examined the effects of changing sodium intake on lipids, glucose tolerance, and insulin sensitivity. Adverse changes have been noted in some studies, but these studies often involved a very large change in sodium intake for only a few days. In the largest and longest controlled trial that addressed the effects of sodium reduction on blood lipids, there was no significant effect of sodium levels within the recommended range of intake (Harsha et al., 2004). Accordingly, the IOM, as part of its Dietary Reference Intake development process for nutrients including sodium, concluded that at the level of intake consistent with the reference value, the preponderance of evidence does not support the contention that the recommended intake would adversely affect any of these measures (IOM, 2005).

Food Safety

Because salt and other sodium-containing compounds function as food preservatives, efforts to reduce their presence have the potential to impact the safety of the food supply.

Past efforts to reformulate foods to improve their nutrient composition have occasionally resulted in foodborne illness. A well-known example is an effort to make sugar-free hazelnut conserve for use in reduced-calorie yogurt products in the United Kingdom (Entis, 2007). The conserve maker substituted aspartame for sugar without altering the rest of the formulation and without altering processing. The sugar present in the original formulation prevented the growth of *Clostridium botulinum*, but with its removal, this organism was able to grow and eventually led to the death of 1 person and serious illness in 25 others. This event is an example of the unfortunate outcomes that are possible if the safety-related functions of ingredients are not considered during reformulation. However, such events are preventable with adequate food safety expertise and product testing.

Consistent with FDA authorities and mission, the proposed changes to the status of GRAS substances must be demonstrated to be safe before they can be incorporated into regulation and implemented. To avoid problems from occurring during sodium reduction, food companies generally evaluate the potential for reduced sodium levels to increase food safety risks and engineer additional hurdles to microbial threats (as described in Chapter 4) into the product. In addition, it is generally standard practice to validate the safety of new and reformulated products using shelf life testing. The results of these tests will determine the limits of sodium reduction for specific food products and provide information that can be used to educate the standard setting process for acceptable conditions of use. Such testing, for example, may help to determine the potential for the growth of *Listeria monocytogenes*—an organism that has raised food safety concerns during UK efforts to reduce salt—in reduced-sodium deli meats or cheeses (Advisory Committee on the Microbiological Safety of Food ad hoc Group on Vulnerable Groups, 2008). Such testing is time consuming, requiring that adequate phase-in periods be provided to ensure that the push for a lower-sodium food supply does not result in unintended food safety problems. Smaller companies may not have as great a capacity to quickly undertake the studies needed to ensure the safety of reformulated foods and may need more time to meet sodium reduction goals than larger companies with significant resources for research and development. Specialized guidance from FDA, trade associations, and the Cooperative Extension service may also help to fill knowledge gaps in companies with limited research and development staffs. With sufficient guidance, standards for conditions of use that recognize food safety limitations, and the regular practice of validating product safety with shelf life testing, most food safety concerns should be avoidable.

Iodine Insufficiency

Until the 1920s, endemic iodine deficiency was a major public health problem in the Great Lakes, Appalachian, and Northwestern regions of the United States (Pearce, 2007). The introduction of iodized salt on a voluntary basis by manufacturers and extensive public education programs by health officials to encourage consumer use of this product resulted in the virtual elimination of goiter in high-risk regions. The question then arises as to whether strategies to reduce salt intake by the U.S. population will result in the unintended consequence of increasing the risk of iodine insufficiency and deficiency among high-risk groups.

To answer this question, it is important to determine the current iodine status of the U.S. population and to anticipate the potential effect of reduced salt intake on iodine status. However, assessing the iodine status of the U.S. population is challenging. Intake data are generally unreliable because they cannot accurately estimate the amount of table salt used by consumers, and information about whether iodized or non-iodized salt is used in food preparation at home or away from home is rarely captured in food composition databases or in dietary interviews. There are wide variations in the iodine content of some common foods. For example, the iodine content per slice of bread was > 300 μg for three varieties of bread and averaged 10 μg for 17 other brands in 2002 (Pearce, 2007), thus making it difficult to assign meaningful composition values to specific food items. The labeling of the iodine content of foods is not mandatory unless claims are made or iodine is added as a nutrient fortificant—practices that to date have been rare. On the other hand, dietary supplements, particularly multivitamin and multimineral supplements, often contain 150 μg of iodine per daily dose and the iodine content of these products is declared on the label.

Because of the difficulty of obtaining accurate estimates of dietary intake, iodine status is generally assessed by urinary excretion of iodine. Iodine is renally excreted, therefore urinary iodine concentrations are an indication of dietary iodine sufficiency (Pearce, 2007). The National Health and Nutrition Examination Surveys (NHANES) have periodically collected casual urine samples from which iodine values have been determined since NHANES I was conducted from 1971–1974. These data have been used to examine trends in urinary iodine excretion over time (Caldwell et al., 2005).

NHANES I levels were considered to be "adequate to excessive" for iodine (Pearce, 2007). Then, a downward trend was noted in urinary iodine concentration between NHANES I (320 ± 6 μg/L in 1971–1974) and NHANES III (145 ± 3 μg/L in 1988–1994). However, NHANES 2001–2002 data indicate that the urinary excretion of iodine stabilized (167.8 μg/L; 95 percent confidence interval: 159.3–177.6 μg/L). NHANES III and NHANES 2001–2002 urinary iodine excretion concentrations are within the range generally considered to be "optimal" for iodine nutriture (Caldwell et al., 2005; Pearce, 2007).

The reasons for the reductions in urinary iodine concentration between

1971–1974 and 1988–1994 cannot be determined precisely, but they appear to be a function of a food industry response to concerns expressed by FDA that manufacturing practices were causing excessive levels of iodine in the food supply. That is, the reduction may have been due to efforts to reduce iodine in the food supply from a potentially toxic level to a more acceptable level of nutriture for the general population. In the 1970s, chemical analysis of an FDA market basket sample of foods representative of U.S. dietary patterns showed extremely high and increasing levels of iodine in dairy products, grain and cereal products, and meat, fish, and poultry (Park et al., 1981). Sugars and adjunct groups (e.g., pudding mixes, jam, jelly, candies) also contained substantial amounts of iodine. Although the sources of iodine in these foods were not definitely determined, they are likely to have been iodophors used at that time as cleaning agents in dairy production, high levels of iodine added to animal feed, use of red color dyes containing iodine, and iodates used as baking conditioners in the making of breads (Pearce, 2007). FDA shared its concerns about these findings with the food industry (Park et al., 1981). The iodine content of the food supply subsequently dropped.

The current iodine status of the U.S. population is within an adequate range according to generally accepted guidelines for assessing iodine nutriture—although some groups (e.g., pregnant women) may be at higher risk than the general population (Caldwell et al., 2005; Pearce, 2007). Given current levels of iodine intake, what is likely to happen if salt reduction strategies were to be implemented? This is addressed by considering the contribution of iodized salt to total intake of iodine.

Currently, the main use of iodized salt is for home table salt—of which about 70 percent of sales are for iodized salt (Pearce, 2007). Non-iodized salt is used in most food processing and restaurant/foodservice applications (Dasgupta, 2008). Current intake data show that only about 5 percent of sodium comes from the use of table salt (see Chapter 5). Much of the iodine in today's diets continues to come from non-salt sources (e.g., iodine-containing food additives, processing aids, foods grown in many regions and countries) (IOM, 2005)—sources that would not be affected by salt reduction. Therefore, if 5 percent of sodium in today's diet is assumed to be associated with iodized salt and the major sodium reduction strategies in this report are addressed to the sodium content of processed and restaurant/foodservice foods, it would appear that the recommended sodium reduction strategies would have minimal impact on iodine intake of the U.S. population. Nonetheless, as a matter of public health prudence, continued and improved monitoring of urinary iodine excretion of the U.S. population and chemical analysis of the iodine content of market basket foods representative of U.S. dietary patterns are warranted.

Potassium in the Food Supply Due to Use of Potassium Chloride as a Salt Substitute

Potassium chloride is used as a salt substitute, and efforts to reduce sodium intake likely will incorporate more uses of potassium chloride as a salt substitute in food. In fact, an IOM committee recently recommended that CDC consider, as a strategy for preventing and controlling hypertension in the U.S. population, advocating for the greater use of potassium/sodium chloride combinations as a means of simultaneously reducing sodium intake and increasing potassium intake (IOM, 2010).

While dietary guidance generally encourages increased intake of potassium (DGAC, 2005), this recommendation is in the context of healthy populations, most of whom would benefit from additional potassium in the diet.

However, there may be unintended consequences for a sizable subpopulation in the United States if potassium chloride is used widely and at high levels, especially since the potassium content of foods is not generally provided in label information. Adverse cardiac effects (arrhythmias) can result from hyperkalemia, which is a markedly elevated serum level of potassium. In individuals whose urinary potassium excretion is impaired by a medical condition, drug therapy, or both, instances of life-threatening hyperkalemia have been reported (IOM, 2005). There have been several case reports of hyperkalemia in individuals who reported use of a potassium-containing salt substitute while under treatment for chronic diseases (Haddad, 1978; Ray et al., 1999; Snyder et al., 1975).

Many Americans are taking medications that result in an increase in serum potassium. Angiotensin-converting enzyme (ACE) inhibitors, angiotensin receptor blockers (ARBs), and potassium-sparing diuretics are common drugs that can significantly reduce potassium excretion (DGAC, 2005). Medical conditions associated with impaired potassium excretion include diabetes, chronic kidney disease, end-stage renal disease, severe heart failure, and adrenal insufficiency. Individuals with these conditions are numerous in the U.S. population.

For the approximately 26 million Americans with chronic kidney disease (Lloyd-Jones et al., 2009), these increased serum levels may be exacerbated by widespread potassium chloride use. There may also be concern relative to people with hypertension using ACE inhibitors and ARBs, which are commonly prescribed and have been shown to cause hyperkalemia (defined in the study as serum potassium concentration > 5.5 mEq/L or mmol/L) in approximately 3.3 percent of those taking them (Yusuf et al., 2008). These drugs are also used in patients with diabetes who have microalbuminuria or frank proteinuria to decrease urinary protein excretion and protect their renal function.

There are approximately 5 million Americans with congestive heart failure,[14] and a mainstay of their treatment is spironolactone, which blocks the hormone aldosterone and is associated with hyperkalemia. Indeed, a study from Canada showed that shortly after a publication reported a positive effect of spironolactone use in patients with congestive heart failure, its use increased markedly and resulted in a more than 400 percent increase in hospitalizations due to hyperkalemia, and mortality rose from 0.3 per 1,000 to 2.0 per 1,000 patients (Juurlink et al., 2004).

The number of Americans potentially at risk for adverse effects from potassium intake warrants vigilance in the increased use of potassium chloride as a salt substitute. Systematic monitoring of the food supply is essential for tracking the use of potassium chloride in foods and to monitor, and in turn mitigate, its ability to cause adverse health effects in those at risk.

MONITORING

The need for monitoring and surveillance is critical to establishing baseline data for and tracking the progress of strategies to reduce sodium intake. Both data on population intake and data on sodium levels in the food supply are needed to provide an information base for implementation of the recommended strategies. More accurate assessment and tracking of (1) specific foods that are contributors to Americans' sodium intake and (2) population-level dietary sodium intake, including the monitoring of 24-hour urinary sodium, were recently recommended by an IOM committee charged with reviewing public health strategies for reducing and controlling hypertension in the U.S. population (IOM, 2010). To date, monitoring efforts have been basic and focused on estimating intake from dietary self-reports collected as part of national surveys. Systematic and relevant approaches to tracking the sodium content of the food supply are lacking. Furthermore, useful and informative surveys conducted at the national level—such as the Total Diet Study and the Food Label and Package Survey—have not been conducted systematically, have failed to release data in timely and useful formats, and do not include sufficient coverage of sodium-related measurements. Although available food composition databases, which are essential to formulating sodium intake estimates based on dietary recall methods, have improved over the years, there is still room for more comprehensive data collection and reporting, especially in the area of restaurant foods.

Importantly, a more accurate measure of total sodium intake such as 24-hour urine collection should be employed in national population surveys, specifically NHANES. Dietary estimation must continue because it

[14] Available online: http://www.nlm.nih.gov/medlineplus/heartfailure.html (accessed November 16, 2009).

is important for identifying dietary patterns and use of foods relevant to increased or decreased sodium intake, but urinary analysis is required for the increased precision needed now for sodium monitoring and surveillance (see Recommendation 5).

It is desirable to explore new approaches for monitoring the sodium content of the food supply. One possibility that could provide detailed sodium content information and trends by individual product and by processed food category, including by sales weight, would be to link Universal Product Code (UPC) sales data to information on the nutrient content of the food as stated on the Nutrition Fact panel. Such a method is currently being used by the NSRI spearheaded by the New York City Health Department. Although such data are limited because they cannot provide information on the amounts of foods consumed or how foods were ultimately prepared and are subject to errors due to the inability to match some UPC codes with nutrient data, they could be a useful snapshot of trends. An approach to developing such a system is described in Appendix K. Further, efforts to appropriately expand or find an alternative to the FDA's Total Diet Study are worthwhile. On a related note, monitoring the use of claims about sodium is important. Efforts to ensure the continuation of FDA's Food Label and Package Survey and the expansion of this survey to encompass tasks important to monitoring strategies for reducing sodium intake should be made (see Recommendation 5).

New and enhanced methods to help consumers self-monitor their sodium intake would be useful in supporting consumer behaviors. Options that would advance the development of such methods include: enhancing currently available tools, such as dietary estimations through the MyPyramid online program; creating new mechanisms for monitoring dietary intake, such as mobile software for tracking individual sodium intake; and exploring kits that could be used for home urine testing to estimate individual intake.

Moreover, monitoring of consumers' knowledge, attitudes, and food selection practices along with the use of food labeling is needed to enhance the picture of factors important to realizing meaningful reductions in sodium intake. Several national surveys have such components, and these could be enhanced and expanded as they relate to sodium intake. Additionally, methods to monitor salt taste preference need attention and, when developed, should become part of the national monitoring system (see Recommendation 5).

Finally, it is always in the best interests of public health when major initiatives such as a population-wide effort to reduce sodium intake are undertaken to ensure that there is monitoring relative to unintended consequences. These range from the careful monitoring that would be needed for the successful stepwise reduction of sodium in the food supply and its impact on consumers and the food industry to the kinds of health consequences discussed above that include iodine insufficiency and potassium excess.

CLOSING REMARKS

The committee's review and integration of the available data resulted in five general recommendations and a set of strategies for each recommendation. The recommendations are identified as either primary, interim, or supporting and are presented in Chapter 9. The topic of next steps is discussed in Chapter 10 and focuses on implementation of the strategies and related research needs.

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9

Recommended Strategies to Reduce Sodium Intake and to Monitor Their Effectiveness

This chapter identifies strategies to address the goal of reducing the intake of sodium to levels consistent with recommendations in the *Dietary Guidelines for Americans*. The primary strategies focus on the U.S. food supply as defined and described earlier. The strategies are predicated on the understanding that (1) a majority of Americans' sodium intake is derived from processed and restaurant/foodservice foods, making reductions in the overall sodium content of the food supply needed to facilitate meaningful reductions in intake, and (2) a broad effort carried out as a gradual and stepwise process will be most successful. Consumers must be assisted in playing a role to reduce their sodium intake, but their ability to meaningfully reduce it will be limited without changes in the food supply.

Further, these primary strategies are based on the recognition that a significant amount of sodium in the American diet is contributed by foods eaten in restaurants and other foodservice operations, thereby requiring a combined effort focused not only on the processed foods purchased by consumers, but also on foods offered to consumers by restaurant/foodservice operators. The strategies address salt (sodium chloride) added to foods by food manufacturers and restaurant/foodservice operators, as well as other sodium-containing compounds added to foods. Interim strategies are also identified and are intended to assist with efforts to reduce the sodium content of the food supply during the time needed to implement the primary strategies.

While efforts to reduce the sodium content of the food supply can result in considerable progress toward reducing sodium intake, supporting strategies are needed to ensure that consumers achieve current recommendations.

Supporting strategies target a range of stakeholders and serve to underpin and augment the primary strategies. Strategies related to monitoring and surveillance are also included so that essential data about sodium intake, salt taste preference, related consumer knowledge and attitudes, and the sodium content of the food supply are available.

PRIMARY STRATEGIES

RECOMMENDATION 1: The Food and Drug Administration (FDA) should expeditiously initiate a process to set mandatory national standards for the sodium content of foods.

Strategy 1.1 **FDA should modify the generally recognized as safe (GRAS) status of salt added to processed foods in order to reduce the salt content of the food supply in a stepwise manner.**

FDA should expeditiously undertake regulatory activities to establish conditions of use for salt in processed food to assist in achieving population intakes of sodium that are consistent with the *Dietary Guidelines for Americans*. The justification for modifying the GRAS status of salt is based on changes in the body of evidence for the health effects of salt that have emerged since it was first recognized as GRAS in 1959.

Reductions in the levels of salt added to foods under the modified GRAS provisions should be accomplished in a stepwise manner to allow time for adaptation of consumer taste preference for salt added to foods and for industry to deal with technical challenges. Moreover, specific and extensive ongoing monitoring is needed to further inform the stepwise process. Implementation of new provisions for the GRAS status of salt should include initial analysis and data gathering by FDA in collaboration with stakeholders. The decisions made should be transparent and science-based. The available array of options for implementation should be considered; special labeling/disclosure statements or informational labeling regarding sodium content, if appropriate, should be incorporated into the implementation process.

Strategy 1.2 **FDA should likewise extend its stepwise application of the GRAS modification, adjusted as necessary, to encompass salt added to menu items offered by restaurant/foodservice operations that are sufficiently standardized so as to allow practical implementation.**

The significant contribution to sodium intake made by restaurant/foodservice menu items warrants targeted attention to this sector of the food supply. The strategy is based on the application of the *Federal Food,* *Drug, and Cosmetic Act* to foods whose components have moved in interstate commerce, thus making the food item subject to the same standards relevant to processed foods. The implementation activities outlined for modification of the GRAS status of salt for processed foods, as well as the process for determining the modification, should apply equally to standardized restaurant/foodservice operations.

Strategy 1.3 **FDA should revisit the GRAS status of other sodium-containing compounds as well as any food additive provisions for such compounds and make adjustments as appropriate, consistent with changes for salt in processed foods and restaurant/foodservice menu items.**

Given that sodium can be added to foods in ways other than by the addition of salt, it is important for FDA to consider these other sources of sodium, take into account their approved conditions of use and function in food, integrate their presence in the food supply into the considerations for modifying the GRAS status of salt, and adjust as necessary the GRAS or food additive provisions for these sodium-containing compounds.

INTERIM STRATEGIES

Voluntary approaches cannot serve as the main focus of future strategies, but may be useful until regulatory approaches can guarantee sustainable strategies. There are questions as to the levels of success that might be achieved in the interim on a voluntary basis. But given impending regulations and heightened attention to sodium reduction, interim strategies may achieve some success and inform the regulatory process.

RECOMMENDATION 2: The food industry should voluntarily act to reduce the sodium content of foods in advance of the implementation of mandatory standards.

Although the regulatory strategies identified above should be initiated immediately, as a practical matter the process of rulemaking requires time. The committee has therefore identified voluntary strategies that could achieve some reductions in sodium intake ahead of the implementation of mandatory standards for the levels of salt added to foods. While identifying these voluntary strategies as important interim steps, the committee underscores that experience would indicate that voluntary standards have not been sufficient to provide adequate breadth and sustainability to the reductions and do not offer the level playing field that is important to realizing meaningful sodium reduction in the food supply.

Strategy 2.1 **Food manufacturers and restaurant/foodservice operators should voluntarily accelerate and broaden efforts to reduce sodium in processed foods and menu items, respectively.**

Some food manufacturers and restaurant/foodservice operators are currently working to reduce the sodium levels in their food products and menu items. The pace and scope of such voluntary efforts should be continued and accelerated during the time mandatory standards are being established. Further, food manufacturers (including retailers with private label brands) and restaurant/foodservice operators who have not initiated such activities are encouraged to do so.

Such voluntary efforts at this time will help to ease the eventual transition to mandatory standards and also offer the opportunity to explore options and new technologies as soon as possible. Experiences gleaned from such activities can help to inform regulatory decision making as it progresses.

Strategy 2.2 **The food industry, government, professional organizations, and public health partners should work together to promote voluntary collaborations to reduce sodium in foods.**

Voluntary efforts operating under the auspices of government authorities as well as public health organizations are currently focusing on initiatives intended to reduce the levels of sodium in foods, often in concert with the food industry. Such public-private partnerships should continue during the time mandatory standards are being established. Again, the experiences gleaned from such public-private partnerships can inform the process of setting mandatory national standards.

SUPPORTING STRATEGIES

RECOMMENDATION 3: Government agencies, public health and consumer organizations, and the food industry should carry out activities to support the reduction of sodium levels in the food supply.

The committee has identified strategies useful to supporting and enhancing the effort to reduce the sodium content of the food supply through modification of the GRAS status of salt. These strategies are directed to a range of stakeholders.

Strategy 3.1 **FDA and the U.S. Department of Agriculture (USDA) should revise and update—specifically for sodium—the provisions for nutrition labeling, related sodium claims, and disclosure/disqualifying**

criteria for sodium in foods, including a revision to base the Daily Value (DV) for sodium on the Adequate Intake (AI).

The current provisions for nutrition labeling, related claims about sodium, and disclosure/disqualifying criteria for sodium on the labels of food products were established at a time when less was known about how consumers effectively interpret and use label information and about relevant technologies and potential unintended consequences related to reducing sodium levels in foods. Overall, the existing regulatory provisions would benefit from review and updating as appropriate in order to provide useful information to consumers and to enhance the food industry's motivation to reformulate foods relative to sodium content. It is anticipated that such activities would be undertaken through notice-and-comment rulemaking in a timely fashion. USDA should move forward with proposed nutrition labeling regulations for single-ingredient, raw meat and poultry to ensure that the sodium content—as would be relevant in the case of meat and poultry enhanced with sodium solutions—is made known to consumers. Similarly, FDA should review its approach to seafood labeling. Further, given a 2005 report from the Institute of Medicine that identifies an AI for sodium—a reference value that had not been established at the time the current regulations for nutrition labeling were finalized—the AI should serve as the basis for the Daily Value for sodium, a component of the Nutrition Facts panel on foods. The AI, from the perspective of public health, provides a truer picture for the consumer of the contribution of the particular food in assembling a healthful diet and is preferable to use of the Tolerable Upper Intake Level (UL). To avoid unintended consequences and disincentives to the food industry given this recommendation, the basis for claims related to "low sodium" and "very low sodium" is worthy of review.

Strategy 3.2 **FDA should extend provisions for sodium content and health claims to restaurant/foodservice menu items and adjust the provisions as needed for use within each sector.**

The *Nutrition Labeling and Education Act* established a framework for providing information about the nutrient content of packaged foods, but its provisions for nutrient-related food label claims were *not* specifically limited to packaged foods. However, in implementing the act, FDA limited its claims regulations to packaged foods. FDA should now undertake activities to provide for sodium content claims (e.g., low sodium, reduced sodium) and related health claims (e.g., "diets low in sodium are associated with a low prevalence of hypertension") on menu items offered by restaurant/foodservice operations that are sufficiently standardized for implementation to be practically accomplished. There will be a need for preliminary activities to gather data and background information about restaurant/foodservice operations and to carry out the stakeholder dialogues that will be necessary to develop, and then implement, workable regulations for claims to be used in such operations.

Strategy 3.3 **Congress should act to remove the exemption from nutrition labeling for food products intended solely for use in restaurant/foodservice operations.**

Currently, U.S. law[1] exempts products intended for restaurant/foodservice operations from bearing nutrition labeling. If small as well as large restaurant/foodservice operators are to be encouraged to take part in efforts to reduce the sodium content of their products, information about the sodium content of the foods they acquire from their distributors is critical information.

Strategy 3.4 **Food retailers, governments, businesses, institutions, and other large-scale organizations that purchase or distribute food should establish sodium specifications for the foods they purchase and the food operations they oversee.**

Groups that purchase large volumes of food products that in turn are either sold to others or served as part of a restaurant/foodservice operation can wield a powerful tool when they set the specifications for products they will purchase and foods served by operations under their authority. Specifically, the nutrition specifications for foods procured are likely to provide incentives for food manufacturers to develop or offer lower-sodium foods, especially given the high levels of procurement expenditures. Further, specifications for the use of sodium in foods served can ensure that foodservice staff will not add excess sodium. Federal, state, and local governments all have the potential to create sodium specifications for foods purchased or served in their facilities or through their programs. Relevant programs include the federal school lunch and breakfast programs as well as the military. To some extent the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) and the Supplemental Nutrition Assistance Program (SNAP) may also be useful to drive change through the use of incentives for participants to purchase lower-sodium food products. State and local governments are also large-scale procurers of foods and can be instrumental in this strategy. Further, food retailers can assist in

[1] 21 USC § 343(q)(5).

lowering sodium intake through their procurement and product display practices.[2]

Strategy 3.5 **Restaurant/foodservice leaders in collaboration with other key stakeholders including federal, state, and local health authorities should develop, pilot, and implement innovative initiatives targeted to restaurant/foodservice operations to facilitate and sustain sodium reduction in menu items.**

Past sodium intake reduction efforts have placed limited focus on restaurant/foodservice operations compared to the processed food industry. Further, consistent with Strategy 1.2, it is not likely that all restaurant/foodservice operations will be subject to mandatory standards for the addition of salt to menu items. While the entire restaurant/foodservice industry will be positively impacted by the advent of mandatory standards, there is a need for additional initiatives to broadly assist the industry in reducing sodium. Since few attempts have been made to reduce sodium in restaurant/foodservice menu items, restaurant/foodservice leaders working in public-private partnership should introduce pilot programs designed to assist operators in reducing the sodium content of menu items, which, in turn, could be widely implemented when shown to be effective. Such programs may include training of both existing and new restaurant/foodservice personnel, support for menu and recipe reformulation, programs to encourage social responsibility, the introduction of voluntary standards, and, as appropriate, local regulations for salt use or sodium labeling. Outreach may be particularly needed to reach independent restaurant/foodservice operators whose foods may not be fully reached by the GRAS modifications detailed in Strategy 1.2, and whose resources for educating workers and menu development activities may be limited.

RECOMMENDATION 4: In tandem with recommendations to reduce the sodium content of the food supply, government agencies, public health and consumer organizations, health professionals, the health insurance industry, the food industry, and public-private partnerships should conduct augmenting activities to support consumers in reducing sodium intake.

It is important to implement strategies targeted to consumers that will result in sustainable, diet-related behavioral changes through selection of lower-sodium foods, portion control, and other healthful food choices by

[2] Where these groups market their own label processed foods, or where they include foodservice operations, their activities are encompassed by Strategy 2.1.

(1) increasing the consumer's understanding of the value of reducing sodium for health throughout the lifespan because all groups are at risk; (2) increasing the consumer's understanding of the ubiquitous nature of sodium in the food supply and the importance of supporting government and industry activities to reduce sodium in foods; (3) changing consumer attitudes toward, and perception about, lower-sodium foods; and (4) facilitating consumer understanding of the role of sodium reduction as part of an overall healthful diet for all life stage groups. While activities targeted to reducing the overall sodium content of the food supply will be primary in reducing the intake of sodium, they are unlikely to be sufficient by themselves. Consumers must also take personal action to reduce sodium intake. The consumer's role in reducing sodium intake requires support through education, the development of tools to assist consumers, and the identification of strategies that lead to behavior change. Such efforts to reach consumers must be carefully planned with consistent overall messages that can also be tailored to the specific interests and dispositions of various subpopulations (including those at greater risk for developing hypertension, ethnic/cultural groups, and a range of life stage groups).

The following two strategies are key to accomplishing these goals.

Strategy 4.1 **The Secretary of Health and Human Services (HHS) should act in cooperation with other government and non-government groups to design and implement a comprehensive, nationwide campaign to reduce sodium intake and act to set a time line for achieving the sodium intake goals established by the *Dietary Guidelines for Americans*.**

A coordinated nationwide campaign to implement, manage, and sustain programs to reach consumers is a valuable component of the overall effort to reduce sodium intake among the U.S. population. While this campaign should be targeted to consumers, it is expected to be complementary to the activities to reduce sodium in the food supply and should include a focus to enlist consumer support for government and industry activities to reduce the sodium content of foods. Vesting specific authority and accountability for such activities at a high level within the federal government would result in the national leadership needed to reduce sodium intake and also foster linkage to health messages related to the *Dietary Guidelines for Americans*.

Moreover, it would be important to ensure that an informed, coordinated process is put in place to establish initial time lines and goals for the overall reductions of sodium intake and for carrying out the implementing tasks that are separate from those for reducing sodium in the food supply. In turn, there must be an active process and responsible authorities to monitor the goals and adjust them as needed while making efforts to maintain consistent vocabulary, focus, and messages to avoid consumer confusion. This activity ensures that the goals remain viable and serves to stimulate the process by making implementers accountable. This activity should be done in close collaboration with FDA so that the overall time line for reducing sodium intake takes into account the regulatory approach and its related time line for reducing sodium in the food supply.

Strategy 4.2 **Government agencies, public health and consumer organizations, health professionals, the food industry, and public-private partnerships should continue or expand efforts to support consumers in making behavior changes to reduce sodium intake in a manner consistent with the *Dietary Guidelines for Americans*.**

The following programs and entities have the potential to reach consumers about sodium and hypertension and have the potential to be effective, especially through the use of public-private partnerships.

- USDA: revision to the MyPyramid Plan for consumers to include sodium as an area of focus.
- Centers for Disease Control and Prevention (CDC): expansion of the State Heart Disease and Stroke Prevention Program to address sodium intake reduction.
- National Institutes of Health (NIH), National Heart, Lung, and Blood Institute (NHLBI): enhancement of the National High Blood Pressure Education Program to elevate the importance of sodium reduction in its professional and public education efforts and to emphasize research on informing and motivating consumers to reduce sodium intake.
- Food industry (including manufacturers, retailers, and restaurant/foodservice operators): activities to support and distribute consumer educational materials about sodium intake and selecting diets lower in sodium.
- Restaurant/foodservice operations: activities to improve the availability of sodium content information at point of purchase or point of consumption.
- Public health, health profession, and consumer associations: activities to support and promote policy initiatives to reduce sodium intake among consumers.
- Education for health professionals: training of new and experienced health professionals on the relationship between sodium intake and health and tools for reducing sodium intake as part of higher education curriculums and continuing education courses.

- Health practitioners: commitment to incorporate guidelines on sodium intake into prevention messages and standards of care.
- Health insurers: incorporation of key messages and efforts to change behavior into their disease management and health and wellness programs.
- Schools: incorporation of messages on sodium and health into nutrition education curriculums.

RECOMMENDATION 5: Federal agencies should ensure and enhance monitoring and surveillance relative to sodium intake measurement, salt taste preference, and sodium content of foods, and should ensure sustained and timely release of data in user-friendly formats.

The importance of immediately beginning activities to determine the baseline levels of sodium intake through measurements of nationally representative 24-hour urine collections, to track the sodium content of processed foods and menu items through the creation of relevant databases, and to monitor changes in salt taste preference cannot be overemphasized. Current monitoring mechanisms are inadequate to track the progress of the recommended strategies and are not sufficient to satisfactorily elucidate the nature of the problem. Without access to reference data and data summaries in a timely and user-friendly manner, such monitoring and surveillance approaches cannot be checked or adjusted as needed. Additionally, as described in Chapter 10, research is needed to provide better tools for relevant monitoring and surveillance.

Ensuring Monitoring

Strategy 5.1 **Congress, HHS/CDC, and USDA authorities should ensure adequate funding for the National Health and Nutrition Examination Survey (NHANES), including related and supporting databases or surveys.**

An adequate budget including resources to ensure enhanced design and content of the major federal dietary and nutrition surveys is important to the process of implementing and tracking strategies to reduce sodium intake.

Expanding and Enhancing Monitoring

Strategy 5.2 **CDC should collect 24-hour urine samples during NHANES or as a separate nationally representative "sentinel site"-type activity.**

Currently, collection and analysis of 24-hour urine provides the most accurate estimates of sodium intake and should be a component of national monitoring. Its inclusion in the national surveys will require pilot testing and innovative techniques. In addition, these surveys should continue to collect estimates of dietary sodium intake by multiple 24-hour recalls.

> ***Strategy 5.3*** **CDC should, as a component of NHANES or another appropriate nationally representative survey, begin work immediately with NIH to develop an appropriate assessment tool for salt taste preference, obtain baseline measurements, and track salt taste preference over time.**

Change in salt taste preference on a population basis is an important goal. However, salt taste preference has not been measured or tracked for the population. It is important to immediately initiate activities to develop and, in turn, incorporate these measurements into national surveys to establish baseline measures and to conduct ongoing monitoring.

> ***Strategy 5.4*** **CDC in cooperation with other relevant HHS agencies, USDA, and the Federal Trade Commission should strengthen and expand its activities to measure population knowledge, attitudes, and behavior about sodium among consumers.**

Monitoring changes in consumers' (1) understanding of the importance of reducing sodium intake, (2) ability to estimate sodium intake, (3) intention to reduce sodium intake, and (4) related attitudes and behaviors is needed to evaluate the effectiveness of health communication strategies and to make the necessary adjustments in the related national initiatives to reduce sodium intake.

> ***Strategy 5.5*** **FDA should modify and expand its existing Total Diet Study and its Food Label and Package Survey to ensure better coverage of information about sodium content in the diet and sodium-related information on packaged and prepared foods.**

Continuous and systematic market basket and labeling studies of the food supply that incorporate approaches relevant to sodium are important and efficient components of monitoring sodium content and the related labeling of foods.

> ***Strategy 5.6*** **USDA should enhance the quality and comprehensiveness of sodium content information in its tables of food composition.**

The accuracy, detail, and timeliness of food composition databases are essential for measuring sodium intake from dietary studies.

> ***Strategy 5.7*** **USDA in cooperation with HHS should develop approaches utilizing current and new methodologies and databases to monitor the sodium content of the total food supply.**

Current databases should be enhanced to more completely assess and track the sodium content of products in the food supply, including processed foods and restaurant or foodservice menu items; they should also be updated with sufficient frequency to allow monitoring and assessment of the stepwise process.

10

Next Steps

This report recommends the use of regulatory tools in an innovative and unprecedented fashion to *gradually* reduce widespread ingredients in foods through a well-researched, coordinated, deliberative, and monitored process. The recommended changes will be challenging and will require coordination and cooperation. The strategies outlined by the committee are specifically stepwise and are intended to expand and grow over time. There is evidence that moving in this area without a staged and thoughtful process, over time, and as part of a learning experience relative to workable strategies would be problematic. This final chapter discusses the next steps for strategies to reduce sodium intake, first in terms of options and approaches for implementation of the strategies and then in terms of research needs. The approaches highlighted below were developed following the committee's recommendations and with the understanding that implementers will—as a first step and as an ongoing activity—need to carry out data gathering and targeted research to ensure appropriate implementation of the strategies. Research needs have been identified based on the major information gaps identified by the committee in conducting its study. Addressing these research needs will be central to the ability to make progress in sodium reduction efforts.

IMPLEMENTATION OF STRATEGIES

By their nature, a number of the strategies recommended by the committee will require analysis and additional data gathering before they can be implemented. There are still many unanswered questions. During its deliberations, the committee outlined a number of implementation approaches. However, it recognized that the level of detail needed to translate a number of the overall strategies into functioning activities was beyond its scope and undoubtedly required information that is not currently available or that needs to be collected and analyzed by specific responsible agencies mentioned in this report, by the food industry, or by other researchers. Implementers therefore will have to further explore these approaches and related options as they become apparent.

Modification to the GRAS Status of Salt

Modifying the generally recognized as safe (GRAS) status of salt will be a complicated and challenging process for the Food and Drug Administration (FDA). It will require considerable information gathering, detailed input from stakeholders, in-depth analysis of the food supply, simulation modeling of the effect of different levels of sodium on total intake, examination of consumers' eating behaviors, adjustments for food safety concerns, and studies of economic impact and potential unintended consequences. This, in turn, will require resources and time. The following approaches at a minimum should be considered by FDA in carrying out these important activities.

Food Category Framework

As a general matter, it anticipated that the overarching goal should be to specify as GRAS the uses and use levels for salt that allow persons to consume such foods as part of a normal diet with a reasonable likelihood of keeping their total daily intake of sodium consistent with the *Dietary Guidelines for Americans*. However, the committee could find no rationale for establishing allowable standards of salt content as a single, across-the-board, quantitative amount of sodium applied to each food equally. Rather, the nature of the food supply suggests that the better approach is to develop standards for the levels of salt added to foods on the basis of food categories. In the United Kingdom, salt targets were set for all product categories, based on the contributions of different foods to salt intake and the feasibility of making reductions given food safety and technical considerations.[1] If foods are grouped by category, the technological feasibility of reducing salt levels can be taken into account along with consumers' taste expectations. Examination of potential sodium reductions on the basis of food categories can also help to set meaningful yet feasible targets for sodium reduction.

[1] Available online: http://www.food.gov.uk/multimedia/pdfs/howsalttargetsmet.pdf (accessed November 17, 2009).

The regulatory process can adjust the GRAS "conditions of use" based on the available data and would allow foods to contain different levels of sodium based on their nature and the way in which they are typically consumed. The United Kingdom, in developing its voluntary program for the food industry, has based its approach on food categories. The voluntary National Salt Reduction Initiative (NSRI) coordinated by New York City, has based its guidelines on food categories as well.

The committee felt that the development of food categories and establishment of appropriate maximum levels would benefit from the rulemaking process, which includes public deliberation, that FDA would be required to undertake, and therefore did not attempt to make recommendations or undertake simulation efforts on these topics. It is expected that FDA would model the dynamics of how different levels of sodium reduction in various product categories would influence population intakes. This information, combined with input from public deliberations on the feasibility of such reductions would factor into the FDA's development of appropriate food categories and maximum usage levels.

Panel A of Figure 10-1 shows a hypothetical example of a product category with a salt content range of 0–100 mg. This maximum level of salt—shown in the figure as 50 mg and labeled "Maximum Level for GRAS Status"—would allow persons to consume such a food from this category in typical fashion as part of a normal diet and yet keep their total daily intake of sodium at recommended levels given all other foods commonly consumed (each with its own category standards for salt content). Foods within this category with amounts at or below 50 mg per serving would be marketable and those above would not.

However, as discussed in Chapter 8, the implementation of the standards is most likely to be successful if a gradual, stepwise approach is used. Panel B in the figure illustrates the stepwise implementation approach relative to this particular example. Given the range of levels in the hypothetical food product category, it is determined that a hypothetical starting point of 80 mg per serving is consistent with an acceptable and non-disruptive reduction from existing current levels because in this example, across the possible range of salt content per serving, most marketed products do not contain 100 mg per serving (the high amount), thus acceptable reductions could begin at 80 mg per serving. The process would hypothetically begin in the year 2015. Foods within this category with more than 80 mg per serving could not be legally marketed after 2015.[2] After an appropriate additional

[2]Use of more than 80 mg of salt per serving in foods within this category would be considered use of an unapproved food additive unless the company marketing the product had received pre-market food additive approval for this level of use. Therefore, the majority of foods with more than 80 mg per serving could not be legally marketed after 2015.

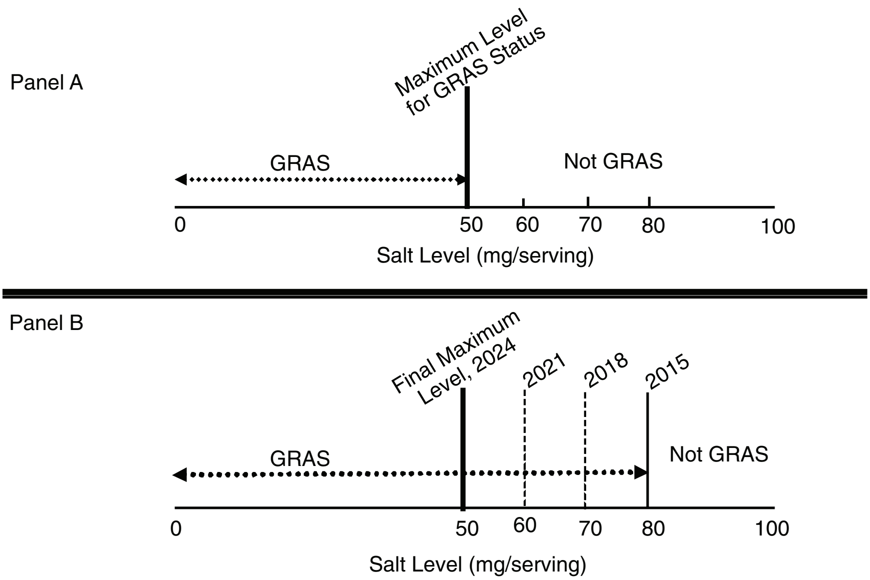

FIGURE 10-1 Modification of the GRAS status of salt for a hypothetical food category. *Panel A:* Final Maximum Level: Regulatory specification of salt content per serving for a hypothetical food category with a range of 0–100 mg of salt per serving. Final maximum level for the GRAS status is set at 50 mg of salt per serving. *Panel B:* Interim Maximum Levels: Use of stepwise reduction plan for achieving a final hypothetical maximum level of 50 mg of salt per serving by the year 2024. A decreasing maximum GRAS level of salt per serving (80 mg, 70 mg, 60 mg) is implemented over time (in 2015, 2018, 2021) with the final maximum level being reached by year 2024.
NOTE: GRAS = generally recognized as safe; mg = milligrams.

period of time, as determined by available data, the next "step" would take place—in this example, in the year 2018—and foods with more than 70 mg per serving could no longer be marketed. This would continue in a gradual stepwise process until the final goal of 50 mg per serving was reached for foods in this category. In this hypothetical example, the amounts of salt per serving are brought down by an additional 10 mg in each of the years 2015, 2021, and finally 2024, when the ultimate goal is reached. In reality, the levels of reduction may need to be larger or smaller, and the times for change may need to be altered. These levels and timeframes would need to be determined based on information gathering and computer simulation modeling carried out by the implementers. Adjustments in timeframes for reductions and the levels of reductions would also be needed should changes in the recommended levels of sodium intake be made. As also discussed in Chapter 8, ongoing research and monitoring would be associated with this activity to identify any potential unexpected impediments to achieving the overall goal.

Use of Labeling as Part of the Stepwise Process

The use of special labeling/disclosure statements or other informational labeling as described in Chapter 6 requires careful attention to the context in which such statements will operate, as well as research to determine that the statements as presented not only have the desired effect but also fail to produce an undesired effect. Little evidence exists regarding the use of such statements as they relate to the sodium content of a food. With this understanding as a starting point, the committee found that it would be worthwhile to consider the use of special labeling or disclosure statements as a component of the stepwise process. Although cautious in its approach, the committee concluded that it may be possible to stimulate food manufacturers to work more quickly toward the appropriate maximum GRAS level if special labeling/disclosure statements were incorporated as part of the specified gradual implementation process. Additionally, the location of the special label/disclosure statement is an important factor. It may be relevant to so-called front-of-package labeling and could appropriately be incorporated as a component of those activities now foreshadowed by FDA.[3]

As an example of the use of labeling as part of the stepwise approach and shown in Figure 10-2, in the initial year 2015 in the hypothetical example discussed above, a food could not be marketed if it contained more salt per serving than the standard of 80 mg. In addition, however, regulators could stipulate that, during this initial step, products containing salt levels between 70 mg per serving (i.e., the next stepwise goal set to occur in 2018) and 80 mg per serving (the legal maximum) would be marketable only with a special label/disclosure statement in an effort to "stimulate" food manufacturers to reformulate to the next step. It is presumed that the labeling would be viewed as undesirable by the food industry, which would work more quickly to reformulate its products. The process would then be repeated at the time of the next stepwise reduction, decreasing the level at which the statement would be required until the year 2021 target (60 mg salt). That is, in the hypothetical example, while a manufacturer could legally market products with up to 70 mg of salt per serving, those containing between 60 and 70 mg would be required to bear the labeling. While this example is illustrated in Figure 10-2, it is possible that the level at which the "stimulating" special labeling/disclosure statement would be

[3] Available online: http://www.fda.gov/Food/LabelingNutrition/LabelClaims/ucm180146.htm (accessed November 17, 2009).

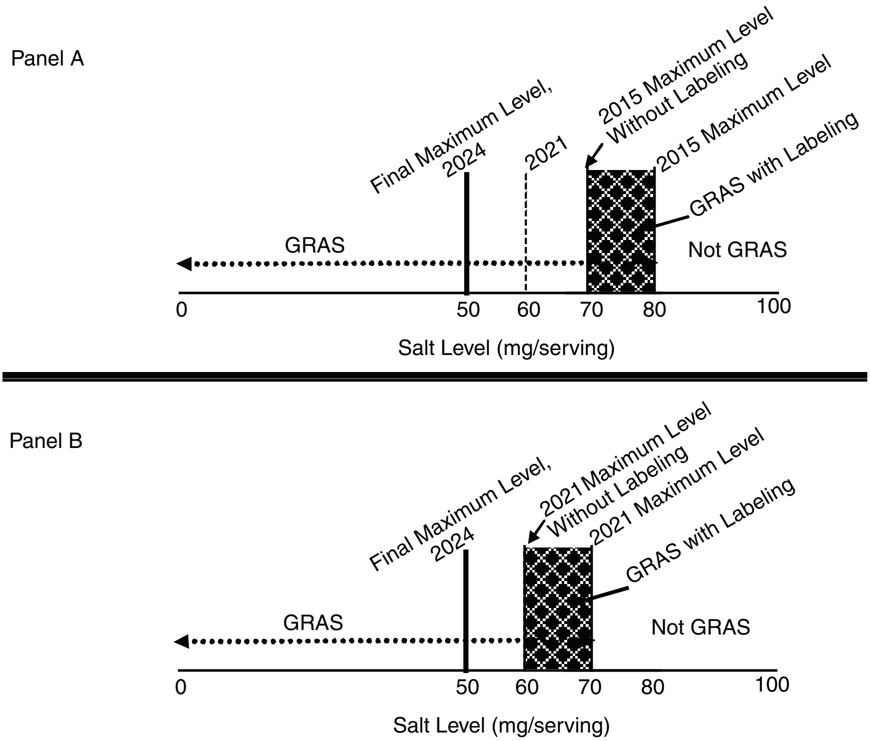

FIGURE 10-2 Example of hypothetical use of special labeling/disclosure statements as part of the stepwise implementation process. *Panel A:* At the time of the first stepwise reduction in the year 2015, foods with amounts per serving between the 2015 target and the target for 2018 (i.e., between 70 and 80 mg) would be required to bear the label. *Panel B:* At the time of the hypothetical second stepwise reduction in 2018, foods with amounts per serving between the 2018 target and target for 2021 (i.e., between 60 and 70 mg) would be required to bear a label. This process would be repeated each time a stepwise reduction is put in place.
NOTES: Other options are possible, including other ways of determining the levels of salt per serving that would bear a label during the stepwise implementation or the possibility that all products between the hypothetical final maximum level and the current stepwise target would bear a label. GRAS = generally recognized as safe; mg = milligrams.

set may not be the next stepwise target and could vary based on other relevant information. Another possibility is that the level could be set based on the final goal—that is, 50 mg per serving in this hypothetical example—in which case all products not consistent with the final goal would be required to bear the labeling during the full time period of the step-down.

Many factors would have to be explored, ranging from the feasibility of requiring the food industry to make relatively rapid labeling changes to consumers' responses to the presence of special labeling/disclosure statements regarding sodium on many familiar foods. If such issues are resolved satisfactorily, it is possible that upon initiation of the stepwise approach, consumers could be informed about the relatively high sodium content of foods that are close to the allowable levels, and manufacturers might be motivated to make changes in their products during the in-between stages of the process rather than waiting until the next stepwise reduction is implemented.

Potential for Exemptions in Order to Remain GRAS

After reviewing the provisions related to Section 409 of the *Federal Food, Drug, and Cosmetic Act* as discussed in Chapter 8, the committee considered that in principle it may be possible to exempt certain foods from the generally provided GRAS conditions for salt because of the special nature of particular foods. Stated another way, the committee considered the possibility of special labeling or other disclosure statements being used to retain permanently the GRAS status of some foods that exceed the final maximum GRAS level once it is set in place. It has not been possible to define the nature of such exemptions as part of the committee's work, but it was anticipated that FDA's in-depth analysis of the food supply, information-gathering efforts, and related consumer behavior may reveal the desirability of such exemptions.

While the use of such labeling on products may not appeal to food manufacturers and thus may motivate them to seek further alternatives to lower the sodium content of their products, it was recognized that, consistent with Section 409 of the *Federal Food, Drug, and Cosmetic Act*, this would have to be based on appropriate research to demonstrate the ability of the labeling to protect public health. If appropriate, the use of such labeling would allow certain food products exceeding the GRAS levels for salt to retain their GRAS status and thus be available to consumers.

The committee agreed that this exemption approach should be explored by FDA and, if appropriate, used in a manner consistent with public health goals; it was agreed that such exemptions should be limited in scope in a fashion consistent with the anticipated FDA in-depth analysis of the food supply and consumers' eating behaviors. The ability to provide for exemptions was regarded by some committee members as consistent with allowing for consumer choice as well as the unknowns that may be encountered in making changes in the food supply. A few committee members expressed doubt about the ability of such labeling to be effective in protecting public health. Others pointed out that the very limited research available demonstrates a change in preference for salty foods following a low-salt diet during which *all* salt sources were restricted, and therefore it is not known whether an opportunity to consume some very salty foods (albeit in small amounts) might not block the taste change that is a desired companion goal to reducing the sodium content of the food supply. A fuller exploration of these options and possibilities was hampered by the limited nature of the data available.

Restaurant/Foodservice Operations

In general, most of the provisions described for processed foods could be applied to sufficiently standardized restaurant/foodservice operations. As appropriate, special labeling/disclosure statements as discussed above could be used in a similar fashion on menu boards and printed menus, although the labeling may have to be adapted for the purposes of restaurant/foodservice use. It may also be important to consider options for providing patrons of restaurant/foodservice operations with quantitative sodium content information for the menu item, as occurs with packaged foods.

However, the relative novelty of such regulatory approaches for restaurant/foodservice operations may require additional considerations during the implementation process. Among the issues to be examined are the impacts of variations in serving sizes, menu item options (e.g., the addition of sides, choice of proteins), limited-time and seasonal menu items, and service formats (e.g., buffets). There are unique challenges to reducing sodium in restaurant/foodservice operations, and as described previously, past initiatives to reduce sodium intake have focused relatively little attention on these operations compared to processed foods. The lack of past focus on sodium in the restaurant/foodservice sector creates a need for additional support and/or initiatives to encourage this sector to rapidly make sodium reduction an issue of importance.

While the entire restaurant/foodservice industry will be impacted positively by the recommended standards for adding salt to processed foods, it was recognized that it may not be feasible to extend these new standards to menu items of all restaurant/foodservice operations, notably those without sufficiently standardized operations. Such operations do contribute sodium to the overall diet. For these reasons, there is a need for activities to reach these operations that would not be required to comply with the GRAS standards and also to accelerate restaurant/foodservice industry efforts to reduce sodium across the entire sector. The challenge, as described in Chapter 6, is that there is a wide range of decision makers for the addition of salt to foods, and no single initiative may work to encourage all restaurant/foodservice operators to reduce sodium. For example, different approaches may be needed to encourage a highly trained menu developer for a large contract restaurant/foodservice company to reduce sodium compared to a line cook finishing a dish by seasoning it with salt.

There may be lessons to be learned from other public health efforts related to restaurant/foodservice employee training. One example is the ServSafe® program, which provides restaurant/foodservice personnel with comprehensive food safety training and certification[4] and has become integral to the ability of restaurants to comply with government-mandated food safety and sanitation practices. Conversely, there are possible limitations to this approach that must be examined, as exemplified by the unsuccessful New York City Department of Health effort to achieve voluntary reductions in restaurant/foodservice artificial *trans* fat use through a campaign that included the education of employees delivered during required food safety classes as one of its components (Angell et al., 2009).

Therefore, a number of approaches ranging from the introduction of voluntary standards to a variety of training methods for restaurant/foodservice personnel (on- or offsite learning, e-learning, trade media articles, etc.) may need to be piloted to identify the most effective approach. These initiatives could be developed by a number of stakeholders including the restaurant/foodservice industry and federal, state, and local health authorities.

Summary

The committee believes that the modification of the GRAS status of salt in processed food could be accomplished best if FDA:

- specifies as GRAS the uses and use levels for salt that allow persons to consume such foods as part of a normal diet with a reasonable likelihood of keeping their total daily intake of sodium consistent with the *Dietary Guidelines for Americans*—these foods could be sold freely;
- implements special labeling/disclosure statements, or informational labeling on foods as part of a stepwise implementation process for modification of the GRAS status of salt, provided research demonstrates that the labeling is effective—such labeling may (1) stimulate efforts on the part of the food industry to implement changes in sodium content more quickly, and/or (2) help inform consumers about foods with relatively high sodium content;
- studies and implements as appropriate specified exemptions from non-GRAS status for certain individual foods and, if research indicates that the availability of such exempted foods with appropriate product special labeling/disclosure statements or other informa-

[4] Available online: http://www.servsafe.com/index.aspx (accessed November 17, 2009).

tional labeling would not preclude the protection of public health, provides for such exemptions or special accommodations (presumably on an infrequent basis); and finally,

- determines those uses and use levels not covered above not to be GRAS, subject to the food additive petition process; such determinations would disallow certain food products from sale because of their salt content, but the petition process could be used as appropriate to allow continued marketing.

Further, the process associated with modifying the GRAS status of salt is also an important factor in implementing the strategy. Consistent with notice-and-comment rulemaking, it is anticipated that activities related to setting salt standards will be carried out in an open, public fashion in consultation and cooperation with interested stakeholders and will incorporate the best available information about the nature of the food supply and consumer eating behaviors. The desirable goal is to use the GRAS provisions for the conditions under which salt can be added to foods to assist in achieving population intakes consistent with the *Dietary Guidelines for Americans*. Further, as described in Chapter 7, the changes associated with implementing the standards are best put in place in a stepwise manner.

Activities important to FDA's successful management of this process include:

- implementation of changes in GRAS uses and use levels in a stepwise fashion so as to allow the food industry as well as the consumer to adjust to reduced sodium content in foods, and as to take into account research on conditions conducive to lowering salt taste preferences;
- establishment of standards by food category, taking into account the relative dietary contribution of the food category, functional and safety issues, and as appropriate, the lessons learned from others who have developed standards for sodium in foods on the basis of food categories;
- incorporation of a decision-making process fully informed by in-depth analysis of the food supply and the uses or functions of salt coupled with simulation modeling of the effects of different levels of sodium content on total intake, examination of consumer eating behaviors, consideration of food safety, and studies of economic impact and potential unintended consequences;
- sensitivity to burdens on small business;
- in the case of non-GRAS uses and use levels, timely and responsive management of the available petition process; and

- regular, systematic, and comprehensive monitoring of the outcomes of the sodium reduction process for foods prior to each stepwise reduction so as to evaluate the impact and success of the prior step and determine any needed adjustments or changes.

Implementation Activities to Reduce the Sodium Content of Foods and Menu Items

Efforts to reduce sodium in the food supply have traditionally focused on food reformulation and the identification of salt substitutes. As suggested during the committee's information-gathering workshop, some of the "easy" food reformulations to reduce the sodium content of processed foods have been achieved by the major food manufacturing companies, and in these cases, efforts to continue lowering the sodium content now require more creative and intense efforts. This topic is specifically highlighted below as a research need, but the committee recognized the importance of exploring these issues through public-private partnerships. Much of the exploration needed to elucidate the biology of taste and flavor, and to better understand the technological abilities to reduce sodium levels in food, may be undertaken by academic and private institutions. On the other hand, certain activities such as changes in manufacturing processes may be more appropriately carried out by the food industry. In any case, collaborative and cooperative partnerships among all stakeholders are desirable.

The identification of universal or widely applicable salt substitutes has been elusive and no safe, non-sodium, primarily salty-tasting molecule has been identified, with perhaps the single exception of potassium chloride. However, potassium chloride causes foods to taste bitter to a number of people so it cannot be used in some products; in many others, the bitterness limits its use and its effectiveness as a replacement of sodium chloride. As described in Chapter 3, there is reason to systematically pursue salt enhancers or alternative methods for delivery of salt taste. Again, this is a situation for which public-private partnerships are appropriate. There is a current focus on sea salts, which are often touted as a salt substitute. However, because sea salt contains large amounts of sodium, it is unclear how effective it might be in reducing overall sodium intake. Further study of sea salt as one of the many approaches to achieving lower intake of sodium is warranted.

What is clear is that waiting for, or expecting to rely heavily upon, a salt substitute or salt enhancer would not be appropriate or in the interests of public health. Such avenues should be explored, and substitute compounds can serve as useful adjuncts; overall, however, the emphasis should be on (1) reducing the sodium content of the food supply, (2) lowering preferences for salty foods, and (3) promoting existing general dietary recommendations that are consistent with a lower sodium intake—specifically, taking in fewer calories and increasing fruits and vegetables in the diet.

Further, there is considerable progress to be made if broader alternative salt reduction approaches are incorporated into restaurant/foodservice operations. These include flavor strategies and culinary techniques that do not rely as much on salt, but rather on increased use of food ingredients naturally low in sodium. For example, use of fruits and vegetables and other minimally processed fresh foods as well as herbs, spices, and aromatics may hold potential for reducing sodium in restaurant/foodservice items. Additionally, alternative cooking techniques and strategies, such as searing to intensify non-sodium flavors, may also be useful strategies to reduce sodium. Additional guidance may come from taking into account experiences drawn from studying food and flavor patterns around the globe. Also, exploration of innovative strategies to reduce portion size could reduce the overall sodium content of restaurant/foodservice meals. Similarly, many menu items, for example in fast food restaurants, are made up of "layers" of high-salt items (e.g., the pickles, catsup, mustard, and cheese on a cheeseburger); strategies to replace some of these items with low-salt alternatives could result in a substantial reduction in sodium particularly in light of the discussions in Chapter 5 regarding food sources of sodium.

As part of the implementation steps, it should be recognized that the restaurants/foodservice sector of the food supply present special challenges in terms of educating and changing the behavior of those involved in various sector operations. In the case of large restaurants and chains, formulation decisions about the salt content of menu items may be centralized and standardized, although implementation may be widely dispersed among a diversity of staff. In the case of small independent restaurants, decisions regarding sodium content are often not standardized or centralized and may vary even daily based upon staffing and ingredients available. In light of limited evidence about how best to accomplish sustainable, widespread, employee-implemented reductions in prepared food sodium levels in menu items across the diversity of foodservice establishments, foodservice leaders will need to explore a range of flexible initiatives and pilot activities targeted to all personnel and the systems within which they operate. Moreover, compared to large chain operations, independents may require considerably more innovative approaches and extensive piloting. In any case, relevant activities include training and other professional development course work (e.g., on- or offsite learning, e-learning); information sharing among members of the industry (e.g., websites, publications, newsletters); so-called thought leadership, such as conferences, webcasting, leadership task forces, forums, and social responsibility statements incorporated into corporate policy; innovative incentive programs; creative mechanisms for involvement with local or regional health and food safety authorities and infrastructure; and the exploration of voluntary and mandatory standards. The goal is to stimulate creative, innovative solutions and build industry consensus around education strategies. Again, public-private partnerships in this area would be especially advantageous.

Outreach to Consumers

The committee concluded that Americans cannot be expected to achieve meaningful reductions in sodium intake without changes in the food supply. However, changes in the food supply must also be accompanied by informed food choices on the part of individual consumers. Consumers have an important role to play and education and skill building efforts can help to motivate consumers and provide them with skills and tools to reduce sodium intake. Even with reductions of sodium in the food supply, consumers will still need to take actions to reduce their intake of sodium and to lower their preference for the taste and flavor of salty foods. For example, many consumers will need to alter dietary patterns to consume more foods that are naturally lower in sodium, consume smaller portions and fewer total calories, and avoid combining or layering higher sodium foods into single eating occasions. Implementation of the strategies related to consumers and behavior change must rest on a foundation of acceptance regarding the importance of reducing sodium intake. This can take the form of efforts to enhance consumer awareness of the importance of sodium reduction, as well as engaging consumers to be supportive of efforts to reduce sodium in the food supply. From this starting point, efforts can focus on improving consumer understanding of the specific behaviors that prevent their success in reducing personal sodium intake ranging from, for example, moderation in the use of bacon on salads to tasting foods before salting at the table. Further, a major label-reading campaign to enhance consumer knowledge about the sodium content of their foods would be appropriate. As highlighted below, the development of methodologies through new research to allow consumers to monitor their own sodium intake would be helpful.

The effectiveness of health communication efforts will be enhanced through guidance from social and behavioral theories and research and through the application of lessons learned from past domestic and international initiatives. Effective communication campaigns can underscore the benefits to be derived from changes in the food supply, which can reduce environmental barriers to sodium reduction. Likewise, these campaigns can be targeted in response to current knowledge of the relationship of sodium intake to health outcomes and attitudes toward reductions in sodium intake. Messages need to additionally be targeted toward increasing skills, including label-reading and food preparation, enhancing self-efficacy to make these changes, and supporting social norms for reduced sodium intake.

Time Line for Reducing Sodium Intake

Because of the number of unknowns regarding the specific process for reducing sodium in the food supply and implementing supporting strategies, it is challenging to identify a time line for the reduction of sodium intake across the U.S. population. The goal is to reduce the current estimated population intake of 3,400 mg/d to the level established by the 2005 *Dietary Guidelines for Americans*, which is 2,300 mg/d. While the new 2010 *Dietary Guidelines for Americans* will soon be released, it is unlikely that the sodium intake goal will have been raised to levels above 2,300 mg/d; instead, it is likely that it will either remain the same or decrease. Therefore, the goal of about a 30 percent or greater reduction is likely to remain the same for many years.

It must be assumed that a carefully conducted regulatory process to establish salt standards for foods will take time, given that stakeholder input and concomitant research and data gathering must occur. Certainly, while data from perceptual studies may point the way to the quantitative levels at which changes in the presence of a substance may not be perceived, much is yet to be learned about the application of such work to the wide range of food products and to other practical considerations in the real world. Further, the pace at which technologies can be developed and used to assist with the process is unknown.

Nonetheless, FDA, as part of its regulatory implementation, will establish a time line for the reduction of sodium in the food supply. However, as a general matter and as described earlier in the context of needed coordination, it would be important to ensure that an informed process is put in place to establish initial time lines and goals for overall reductions in sodium intake among Americans and for carrying out the implementing tasks that are separate from those for reducing sodium in the food supply. In turn, there must be an active process and responsible authorities to both coordinate and monitor these goals and adjust them as needed to ensure that they remain viable and serve to stimulate the process, making implementers accountable. For this reason, the existing strategies include the recommendation that the Secretary of Health and Human Services be responsible for this important activity.

Funding

The task of this committee did not include recommendations regarding the funding required to implement and evaluate strategies to reduce sodium intake. Substantial data-gathering from stakeholders, research, and decision making is needed as part of the development of the proposed strategies making it difficult to anticipate the total costs of such initiatives, and in turn, the level of funding needed. As several studies suggest, the reduction of sodium intake will likely reduce health-care costs, which will be of benefit to the public (Bibbins-Domingo et al., 2010; Palar and Sturm, 2009; Smith-Spangler et al., 2010). However, it is also important to acknowledge that the proposed strategies will also require investment by industry and government. Funding is pivotal to the success of these strategies, and the importance of reducing sodium intake as a public health measure warrants funding at the federal, state, and local levels as appropriate. The report makes no recommendations concerning funding for FDA, U.S. Department of Agriculture (USDA), or other government agencies; however, the committee recognizes that additional or reallocated resources will be required to fully implement the recommended changes. It should also be acknowledged that reducing the sodium content of the food supply may incur significant reformulation costs for the industry that will likely be passed on at least in part to consumers. These overall costs, however, will be necessary to fully realize the public health benefits of reducing sodium intake.

RESEARCH NEEDS

Overall, the major research needs identified by the committee can be grouped into four general areas: (1) understanding salt taste reception and taste development; (2) developing innovative methods to reduce sodium levels in foods while maintaining palatability, physical properties, and safety; (3) enhancing current understanding of factors impacting consumer awareness and behavior relative to sodium reduction; and (4) monitoring sodium intake, sodium in the food supply, and salt taste preference. Research needs related to sodium intake reduction are considerable. The committee has focused on the most critical and germane so as to encourage the prudent use of limited resources to better support efforts to reduce sodium intake. The committee noted that with few exceptions the research needs identified may benefit from strong cooperation among public agencies, non-profit organizations, and private entities. In addition, it was felt that a renewed focus on many of the identified research needs should commence immediately, in hopes that such research might be able to inform the recommended strategies identified in Chapter 9. Given current estimates of the financial benefits of reducing the incidence of deaths resulting from hypertension and other diseases related to excessive salt intake (Bibbins-Domingo et al., 2010; Palar and Sturm, 2009; Smith-Spangler et al., 2010), funds to support these initiatives will be well spent.

Salt Taste

There are many scientific gaps pertaining to salt taste perception. Research on salt taste and its modification would help policy makers and the food industry identify additional effective approaches to achieving sodium reductions in foods that are acceptable to consumers. This is an area of research in which the National Institutes of Health (NIH) could play a productive role and an area that could benefit from the development of public-private partnerships. Research needs in this area include the following:

- Although the hypothesis that epithelial sodium channels are one set of salt taste receptors is currently accepted by most sensory scientists, questions remain as to why discrepancies exist between human and experimental animal studies regarding these receptors. It is also believed that at least one additional salt taste receptor exists, but the structure, location within the oral cavity, and mechanism of reception are unknown. Research to elucidate the mechanism(s) by which salty tastes are perceived could facilitate the development of salt taste enhancers, allowing for reduction of sodium levels in food while maintaining desirable tastes and flavors.
- More research is also needed to understand the development of salt taste preferences and their modification. Information gaps in this area include understanding how taste preferences develop in early childhood. For example, several studies have indicated that experience with salt taste in infancy and early childhood influences taste preferences, which some researchers believe may set lifelong preferences for the level of saltiness in food that is appealing. Further investigation of such topics may be highly valuable in determining whether reduced sodium exposure in early life can reduce preferences for high-sodium diets in adulthood and whether strategies to focus on early interventions should be pursued.
- There is evidence to show that salt taste preferences can be changed in adulthood when sodium is reduced across all foods. However, several important issues remain unknown that may impact the success of this strategy to successfully reduce salt intake of the population. First, the time course of changes in preference for salty foods in response to changes in salt intake is not well understood. Second, there are questions on the extent of the salt reduction that can be accomplished in a single reformulation without greatly altering the palatability of the food. The size of such reductions may be food category specific, but further research may reveal general principles that will permit predictions in different food systems. Third, it is unknown whether individuals are able to acclimate to lower-sodium foods when some high-sodium foods remain part of their diet. For example, it is not known whether sensory accommodation would occur if salt were reduced in a single product category such as soup or bread or if the majority of the diet were low in sodium but consumers occasionally consumed foods that might

be exempted from sodium reduction (anchovies, olives, etc.). This gap in current knowledge has been a concern for some committee members in determining whether exemptions should be considered for salty foods consumed in small quantities.

Sodium Reduction in Food

Current and ongoing industry reformulation has demonstrated that substantial reductions in sodium can be achieved based on existing technology and science. However, given the need to significantly reduce the sodium content of the food supply to achieve recommended population intake levels, additional innovations and research will be necessary to secure reductions while maintaining product taste, texture, safety, and shelf life. Undoubtedly, heightened attention to such innovation could be sparked by regulatory efforts to reduce sodium throughout the food supply. Research needs in this area include the following:

- For some products, there is a need to develop new methods to achieve palatability given reduced sodium content. Although development of salt enhancers and replacers may be a useful step toward achieving palatability in such products, other innovations are also promising. For example, salt is often added to foods to decrease the perception of bitterness. Research to develop methods for non-sodium ingredients to reduce unappealing bitterness may in turn lead to decreases in the sodium content of certain foods. Bitterness reducers may also permit higher substitution levels for potassium chloride. Other innovations such as change of salt crystal structure or location of salt crystals within a food product show potential as well. Product and menu development research focusing on enhancing other tastes and flavors within food products while reducing sodium content may also be useful. Such research could examine how the addition of herbs, spices, and other ingredients and innovative culinary techniques may create foods that are well accepted by consumers despite their lower salt content.
- Research is also needed to continue the development of processing methods or alternative ingredients to replace sodium to create physical properties within some foods. While a number of alternatives exist for replacing sodium functionality in reduced-sodium foods, many of these alternatives are limited to particular applications, and more alternatives may be found if increased attention is given to this area.
- Research is needed to better understand the minimal levels of sodium necessary for those products in which salt provides a safety

function, including allowing adequate shelf life. As products are reformulated to reduce sodium content it will be essential that manufacturers test the new formulations to ensure that the product remains safe over its intended shelf life, factoring in common mishandling of the product. It may also be important for manufacturers to account for changes in the shelf life of their products in establishing expiration dates.

- To aid manufacturers in maintaining safety, government agencies, trade associations, and research institutions may need to work with food processors—particularly smaller processors with limited research capacity—to help them avoid reformulations that might heighten the risk for foodborne disease. These research efforts might include work to expand and promote the use of computer models for predicting microbial growth in foods, such as the USDA's Predictive Microbiology website,[5] and efforts to research the potential of incorporating alternative hurdles to microbial growth as sodium is reduced.

Supporting Consumers

A third area involves the need for more refined understanding of approaches to effectively change consumers' knowledge, attitudes, and behavior regarding sodium. Research needs relevant to this interest are often cited in consensus reports on diet and health, and generally focus on experimental research examining the fundamental factors involved in changing dietary behaviors and experimental and observational research examining the most important established and novel factors that drive changes in population health. All such efforts would assist in improving the support given to consumers for behavior change relative to sodium intake, but three specific research areas are highlighted below.

1. The strategies recommended in this report represent an innovative approach to dietary change that embeds a health communication campaign in the context of large-scale changes in the levels of sodium in the food supply. This has clear implications for dietary and other health behaviors that are potentially associated with reducing sodium intake, such as reducing calorie intake. Evaluation of the relative contributions of these associated interventions to sodium intake reduction is warranted, using a range of available evaluation methodologies.

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[5] Available online: http://fsrio.nal.usda.gov/document_reslist.php?product_id=66 (accessed November 17, 2009).

2. In today's environment, messages about sodium reduction compete with dietary recommendations about other nutrients and with recommendations about diseases other than hypertension. It is possible that consumers often have difficulty translating diet and health information into food choices compatible with all diet recommendations and may focus on one nutrient and fail to act on other nutrients. Research is therefore needed to elucidate the effectiveness of a single nutrient message as would be the case for sodium reduction, and consumers' ability to integrate messages for sodium into existing well-established dietary guidance consistent with sodium reduction, such as increasing consumption of fruits and vegetables and lowering calorie intake.
3. The appeal of salt taste has been documented. An important research area is the question of how behavior change models for sodium reduction can effectively be structured when the behavior in question is strongly motivated by the pleasure of taste.

Monitoring Sodium Intake, Sodium in the Food Supply, and Salt Taste Preference

There are a range of monitoring and surveillance research needs.

- The importance of better monitoring the intake of sodium among the U.S. population has resulted in the recommendation that 24-hour urine collection be carried out as part of U.S. national surveys. Because 24-hour urine collection is complicated under the best of circumstances, as a first step to implementing this activity, it is possible to use existing surplus urine samples from the National Health and Nutrition Examination Surveys (NHANES) to pilot-test methodologies for comparing casual collection outcomes with measurements obtained from 24-hour collections and for improving the approaches to collecting 24-hour urine samples. Further, other methodologies should be explored, including improved and simpler approaches for use in large surveys. Research is needed to develop a more easily obtainable marker of sodium intake than 24-hour urine collection that is reliable, economical, and easy to administer for population surveys.
- Research is needed to develop technologies to assist individuals in assessing their sodium intake. It is important to help consumers monitor their individual sodium intake through readily available and accurate measures of sodium intake. Even within the context of reducing overall sodium levels in the food supply, individuals must still take individual actions to reduce sodium intake. To do so,

the ability to measure one's own intake over time would be advantageous. This is particularly important for high-risk individuals.

- Research is needed to better track the sodium content of the food supply. The development of new and refined methodologies would be useful. Such methodologies might range from opportunities to link Universal Product Code-level sales data to information on the nutrient content of the food as stated on the Nutrition Facts panel, to the development of databases relative to the sodium content of foodservice menu items.
- Research is needed to expand the development of and continue to validate brief salt taste tests to monitor changes in perception following reduction of salt in the food supply. A recommendation has been made to complete development of an appropriate methodology and, in turn, initiate monitoring of salt taste preference on a national level. It is expected that consumers will adapt their sensory preferences toward lower salt levels as they are exposed to them during the stepwise reduction of salt and sodium in the food supply, and monitoring of this is critical to measuring the effectiveness of and adjusting the approaches to reducing sodium intake. To accomplish taste monitoring, there is a need for the development, testing, and validation of brief taste tests that can be incorporated into population-based monitoring efforts, such as NHANES. Efforts for other aspects of taste are currently under development as part of the NIH Toolbox for Assessment Initiative,[6] and these could serve as a model.

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Committee Member Biographical Sketches

JANE E. HENNEY, M.D. (*Chair*), is professor of medicine at the University of Cincinnati College of Medicine. Previously, she was senior vice president and provost of Health Affairs at the University of Cincinnati. Her experience and expertise lie in managing complex organizations that provide direct health services, regulate science-based products, educate the next generation of health professionals, and conduct biomedical research. She has served in a series of senior health policy leadership positions including commissioner of the U.S. Food and Drug Administration (1999–2001); deputy director of the National Cancer Institute; vice chancellor, Health Programs, of Kansas Medical Center; interim dean of the University of Kansas School of Medicine; and vice president for Health Sciences at the University of New Mexico. Dr. Henney currently serves on several not-for-profit boards including the Commonwealth Foundation, the China Medical Board, and her alma mater, Manchester College. She is also a member of the board of three for-profit companies: AmerisourceBergen Corp., AstraZeneca Ltd., and Cigna Corp. She served on several Institute of Medicine (IOM) committees including the Planning Committee for *The IOM Drug Safety Report: Resource Implications* (A Workshop), the Committee on Improving Mammography Quality Standards, and the IOM Membership Committee, and she is currently serving as IOM Membership Section 12 chair. Dr. Henney received her undergraduate degree from Manchester College and her medical degree from Indiana University; she completed her subspecialty training in medical oncology at the M.D. Anderson Hospital and Tumor Institute and the National Cancer Institute. She is an IOM member.

CHERYL A. M. ANDERSON, Ph.D., M.P.H., is assistant professor of epidemiology at The Johns Hopkins Bloomberg School of Public Health in Baltimore, Maryland. Dr. Anderson's research centers on diet and the prevention of chronic diseases in minority and underserved populations. Her current research projects address the effects of sodium and potassium intake on clinical and subclinical cardiovascular disease, diet and the prevention of cardiovascular disease (CVD) in the context of chronic kidney disease, and the optimal macronutrient intake in CVD prevention. Dr. Anderson is a member of the American Heart Association Committee on Nutrition and Physical Activity. She is also a Dannon Institute Nutrition Leadership Institute (NLI) scholar and past president of the NLI Alumni Association. She has served on the National Institutes of Health (NIH) National Institute of Neurological Disorders and Stroke Writing Group on Primary Prevention of Stroke. Dr. Anderson recently completed committee service on the IOM-NAS (National Academy of Sciences) Committee on Use of Dietary Supplements by Military Personnel (2006–2008). Prior to her appointment at Johns Hopkins, Dr. Anderson was an instructor of epidemiology at the University of Pennsylvania School of Medicine, Center for Clinical Epidemiology and Biostatistics. She has a B.A. from Brown University, an M.P.H. from the University of North Carolina at Chapel Hill, an M.S. in epidemiology, and a Ph.D. in nutritional sciences from the University of Washington School of Public Health and Community Medicine.

SONIA Y. ANGELL, M.D., M.P.H., is director of the Cardiovascular Disease Prevention and Control Program at the New York City Department of Health and Mental Hygiene. She is responsible for overseeing the development of citywide and targeted initiatives and policies designed to prevent cardiovascular morbidity and mortality among New York City residents and to eliminate related health disparities. One such activity includes the regulation of *trans* fat in city restaurants; a new focus for her agency includes the reduction of population sodium intake. Dr. Angell received her M.D. from the University of California at San Francisco and completed a primary care internal medicine residency at Brigham and Women's Hospital in Boston. She is an Assistant Clinical Professor of Medicine at the College of Physicians and Surgeons of Columbia University and Assistant Attending Physician at New York Presbyterian Hospital. Dr. Angell has a diploma in tropical medicine and hygiene from the London School and an M.P.H. from the University of Michigan. She is a former Robert Wood Johnson clinical scholar.

LAWRENCE J. APPEL, M.D., M.P.H., is professor of medicine in the Welch Center for Prevention, Epidemiology and Clinical Research at The Johns Hopkins University School of Medicine, Baltimore, Maryland. Con-currently, he holds adjunct appointments in epidemiology and international health (human nutrition) at The Johns Hopkins University Bloomberg School of Public Health. The focus of Dr. Appel's career has been the conduct of clinical research pertaining to the prevention of hypertension, cardiovascular disease, and renal disease, through both pharmacologic and non-pharmacologic approaches, typically nutrition-based. He has served as an investigator in a number of hypertension clinical trials, including Trials of Hypertension Prevention, Trials of Non-pharmacologic Interventions in the Elderly, PREMIER, DASH (Dietary Approaches to Stop Hypertension), DASH-Sodium, and the African-American Study of Kidney Disease and Hypertension. Dr. Appel previously served as chair of the IOM-NAS Committee on Dietary Reference Intakes for Electrolytes and Water (2002–2004) as well as a member of the Committee on Examination of the Evolving Science for Dietary Supplements (2001–2002) and the Committee on Nutrition Services for Medicare Beneficiaries (1999–2000). He received his M.D. from the New York University School of Medicine and his M.P.H. from Johns Hopkins University.

GARY K. BEAUCHAMP, Ph.D., is director and president of the Monell Chemical Senses Center in Philadelphia. Monell was established in 1968 as the world's first scientific institute for multidisciplinary research on taste, smell, and chemosensory irritation, based at the University of Pennsylvania. The two institutions continue to maintain a close relationship. Dr. Beauchamp is an adjunct professor in the Department of Psychology and in the School of Veterinary Medicine at the University of Pennsylvania. He has served as Monell's director since 1990. His research relates to genetics of taste perception; development of human chemosensory perception and preference; genetics and behavior of individual olfactory identity; and adult human taste perception with a special interest in salt taste. Dr. Beauchamp has published more than 250 publications in peer-reviewed journals. He is a director of the Ambrose Monell Foundation and the G. Ungar Vetlesen Foundation. He has served on many NIH committees and served as a member of the National Institute on Deafness and Other Communication Disorders (NIDCD) Advisory Council of the NIH (2001–2005). He received his B.A. from Carleton College and his Ph.D. in biopsychology from the Pritzker School of Medicine, University of Chicago.

RONETTE R. BRIEFEL, Dr.P.H., R.D., is a senior fellow at Mathematica Policy Research in Washington, DC. Her expertise includes nutrition monitoring, dietary intake assessment, and the evaluation of nutrition programs and policies to promote health and prevent disease. She was senior research epidemiologist and nutrition policy adviser at the Centers for Disease Control and Prevention, National Center for Health Statistics. Through her work, Dr. Briefel has analyzed national data on food consumption and health including sodium intakes, obesity, and hypertension in the population and authored more than 100 publications in peer-reviewed journals. Her current research at Mathematica focuses on the dietary intakes of infants and preschoolers, and the relationship between the school food environment and children's diets and obesity. Dr. Briefel's IOM-NAS committee service includes the Panel on Enhancing the Data Infrastructure in Support of Food and Nutrition Programs, Research, and Decision-Making (2004–2005), Committee on the Scientific Basis for Dietary Risk Eligibility Criteria for WIC Programs (2000–2002), and Committee on Food Additives Survey Data (1988–1990). Dr. Briefel received her B.S. in nutrition from Pennsylvania State University, and her M.P.H. in maternal and child health and Dr.P.H. in chronic disease epidemiology from the University of Pittsburgh.

MARSHA N. COHEN, J.D., is a professor of law at the University of California Hastings College of the Law in San Francisco, where she has also served twice as acting associate dean of admissions. Her primary teaching assignments have been food and drug law, torts, and administrative law, and for many years she supervised the college's large judicial externship program. Professor Cohen began to specialize in food and drug law as a staff attorney with the Washington Office of Consumers Union. Thereafter she served for two terms as a member of the California State Board of Pharmacy and was its first non-pharmacist president. She is the author (with the late William L. Marcus) of *Pharmacy Law for California Pharmacists*, now in its sixth edition. Professor Cohen has served on three National Research Council and Institute of Medicine committees: the Committee on Review of the Use of Scientific Criteria and Performance Standards for Safe Food (2002–2003), the Committee on Ensuring Safe Food from Production to Consumption (1998), and the Committee on State Food Labeling (1991–1992). She has also served on the Food and Drug Administration's (FDA's) Food Advisory and Device Good Manufacturing Practices Advisory Committees, the National Institute of Environmental Health Sciences Council, and the Department of Health, Education, and Welfare (HEW) Review Panel on New Drug Regulation. Professor Cohen is coauthor, with Professor Michael Asimow, of *California Administrative Law* (2002) and has written numerous law review articles and opinion pieces, most on issues pertaining to food and drugs. She earned her bachelor's degree from Smith College and her law degree from Harvard Law School.

CHRISTINA A. MIRELES DEWITT, Ph.D., is associate professor of food chemistry at Oklahoma State University. Her experience is broad-based in the area of food science, focusing on investigations into alternative processes that alter protein functionality in fresh and processed meat. Results from these studies suggest possible replacements for sodium-based salts in terms of their traditional role as a solubilizer for protein-based foods. Her earlier work focused on alternative processing methods to alter protein functionality and the chemistry related to replacing phosphate with solubilized proteins, as well as the application of alkaline enhancement solution on meat products. She has recently taken on research targeted to the task of reducing salt in foods through the use of protein-based flavor enhancers and functional proteins. Previous experience as food chemistry operations manager at Silliker Laboratories provided her extensive experience on the issues regarding nutrition labeling and the analysis of foods. Dr. DeWitt has a B.S. in food science from Texas A&M University and a Ph.D. in food science from Oregon State University.

GREG DRESCHER is executive director of Strategic Initiatives at the Culinary Institute of America (CIA). The only non-scientist in the group of seven experts who authored the keystone paper published in the peer-reviewed *American Journal of Clinical Nutrition* that set out the principles of the traditional, healthful Mediterranean diet, Mr. Drescher has spent much of his career studying and investigating healthful "flavor strategies" of food cultures around the world and how they can be used to promote more healthful American diets. He is the creator of the CIA's influential conferences and leadership retreats, including the annual Worlds of Flavor International Conference and Festival (now in its 13th year), the Flavor Summit, and Worlds of Healthy Flavors, a partnership between the CIA and Harvard School of Public Health that for many years has brought together America's leading nutrition researchers, corporate chefs of volume foodservice operations, and world cuisines experts to foster innovation around more healthful menu choices. Mr. Drescher has been honored with a Food Arts Silver Spoon Award and three James Beard awards, in large part for his leadership in researching and documenting the gold standards of cuisines from Europe and Asia to Latin America and making these flavors more accessible to American chefs. He studied western philosophy at the University of the Pacific in Stockton, California.

MARY K. MUTH, Ph.D., is director of the Food and Agricultural Policy Research Program at RTI International in North Carolina. She is also an adjunct associate professor in the Department of Agricultural and Resource Economics at North Carolina State University. Her expertise lies in economic impact analysis as well as applications of industrial organization, applied welfare analysis, and econometrics in evaluating food and agricultural policy and providing information for policy development. Dr. Muth also specializes in developing computer models and databases to support economic impact analyses of regulations, developing industry survey instruments, and analyzing industry survey data. Dr. Muth earned her B.S. degree in agricultural and managerial economics from the University of California at Davis, her M.S. in agricultural economics from Cornell University, and her Ph.D. in economics from North Carolina State University.

ROBERT J. RUBIN, M.D., F.A.C.P., is currently clinical professor of medicine in the Division of Nephrology and Hypertension at the Georgetown University School of Medicine and an independent health-care consultant. Previously, Dr. Rubin was president of the Lewin Group, an international health-care consultancy, for 17 years. During that time, Dr. Rubin served as medical director for a pharmaceutical benefit management company, as well as chair of the board of a biotech start-up. From 1981 to 1984, Dr. Rubin was the assistant secretary for planning and evaluation at the U.S. Department of Health and Human Services (HHS), as well as assistant surgeon general. In the former capacity he was chair of the task forces charged with the design, passage, and implementation of Medicare's Prospective Payment System as well as the primary policy adviser to the HHS Secretary. Currently, as a health-care consultant, he works extensively with pharmaceutical, medical device, and biotech companies to develop strategic and marketing plans for new devices and drugs. He also works with physician groups and providers of nephrologic services. In addition, he advises several government agencies on health-care policy. Dr. Rubin has served on the Robert Wood Johnson Health Policy Fellowships Board (1988–2002), the IOM-NAS Committee to Develop a National Research Agenda on Aging (1988–1991), and the Committee to Study the Future of Public Health (1987–1988). Dr. Rubin received his M.D. from Cornell University Medical College and his undergraduate degree from Williams College.

JOHN RUFF, M.A., retired in 2008 as senior vice president, Global Quality, Scientific Affairs and Nutrition, for Kraft Foods in the United States. Prior to joining Kraft, Mr. Ruff was a technical brand manager for Procter & Gamble in England. During his 36-year career with Kraft and the former General Foods, Mr. Ruff worked in six countries and gained experience in product and process development for beverages, coffee, confectionery, desserts, and meals. He has led major basic research programs in sugar and salt substitutes, food safety initiatives, and "greenfield" site startups. Mr. Ruff headed research and development groups for both Kraft International and North American businesses where he successfully integrated the technical operations of numerous acquisitions and established global centers of expertise to maximize research and development effectiveness. In his most recent role, he established and led a worldwide advisory council consisting of external experts who have helped guide Kraft's health and wellness initiatives. Mr. Ruff is just completing his term as president of the International Life Sciences Institute and sits on the boards of the Institute of Food Technologists (IFT) and the Joffrey Ballet. He is past chair of the Food Processors Association, past chair of the IFT Foundation, and a fellow of the Institute of Food Science and Technology in the United Kingdom. Mr. Ruff received his M.A. in biochemistry and B.A. in natural science from Cambridge University in the United Kingdom.

GLORIAN SORENSON, Ph.D., M.P.H., is professor in the Department of Society, Human Development, and Health at the Harvard School of Public Health in Boston and director of the Center for Community-Based Research at the Dana-Farber Cancer Institute. She also directs the Dana-Farber's Office for Faculty Development. Dr. Sorensen's research interests are in cancer prevention and control, worksite and community intervention research, and tobacco control and other health behaviors, in various multiethnic community settings. She has been principal investigator of multiple National Cancer Institute-funded projects focusing on cancer control in working class multiethnic populations. Her past IOM-NAS committee service includes the Committee to Assess Worksite Preventive Health Program Needs of NASA Employees (2004–2005), Committee on the Health and Safety Needs of Older Workers (2001–2005), Committee for Behavior Change in the 21st Century: Improving the Health of Diverse Populations (2000–2002), and Committee on Capitalizing on Social Science and Behavioral Research to Improve the Public's Health (1999–2000). She is the principal investigator for the Harvard School of Public Health Center for Work, Health, and Well-being and for the Massachusetts Cancer Prevention Community Research Network. Dr. Sorensen was recently awarded a research grant from the National Cancer Institute to study tobacco control among teachers in India, building on collaborations established through a Fulbright Award (2003–2004). She was a member of the National Cancer Institute's (NCI's) National 5-A-Day for Better Health External Advisory Group and a member of the NIH study section on Community Prevention and Control; she recently chaired several study sections for the National Institute for Occupational Safety and Health. In addition, Dr. Sorensen is a member of the editorial board for the journal *Cancer Epidemiology, Biomarkers, and Prevention*, and she formerly served on the editorial boards of the *American Journal of Health Promotion* and the *Journal of Health and Social Behavior*. She received her Ph.D. degree from the University of Minnesota.

ELIZABETH A. YETLEY, Ph.D., is a retired government scientist. Her career spans more than 28 years of government service including 24 years at the Food and Drug Administration culminating with her appointment as lead scientist in nutrition. From 2004 until her retirement, she was a senior nutrition research scientist with the National Institutes of Health, Office of Dietary Supplements. Her leadership activities in the field of nutrition public health policy have been considerable and impactful. She has been responsible for national food fortification programs, use of national nutrition monitoring and surveillance systems to support nutrition and food safety health policies, nutrition labeling including health claims to reduce sodium intakes, infant formula and medical food reviews and regulatory oversight, dietary supplement regulation, and the use of nutrient-related reference values in public health policy formulation. She has received more than 75 honors, commendations, and letters of recognition for her service and has served as a scientific representative for the U.S. government on more than 50 associations, panels, and committees. She has authored or coauthored approximately 100 scientific and peer-reviewed publications. Dr. Yetley received her Ph.D. in nutrition with a minor in biochemistry and physiology from Iowa State University.

Appendix A

Acronyms, Abbreviations, and Glossary

24-hour recall A method of dietary assessment in which an individual is asked to remember everything eaten during the previous 24 hours.

ACE Angiotensin-converting enzyme
ADA American Dietetic Association
Adequate Intake (AI) The recommended average daily intake level of a nutrient based on observed or experimentally determined approximations or estimates of intakes that are assumed to be adequate for a group (or groups) of apparently healthy people; used when the RDA (Recommended Daily Allowance) cannot be determined.
Advertising A paid public presentation and promotion of ideas, goods, or services by a sponsor that is intended to bring a product to the attention of consumers through a variety of media channels, such as broadcast and cable television, radio, print, billboards, the Internet, or personal contact.
AHA American Heart Association
AICR American Institute for Cancer Research
Aldosterone A hormone made by the outer portion (cortex) of the adrenal gland that regulates the balance of salt and water in the body.
AMA American Medical Association
Amino acid An organic compound containing an amino group and a carboxyl group that links with other amino acids to form proteins.
Anion A negatively charged ion.
ANPR Advanced Notice of Proposed Rulemaking
APHA American Public Health Association

ARB Angiotensin receptor blocker

Aroma See *Flavor*.

Aspartame A low-calorie non-nutritive sweetener made of aspartic acid and phenylalanine. It should not be consumed by individuals with phenylketonuria and is unstable for cooking because its flavor changes when heated.

Atherosclerosis Clogging, narrowing, and hardening of the body's large arteries and medium-sized blood vessels; can lead to stroke, heart attack, eye problems, and kidney problems.

Away-from-home foods Foods categorized according to where they are obtained, such as restaurants and other places with wait service; quick-serve restaurants, and self-service or take-out eateries; schools, including child care centers, after-school programs, and summer camp; and other outlets, including vending machines, community feeding programs, and eating at someone else's home.

Bars Establishments variously known as bars, taverns, nightclubs, or drinking places that are primarily engaged in preparing and serving alcoholic beverages for immediate consumption.

Body mass index (BMI) An indirect measure of body fat calculated as the ratio of a person's body weight in kilograms to the square of a person's height in meters: BMI (kg/m^2) = weight (kilograms)/height $(meters)^2$ or BMI (lb/in^2) = weight (pounds)/height $(inches)^2 \times 703$.

Cafeteria An establishment in which patrons select from food and drink items on display in a continuous line or from buffet stations (also includes grill-buffets and buffets).

Calorie A kilocalorie (kcal) is defined as the amount of heat required to change the temperature of 1 gram of water from 14.5°C (degrees Celsius) to 15.5°C. In this report, calorie is used synomously with kilocalorie as a unit of measure for energy obtained from foods and beverages.

CARDIA Coronary Artery Risk Development in Young Adults

Cardiovascular disease (CVD) Any abnormal condition characterized by dysfunction of the heart and blood vessels; includes atherosclerosis (especially coronary heart disease), cerebrovascular disease, and hypertension.

Casual dining full-service restaurant Establishment providing waiter or waitress service, where the order is taken while the patron is seated; patrons pay after they eat; average per-person dinner checks are in the $10–$25 range.

Cation A positively charged ion.

CDC Centers for Disease Control and Prevention

Cerebrovascular disease Damage to blood vessels in the brain that occurs when vessels burst and bleed or become clogged with fatty deposits. When blood flow is interrupted, brain cells die or are damaged, resulting in a stroke.

Chemesthesis Sensations that arise when chemical compounds activate receptor mechanisms for other senses, usually those involved in pain, touch, and thermal perception in the eye, nose, mouth, and throat.

Cholesterol A waxy, fat-like substance that occurs naturally in all parts of the body; high levels of cholesterol in the blood can increase the risk of heart disease.

Congestive heart failure Inability to pump enough blood to avoid congestion in the tissues.

CSPI Center for Science in the Public Interest

CVD Cardiovascular disease

Daily Value (DV) A term on food labels based on the RDA (Recommended Dietary Allowance) designed to help consumers use food label information to plan a healthful diet. DV declarations within the Nutrition Facts panel play an important role in informing consumers about the nutritional content of the packaged foods they purchase by placing the food's nutritional contribution within the context of a total daily diet, the general target toward which consumers should strive.

DASH Diet Dietary Approaches to Stop Hypertension: a diet rich in fruits, vegetables, and low-fat dairy products and reduced in saturated fat, total fat, and cholesterol.

DGAC Dietary Guidelines Advisory Committee

Diastolic blood pressure The minimum pressure in the arteries when the heart is at rest.

Dietary Guidelines for Americans A federal summary of dietary guidance for the American public based on current scientific evidence and medical knowledge. The guidelines are issued jointly by the U.S. Department of Health and Human Services (HHS) and the U.S. Department of Agriculture (USDA) and are revised every 5 years.

Dietary Reference Intake (DRI) A set of four distinct nutrient-based reference values that replaced the former Recommended Dietary Allowance in the United States. These include Estimated Average Requirement (EAR), Recommended Dietary Allowance (RDA), Adequate Intake (AI), and Tolerable Upper Intake Level (UL).

Disappearance data Data that refer to food and nutrients that disappear from the marketplace. The term refers to food and nutrient availability for a population that is calculated from national or regional statistics by the inventory-style method.

Dose-response assessment Determination of the relationship between nutrient intake (dose) and some criterion of either adequacy or adverse effect.

ENaC Epithelial sodium channel, ion channel, or pore hypothesized to play a role in salt taste perception.

Epithelium Membranous tissue covering internal organs and other internal surfaces of the body.

Estimated Average Requirement (EAR) The average daily nutrient intake level that is estimated to meet the requirements of half of the healthy individuals in a particular life stage and gender group.

Family dining full-service restaurant Establishment providing waiter or waitress service, where the order is taken while the patron is seated; patrons pay after they eat; average per-person dinner checks of $10 or less.

FDA U.S. Food and Drug Administration

Fermentation A common process for preserving foods in which fresh foods are transformed to foods that can be preserved for longer periods of time than their fresh counterparts due to the actions of particular types of microbes.

Fine dining full-service restaurant Establishment providing waiter or waitress service, where the order is taken while the patron is seated; patrons pay after they eat; average per-person dinner checks of $25 or higher.

FITS Feeding Infants and Toddlers Study

Flavor The sensory impression of a food or other substance, determined by the chemical senses of taste and smell; or a substance added to food to give it a particular taste.

Folate A B vitamin that helps the body make healthy new cells; foods containing folic acid include leafy green vegetables, fruits, dried beans, peas, and nuts.

Food industry In this report, the term encompasses both processed food manufacturers and restaurant and/or foodservice operations.

Food manufacturing An industry that transforms livestock and agricultural products into products for intermediate or final consumption.

Food processors Businesses that conduct food manufacturing.

Foodservice The dispensing of prepared meals and snacks intended for on-premise or immediate consumption, including "take-out foods" that are consumed in the home or at another location outside of the establishment and "fresh, prepared, deli foods" purchased from retailers.

Foodservice contractors Establishments primarily engaged in providing food services at institutional, governmental, commercial, or industrial locations belonging to others, based on contractual arrangements with these organizations for a specified period of time; management staff is always provided by the foodservice contractors (also referred to as managed services and onsite foodservice).

FSA Food Standards Agency (United Kingdom)

FSAI Food Safety Authority of Ireland

Full-service restaurant Waiter or waitress service is provided and the order is taken while the patron is seated; patrons pay after they eat.

GDA Guideline Daily Amount

Glucose tolerance The body's ability to break down (metabolize) blood sugar.

Glutamic acid An amino acid occurring in proteins; used in monosodium glutamate to enhance the flavor of meats.

GMA Grocery Manufacturers Association

GRAS Generally recognized as safe

HHS U.S. Department of Health and Human Services

Hyperkalemia Serum potassium concentration > 5.0 mEq/L or mmol/L.

Hypertension/Hypertensive Systolic blood pressure ≥ 140 or diastolic blood pressure ≥ 90 mm Hg.

Hypokalemia Serum potassium concentration < 3.5 mEq/L or mmol/L.

IFIC International Food Information Council

Incidence The occurrence of new cases of disease that develop in a candidate population over a specified time period.

INTERSALT The largest study, and among the most often referenced in the literature, relating electrolyte intake to blood pressure. Analyzed a single 24-hour urine collection from subjects in 32 countries during 1985–1987. Approximately 200 men and women ages 20–59 years were recruited at each center.

Iodized salt Table salt with iodine added.

IOM Institute of Medicine

Ion A particle that is electrically charged (positively or negatively).

Left ventricular hypertrophy Enlargement of the muscle tissue that makes up the wall of the heart's main pumping chamber (left ventricle); develops in response to some factor, such as high blood pressure, that requires the left ventricle to work harder.

Level playing field As used in this report, a coordinated lowering of salt in foods by all manufacturers and restaurant/foodservice operations.

Limited-service restaurant Patrons generally order at a cash register or select items from a food bar and pay before they eat (also quick-service restaurant).

Lipid A naturally occurring molecule, such as fat, wax, sterol, fat-soluble vitamin, monoglyceride, diglyceride, phospholipid, or others; the main biological functions of lipids include energy storage, as structural components of cell membranes, and as important signaling molecules.

Mobile food services Establishments primarily engaged in preparing and serving meals and snacks for immediate consumption from motorized vehicles or non-motorized carts.

MSG Monosodium glutamate, a well-known flavoring compound that imparts to food a savory taste (called "umami") as well as a salt taste.

NCHS National Center for Health Statistics

NHANES National Health and Nutrition Examination Survey, conducted by the National Center for Health Statistics of the Centers for Disease Control and Prevention.

NHLBI National Heart, Lung, and Blood Institute

NIH National Institutes of Health

NLEA *Nutrition Labeling and Education Act* of 1990

NRA National Restaurant Association

NRC National Research Council

NSRI National Salt Reduction Initiative

Nutrition Facts panel Standardized detailed nutritional information about the contents and serving sizes of nearly all packaged foods sold in the marketplace. The panel was designed to provide nutrition information to consumers and was mandated by the *Nutrition Labeling and Education Act* (NLEA) of 1990.

Olfactory Of or relating to the sense of smell.

Pathogenesis The step-by-step development of a disease, and the chain of events leading to that disease, resulting from a series of changes in the structure and/or function of a cell, tissue, or organ caused by a microbial, chemical, or physical agent.

Pellagra A disease that occurs when a person does not get enough niacin or tryptophan.

Potassium The major cation of intracellular fluid that, along with sodium, is involved in maintaining a normal water balance, osmotic equilibrium, and the acid-base balance; also important in the regulation of neuromuscular activity and cell growth.

Potassium chloride (KCl) Can serve as a salt substitute, but can impart a bitter taste to foods.

Prevalence A measure of the frequency of existing disease, defined as the proportion of the total population that is diseased.

Processed food While the definition of processing may include minimal manipulations such as cutting meat or slicing fresh produce, in this report the term "processed food" is used for more complex products, such as baked goods, canned soups, and frozen meals.

Proteinuria A condition in which urine contains an abnormal amount of protein (also called albuminuria or urine albumin).

Quick-casual restaurant An attractive and comfortable establishment serving freshly prepared, wholesome, authentic food in a reasonably fast service format; checks average in the $7–$9 range.

Quick-service (fast food) restaurant Establishment primarily engaged in providing food service where patrons generally order or select items and pay before eating; food and drink may be consumed on premises, taken out, or delivered; also includes snack and non-alcoholic beverage bars; checks average in the $3–$6 range.

RACC Reference amount customarily consumed

Recommended Dietary Allowance (RDA) The average daily dietary intake level that is sufficient to meet the nutrient requirements of nearly all (97–98 percent) healthy individuals in a particular life stage and gender group.

Saccharin A sweet, white, powdered, synthetic product derived from coal tar, 300–500 times sweeter than sugar, that is used as a non-nutritive (artificial) sweetener.

SACN Scientific Advisory Committee on Nutrition (United Kingdom)

Salt (sodium chloride, NaCl) A food seasoning and preservative that is obtained from sea water or rock deposits as a crystalline solid; overconsumption of salt increases the risk of health problems, including high blood pressure. One gram of sodium chloride contains 393 mg sodium; this report estimates 6 g of sodium chloride to contain 2,400 mg sodium.

Salt disappearance See *Disappearance data*.

Salt sensitivity The extent of blood pressure change in response to a reduction of salt intake; the term "salt-sensitive blood pressure" applies to individuals or subgroups who experience the greatest reduction in blood pressure from a given reduction in salt intake.

Salt taste preference The preference for foods to which salt has been added.

Saturated fat Fat that consists of triglycerides containing only saturated fatty acid radicals (i.e., they have no double bonds between the carbon atoms of the fatty acid chain and are fully saturated with hydrogen atoms). Dairy products, animal fats, coconut oil, cottonseed oil, palm kernel oil, and chocolate can contain high amounts of saturated fats.

SCOGS Select Committee on GRAS Substances

SD Standard deviation

SE Standard error

Sea salt Unrefined salt obtained through the evaporation of sea water.

Sensory receptor A sensory nerve ending that recognizes a stimulus in the internal or external environment of an organism.

Slotting fee A one-time payment made by food processors to retailers in return for placement of a new product on store shelves.

Snack and non-alcoholic beverage bars Establishments that generally promote and sell a unique snack, such as ice cream, frozen yogurt, cookies, popcorn, or a non-alcoholic beverage, such as coffee, juice, or soda.

SNAP Supplemental Nutrition Assistance Program

SNDA School Nutrition Dietary Assessment

Social caterer An industry segment primarily engaged in providing single-event-based food services, generally at an off-premises site.

Sodium (Na^+) The major cation of extracellular fluid that is involved in the regulation of its volume and plasma volume; also aids in nerve impulse conduction and muscle contraction control.

Sodium benzoate A white, odorless, granular or crystalline powder, used as an antifungal agent.

Sodium bicarbonate Compound used as a gastric and systemic antacid.

Sodium chloride See *Salt*.

Spironolactone A medication used to treat certain patients with hyperaldosteronism (production of too much aldosterone by the body); low potassium levels; high blood pressure; and edema caused by various conditions, including heart, liver, or kidney disease.

Stroke An interruption of the blood supply to any part of the brain.

Systolic blood pressure The maximum pressure exerted when the heart contracts.

Tastant Taste compound.

Taste The sense that distinguishes the sweet, sour, salty, and bitter qualities of dissolved substances in contact with taste buds on the tongue.

Taste bud A specialized structure made up of taste receptor cells and supporting cells; the smallest functional unit of the sensing portion of the gustatory system.

TDS Total Diet Study

Tolerable Upper Intake Level (UL) The highest average daily nutrient intake level that is likely to pose no risk of adverse effects to almost all individuals in the general population. As intake increases above the UL, the potential risk of adverse effects may increase.

Umami A pleasant savory taste imparted by glutamate and ribonucleotides that occur naturally in many foods including meat, fish, vegetables, and dairy products.

UPC Universal Product Code

Urea Product of the urea cycle containing two nitrogen atoms and carbon dioxide; it is the chief form in which nitrogenous end products are excreted.

USDA U.S. Department of Agriculture

Usual intake The long-run average intake of food, nutrients, or a specific nutrient for an individual.

WASH World Action on Salt and Health

Water activity A dimensionless quantity used to represent the energy status of the water in a system.

WCRF World Cancer Research Fund

WHO World Health Organization

WIC The Special Supplemental Nutrition Program for Women, Infants, and Children

Appendix B

Government Initiatives and Past Recommendations of the National Academies, the World Health Organization, and Other Health Professional Organizations

TABLE B-1 Government Initiatives

Date	Program/Initiative/Report Title	Recommendations/Initiatives/Actions	Target Population (if specified)
White House Conference			
1969	Conference on Food, Nutrition, and Health: Final Report (White House Conference, 1969)	Provided advice on the desirability of reducing sodium intake	Hypertensive individuals
		Encouraged food processors to minimize the amount of salt in processed foods	Food processors
		Identified a need for food labeling of sodium	
U.S. Senate—Select Committee on Nutrition and Human Needs			
1977	Dietary Goals for the United States, 2nd edition (Select Committee on Nutrition and Human Needs, 1977)	Decrease salt intake to about 5 g/d	All Americans
U.S. Department of Health and Human Services—Centers for Disease Control and Prevention (CDC)			
2009	The *Congressional Omnibus Appropriations Act*[a] (2009) included language encouraging CDC to work with major food manufacturers and chain restaurants to reduce sodium content in their products and to submit to the Committee on Appropriations and the House of Representatives and the Senate an evaluation of its sodium-reduction activities within 15 months of enactment of the act, and annually thereafter	CDC plans to explore existing national and international public and private initiatives to reduce sodium in the food supply In fiscal years 2009–2010, CDC plans to convene public and private stakeholders to build relationships and partnerships to investigate approaches for reducing sodium consumption CDC will explore knowledge gaps, utilizing its data systems to analyze and release pertinent sodium related data (CDC, 2009)	Food manufacturers and chain restaurants

U.S. Department of Health and Human Services—Surgeon General			
1979	Healthy People: Surgeon General's Report on Health Promotion and Disease Prevention (Public Health Service, 1979)	Consume less salt; cook with only small amounts of salt, avoid adding salt at the table, avoid salty prepared foods	All Americans
1988	Surgeon General's Report on Nutrition and Health (Public Health Service, 1988)	Reduce intake of sodium by choosing foods relatively low in sodium and limiting the amount of salt added in food preparation and at the table	All Americans
U.S. Department of Health and Human Services—Public Health Service			
1980	Promoting Health and Preventing Disease: Objectives for the Nation (Public Health Service, 1980)	By 1990: • Reduce the average daily sodium ingestion (as measured by excretion) for adults to at least the 3,000–6,000 mg range • > 75% of the population should be able to identify the principal dietary factors for high blood pressure and three other diseases • 70% of adults should be able to identify the major foods that are low in sodium • Sodium in processed foods should be reduced by 20% from present levels	All Americans
1990	Healthy People 2000 (NCHS, 2001)	Increase % of persons preparing foods without adding salt from 43% (baseline) to a target of 65% Increase % of persons rarely or never using salt at the table from 60% (baseline) to 80% Increase % of persons regularly purchasing foods with reduced salt and sodium content from 20 (baseline) to 40%	All Americans
2001	Healthy People 2000 Review (NCHS, 2001)	During the mid-1990s, overall the percent of persons rarely or never using salt at the table ranged from 56–62%, and the % of persons regularly purchasing foods with reduced salt and sodium content was 19%	All Americans

continued

TABLE B-1 Continued

Date	Program/Initiative/Report Title	Recommendations/Initiatives/Actions	Target Population (if specified)
2000	Healthy People 2010 (HHS, 2000)	Increase the percentage of persons who consume ≤ 2,400 mg/d sodium from baseline (21% based on the National Health and Nutrition Examination Survey [NHANES] 1988–1994) to 65% (only 13% met target in 2003–2004 [Public Health Service, 2008])	Persons 2 or more years of age
U.S. Department of Health and Human Services—National Heart, Lung, and Blood Institute (NHLBI), the National Institutes of Health			
1972	National High Blood Pressure Education Program (NHLBI, 2010)	Cooperative effort among professional and voluntary health agencies, state health departments, and many community groups with the goal to reduce death and disability related to high blood pressure through programs of professional, patient, and public education	All Americans
1993	Working Group Report on Primary Prevention of Hypertension (National High Blood Pressure Education Program) (Whelton et al., 1993)	Reduce salt intake to no more than 6 g per day	All Americans
1995, 1999	Statement from the National High Blood Pressure Education Program Coordinating Committee (NHLBI, 1999)	Moderate salt and sodium intake Establish 2,400 mg/d sodium as a national dietary goal	
1996	Workshop: Implementing Recommendations for Dietary Salt Reduction: Where Are We? Where Are We Going? How Do We Get There? (NHLBI, 1996)	Develop public and professional education activities within the primary prevention campaign to convey the rationale for and benefits of lowering dietary salt/sodium for hypertension prevention to the appropriate target audiences The salt/sodium messages must be consistent with and often integrated into overall healthful lifestyle diet messages, such as the Dietary Guidelines, USDA Food Guide Pyramid, and FDA food labels	

		Experiences with intervention studies should be transferred to clinical and/or community settings after reviewing or evaluating and adapting, if necessary, strategies, methods, and materials Gradual "silent" or "transparent" lowering of salt or sodium in the food supply will need to occur along with the opportunity for effective marketing strategies and the promotion of reduced-sodium as well as low-sodium, low-salt, and no-salt food products. These recommendations are applicable to the food production industry, as well as restaurant, catering, and foodservice industries Data from completed clinical trials should be analyzed for the adequacy of simpler methods (e.g., casual urine collections, chloride titrator strips) as measures of sodium intake and for the validity of dietary recalls in order to consider the best feasible methods for individual and national-level assessments of sodium intake Other research needs identified in the areas of food technology; basic mechanisms of salt taste; and knowledge, attitudes, and skills of the public	
1997	The Sixth Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (NHLBI, 1997)	Reduce sodium intake to ≤ 100 mmol/d (2,400 mg sodium or 6 g sodium chloride)	
2002	National High Blood Pressure Education Program (update of 1993 report) (NHLBI, 2002)	Reduce dietary sodium intake to no more than 100 mmol/d (approximately 2,400 mg of sodium or 6 g of sodium chloride)	All Americans
2003	The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (NHLBI, 2004)	Reduce sodium intake to no more than 100 mmol/d (2,400 mg sodium or 6 g sodium chloride)	

continued

TABLE B-1 Continued

Date	Program/Initiative/Report Title	Recommendations/Initiatives/Actions	Target Population (if specified)
2005	Prevent and Control America's High Blood Pressure: Mission Possible (NHLBI with CDC and the American Heart Association [AHA] as supporting partners; 22 states participated) (NHLBI, 2005)	Promoted awareness and education materials to help the public health community attract new partners and revitalize relationships with existing partners to fight high blood pressure	Persons at high risk for hypertension
		States distributed materials to public health departments; hospitals and clinics; schools; senior centers; refugee centers; faith-based organizations; work sites; primary care practices; emergency medical service groups; state health benefit plans; and disease-related organizations, such as diabetes, kidney failure, and cancer groups	Low-SES (socioeconomic status) and minority populations
2006	NIH Radio (NIH, 2006)	Produced a broadcast-ready public service announcement about fighting high blood pressure through diet	All Americans
U.S. Department of Agriculture and U.S. Department of Health and Human Services (USDA/HHS)			
1980	*Dietary Guidelines for Americans* (USDA/HHS, 1980)	Avoid too much sodium	"Most Americans"
1985	*Dietary Guidelines for Americans* (USDA/HHS, 1985)	Avoid too much sodium	"Most Americans . . . those who are already healthy"
1990	*Dietary Guidelines for Americans* (USDA/HHS, 1990)	Use salt and sodium only in moderation	Healthy Americans 2 or more years of age
1995	*Dietary Guidelines for Americans* (USDA/HHS, 1995)	Choose a diet moderate in salt and sodium. "The Nutrition Facts Label lists A Daily Value of 2,400 mg"	Healthy Americans 2 or more years of age

2000	*Dietary Guidelines for Americans* (USDA/HHS, 2000)	Choose and prepare foods with less salt	Healthy Americans 2 or more years of age
2005	*Dietary Guidelines for Americans* (USDA/HHS, 2005)	Consume < 2,300 mg/d of sodium (~1 tsp salt) Choose and prepare foods with little salt, and consume potassium-rich foods, such as fruits and vegetables	Americans 2 or more years of age
		Individuals with hypertension, African Americans, and middle-aged and older adults: Aim to consume no more than 1,500 mg/d of sodium, and meet the potassium recommendation (4,700 mg/d) with food	High-risk populations
2010	*Dietary Guidelines for Americans*	Convened expert Advisory Committee to update the *Dietary Guidelines for Americans* for the year 2010. Sodium intake is included as a topic area for discussion (results pending)	
U.S. Food and Drug Administration (FDA)			
1973	Food labeling (HHS/FDA, 1973)	Required specific format when a nutrition claim was made in labeling or advertising or when a nutrient was added to a food Better information about the sodium content of foods was an early focus	
1979	Evaluation of the health aspects of sodium chloride and potassium chloride as food ingredients (SCOGS, 1979)	Consumption of sodium chloride should be reduced Guidelines should be developed for restricting salt in processed foods The sodium content of processed foods should be labeled	
1981	Initiative with NHLBI (Derby and Fein, 1995)	Educate the public about sodium Encourage manufacturers to display the sodium content on food labels	

continued

TABLE B-1 Continued

Date	Program/Initiative/Report Title	Recommendations/Initiatives/Actions	Target Population (if specified)
1982	Rejected petitions requesting reclassification of salt's status from "GRAS" (generally recognized as safe) to "food additive" and the addition of warning labels to high-sodium foods and salt packets by deferring action on GRAS status of salt (HHS/FDA, 1982)	Deferred action pending assessment of the impact of • Sodium labeling regulations • Manufacturer efforts to voluntarily reduce salt Indicated that a voluntary program would produce the desired results with less regulatory burden and affirmed that the food industry was in the best position to reduce sodium levels in processed foods and should be given a chance to do so	
1984	Sodium labeling (HHS/FDA, 1984)	Sodium added to mandatory list of nutrients to be declared on food labels Defined the terms for sodium content claims	
1993–2005	Nutrition Labeling Final Rules (HHS/FDA, 1993a,b,c, 1994, 2005)	Established a Daily Value (DV) of 2,400 mg for sodium labeling Mandated declaration of sodium content on all foods (mg and % DV) Established labeling rules: • Nutrient content claims for "free" (< 5 mg sodium per serving), "low" (≤ 140 mg sodium per serving), and "reduced or less than" (≥ 25% less sodium per serving than an appropriate reference food) • Foods labeled as "healthy" to contain ≤ 480 mg sodium per serving until Jan. 1, 1998, at which time sodium levels were to decrease to ≤ 360 mg per serving • Health claim: "Diets low in sodium may reduce the risk of high blood pressure" (foods ≤ 140 mg per serving) • Disqualifying or disclosure levels (≤ 480 mg per serving)	
2005	Final rule regarding sodium levels in foods labeled as "healthy" (HHS/FDA, 2005)	Retained 1993 level of ≤ 480 mg sodium per serving; eliminated requirement that this level drop to ≤ 360 mg Rationale: • Technological barriers to reducing sodium in processed foods • Poor sales of products meeting lower-sodium levels • More restrictive sodium levels would inhibit the development of new "healthy" food products	

2007	Public hearing in response to a 2005 petition (CSPI, 2005) requesting rulemaking regarding salt and a House of Representatives' Committee on Appropriations 2005 statement encouraging the agency to focus on ways—both voluntary by the food industry and regulatory by FDA and USDA—to reduce salt in processed and restaurant foods (HHS/FDA, 2007a)	The petition specifically requested FDA to • revoke the GRAS status of salt • amend any prior sanctions for salt • require food manufacturers to reduce the amount of sodium in all processed foods • require health messages on retail packages of salt (0.5 oz.+); reduce the DV for sodium from 2,400 to 1,500 mg Issues discussed—GRAS vs. food additive status: • Could a food additive regulation be constructed to prescribe limitations for uses of salt? If so, how? • Would reducing the salt content of food, even in a modest way, impact the safety or quality of various foods given the wide variety of technical functions for which salt is used in food? How feasible would it be to mitigate this impact, if true? Could it be mitigated by the addition of other ingredients? • If you agree that the sodium content of processed foods should be reduced, what actions (other than those suggested by the petitioner) would you recommend? • How could FDA partner with interested stakeholders regarding the development of appropriate recommendations or other information to reduce the salt content of processed foods? Issues discussed—food labeling: • What is the effectiveness of FDA labeling regulations in reducing salt intake by the public? • What data are available regarding the potential for label statements about the health effects of salt to reduce salt intake? • To what extent could FDA's labeling policies provide incentives to manufacturers to reduce the salt content of processed foods?

continued

TABLE B-1 Continued

Date	Program/Initiative/Report Title	Recommendations/Initiatives/Actions	Target Population (if specified)
2007	Advanced Notice of Proposed Rulemaking (ANPR): Nutrition Labeling (HHS/FDA, 2007b)	Requested comments on questions including: • Should the Daily Reference Value (DRV) for sodium be based on the Tolerable Upper Intake Level (UL) for sodium (2,300 mg) or on the Adequate Intake (AI; 1,500 mg/d) using the population-coverage approach? • If the UL is used, should it be adjusted using the same approach (population-weighted or population-coverage) as the other Dietary Reference Intakes (DRIs)?	
2007	Public Hearing (HHS/FDA, 2007c)	Discussed: use of symbols to communicate nutrition information, consideration of consumer studies and nutrition criteria	
U.S. Department of Agriculture (USDA)			
1993	Nutrition Labeling (USDA, 1993)	Adopted similar food labeling provisions as FDA for USDA-regulated products (notably meat and meat products)	
1995	Commodity Distribution Program (provides 15–20% of school lunch program foods)	Recommended specific sodium reductions for 10 commodity food categories in USDA's Commodity Distribution Program: canned beef, pork, poultry, luncheon meat, refried beans, salmon, tuna, ready-to-eat cereals, ham, and carrots Excluded many other products due to the assumption that school children would find modifications unacceptable (USDA, 1995)	Children consuming school meals
2004	HealthierUS School Challenge (encourages elementary, middle, and high schools to improve the nutrition content of foods provided to children and youth) (FNS, 2010)	Rewards changes in the school nutrition environment, including providing lower-sodium foods to all children and youth: • Gold, silver, or bronze recognition: Foods with ≤ 480 mg sodium per non-entrée or ≤ 600 mg sodium per entrée • Gold award of distinction: Non-entrées with ≤ 200 mg sodium and entrées with ≤ 480 mg	Children and youth consuming school meals

2007	Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) (provides vouchers to participants for the purchase of specific food items to meet nutritional needs) (USDA/FNS, 2007)	Requires that in certain food categories, foods must be lower in sodium or not have added sodium to qualify as a product that can be purchased with WIC vouchers	Low-income, nutritionally at-risk, pregnant and postpartum women; infants and children up to 5 years
2008	Commodity Distribution Program (FNS, 2008)	Plans to purchase low-sodium canned vegetables with the goal to reduce sodium levels of all canned vegetables to ≤ 140 mg per serving by school year 2010	Children consuming school meals
State and Local (Sodium Labeling Initiatives)[b]			
2008	California	Requires restaurant chains with ≥ 20 outlets statewide to disclose sodium information at point of sale	
2008	King County (Seattle)	Requires posting of sodium content on menus for restaurant chains with ≥ 15 outlets nationwide or $1 million in annual sales (collectively for the chain); if a menu board is used, nutrition information (including sodium) must be provided at point of ordering	
2008	Philadelphia	Requires posting of sodium content on menus for restaurant chains with ≥ 15 outlets nationwide	
2009	Montgomery County (Maryland)	Requires restaurant chains with ≥ 20 outlets nationwide to disclose sodium information (in writing) on the premises, upon request	
2009	Oregon	Requires restaurant chains with ≥ 15 outlets nationwide to provide sodium information on the premises, upon request	

continued

TABLE B-1 Continued

Date	Program/Initiative/Report Title	Recommendations/Initiatives/Actions	Target Population (if specified)
Government/Non-government Organization Partnership			
2009	National Salt Reduction Initiative (see Appendix G)	Partnership of over 45 cities, states, and national health organizations working to reduce U.S. population salt intake by 20% over 5 years by working with industry to set salt reduction targets that are designed to allow for gradual reductions in the sodium content of packaged and restaurant foods	U.S. population

[a] Public Law 111-8, Joint Explanatory Statement: Division F—Labor, Health and Human Services, and Education, and Related Agencies Appropriations, 2009.

[b] Implemented or passed into law as of February 16, 2010. See Appendix J for more information.

NOTE: d = day; g = gram; mg = milligram; tsp = teaspoon.

TABLE B-2 Past Recommendations from the National Academies and the World Health Organization

Date	Program/Initiative/Report Title	Recommendations/Initiatives/Actions	Target Population (if specified)
The National Academies			
1970	Safety and suitability of salt for use in baby foods (NRC, 1970)	Recommended ≤ 0.25% salt be added to commercial baby food	Infant food manufacturers
1980	Toward Healthful Diets (NRC, 1980a)	Use salt in moderation; adequate but safe intakes are considered to range between 3–8 g/d salt (1,200–3,200 mg/d sodium)	
1980	Recommended Dietary Allowances, 9th ed. (NRC, 1980b)	Estimated Safe and Adequate Daily Dietary Intake of sodium: 1,100–3,300 mg	Adults
1989	Recommended Dietary Allowances (NRC, 1989a)	Estimated minimum requirements for sodium of 500 mg/d	Healthy persons ≥ 10 years of age
1989	Diet and Health: Implications for Reducing Chronic Disease Risk (NRC, 1989b)	Limit total daily intake of salt (sodium chloride) to ≤ 6 g, although ≤ 4.5 g would probably confer greater health benefits Limit use of salt in cooking and avoid adding it to food at the table Salty, highly processed salty, salt-preserved, and salt-pickled foods should be consumed sparingly	
2005	Dietary Reference Intakes for Sodium (IOM, 2005)	Established Adequate Intake: • 1.5 g/d for persons 9–50 y • 1.3 g/d for persons 51–70 y • 1.2 g/d for persons > 70 y Established Upper Limit: • 2.2 g/d for persons 9–13 y • 2.3 g/d for persons >13 y	

continued

TABLE B-2 Continued

Date	Program/Initiative/Report Title	Recommendations/Initiatives/Actions	Target Population (if specified)
2010	Strategies to Reduce Sodium Intake (IOM, 2010)	Recommended a coordinated approach to set standards for safe levels of sodium in food using existing FDA authorities to modify the generally recognized as safe (GRAS) status of salt and other sodium-containing compounds Recommended a nationally organized campaign to educate the public about the risks of excess sodium intake and healthful food choices, build support for government and industry activities, and support consumers in making behavior changes to reduce sodium intake	U.S. population
World Health Organization (WHO)			
1990	Diet, Nutrition, and the Prevention of Chronic Diseases (WHO, 1990)	Upper limit 6 g/d salt Lower limit not defined	
2003	Diet, Nutrition, and the Prevention of Chronic Diseases (WHO, 2003)	< 5 g/d salt	

NOTE: d = day; g = gram; mg = milligram; y = years.

TABLE B-3 Past Recommendations from Health Professional Organizations

Date	Program/Initiative/Report Title	Recommendations/Initiatives/Actions	Target Population (if specified)
American Heart Association (AHA)			
1973	Diet and Coronary Heart Disease (AHA, 1973)	Moderate sodium intake	
1986	Dietary Guidelines for Healthy American Adults (AHA, 1986)	Consume no more than 3,000 mg/1,000 kcal/d sodium	Adults
1988	Dietary Guidelines for Healthy American Adults (AHA, 1988)	Consume no more than 3,000 mg/d sodium	Adults
1996	Dietary Guidelines for Healthy American Adults (Krauss et al., 1996)	Consume no more than 6 g/d salt (2,400 mg/d)	Adults
1998	Dietary Electrolytes and Blood Pressure (Kotchen and McCarron, 1998)	Consume ≤ 6 g/d salt	Adults
2000	Dietary Guidelines (Krauss et al., 2000)	Limit salt intake to 6 g/d, ~100 mmol/d of sodium	General population
2006	Diet and Lifestyle Recommendations (Revision) for CVD Risk Reduction (Lichtenstein et al., 2006)	Choose and prepare foods with little salt "In view of the available high-sodium food supply and the currently high levels of sodium consumption, a reduction in sodium intake to 1,500 mg/d (65 mmol/d) is not easily achievable at present. In the interim, an achievable recommendation is 2,300 mg/d (100 mmol/d)" Information dissemination program	Adults and children over 2 years of age

continued

TABLE B-3 Continued

Date	Program/Initiative/Report Title	Recommendations/Initiatives/Actions	Target Population (if specified)
2006	Alliance for a Healthier Generation (joint initiative of AHA and the William J. Clinton Foundation) (Alliance for a Healthier Generation, 2009)	Established voluntary nutrition guidelines (based on the 2005 Dietary Guidelines and AHA's 2006 Diet and Lifestyle Recommendations) for competitive school foods (e.g., foods in vending machines) as part of its goal to reduce prevalence of childhood obesity; leading industry groups have signed on	
American Medical Association			
1979	Concepts of Nutrition and Health (Council on Scientific Affairs, 1979)	Moderate intake of salt to less than 12 g/d (4,800 mg/d sodium)	
2006	Report of the Council on Science and Public Health (Dickinson and Havas, 2007; Havas et al., 2007)	Recommended a stepwise, minimum 50% reduction in sodium in processed foods, fast food products, and restaurant meals over the next decade; recommended that FDA revoke GRAS (generally recognized as safe) status of salt	
American Dietetic Association			
2007	Nutrition Fact Sheets and web page (www.eatright.org)	Provided sodium guidance on the meaning of sodium label claims and food purchasing or preparation techniques to reduce sodium intake	
American Public Health Association			
2002	Policy Statement: Reducing sodium content in the American diet (APHA, 2002)	Urged manufacturers to reduce the sodium content of processed foods by 50% over the next decade at a suggested rate of 5% per year	

American Institute for Cancer Research and World Cancer Research Fund			
1997	Food, Nutrition, and the Prevention of Cancer: A Global Perspective (WCRF/AICR, 1997)	Limit salt from all sources to < 6 g/d Limit consumption of salted foods and use of cooking and table salt	Adults
2007	Food, Nutrition, and the Prevention of Cancer: A Global Perspective (WCRF/AICR, 2007)	Limit consumption of salt Population average consumption of salt from all sources to be < 5 g/d (2,000 mg/d sodium) Proportion of the population consuming more than 6 g salt (2,400 mg sodium)/d should be halved every 10 years	
World Action on Salt and Health			
Annually since 2008	World Salt Awareness Week (World Action on Salt and Health, 2009)	The 2009 awareness week focused on the often high amount of hidden salt in foods obtained and consumed outside the home, and highlighted the importance of adding less salt to food and the long-term health implications of eating a high salt diet	
World Hypertension League and World Action on Salt and Health			
Annually since 2005	World Hypertension Day (World Hypertension League, 2009)	The 2009 day urged health experts and chefs to raise awareness of two "silent killers": salt and high blood pressure	

NOTE: d = day; g = gram; kcal = calorie; mg = milligram.

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Appendix C

International Efforts to Reduce Sodium Consumption

It is estimated that worldwide, 62 percent of cardiovascular disease and 49 percent of ischemic heart disease are the result of elevated blood pressure (WHO, 2002). Because of this, worldwide efforts have been made to set dietary guidance for sodium intake and to encourage sodium reduction. A World Health Report, published by the World Health Organization (WHO) in 2002, concluded that implementing salt reduction strategies population-wide would be the most cost-effective way to lower the risks associated with cardiovascular disease (WHO, 2002). In 2003, a technical report by WHO and the Food and Agriculture Organization (FAO) of the United Nations (UN) recommended a population-wide daily salt intake of no more than 5 g (2,000 mg sodium) (WHO, 2003).

In 2006 a WHO Forum and Technical Meeting was held to discuss implementation strategies and develop recommendations for population-wide salt reduction interventions. A report released after the meeting stated that participants agreed on the following points: there is a strong scientific link between high salt consumption and a number of chronic diseases; intervention programs repeatedly prove to be cost-effective; salt alternatives need to be explored further (with a continued focus on iodization); and stakeholders (namely, the food industry) must be involved in salt reduction strategies to ensure success (WHO, 2007).

A number of nations have also taken steps to reduce the sodium intake of their populations. This appendix summarizes sodium reduction efforts in several areas outside the United States.

CANADA

The 2004 Canadian Community Health Survey, a self-reported dietary recall survey, showed that among people 19 to 70 years of age, more than 85 percent of men and more than 60 percent of women consumed more than 2,300 mg sodium daily (the maximum intake level recommended in Canada) (Garriguet, 2007). Among children, 77 percent ages 1 to 3 years and 93 percent ages 4 to 8 years exceeded Tolerable Upper Intake Levels (ULs) of 1,500 and 1,900 mg/d, respectively (as established by the Institute of Medicine). Average sodium intake for both genders combined was 3,236 mg for ages 9 to 13 years; 3,534 mg for ages 14 to 18 years; 3,430 for ages 19 to 30 years; 3,207 mg for ages 31 to 50 years; and 2,954 mg for ages 51 to 70 years.

In 2006, the first Chair in Hypertension Prevention and Control was appointed. The chair, with support from health-related and science organizations, works to lobby the government to implement policies aimed at reducing the addition of salt to food (Campbell, 2007). A year later, the Minister of Health established a working group tasked with developing and implementing a strategy for reducing sodium intake among Canadians.

The Multi-Stakeholder Working Group on Sodium Reduction

Health Canada oversees the sodium working group, which consists of 23 representatives from the following areas: government (6), scientific and health-professional community (5), health-focused and consumer nongovernmental organizations (5), and food manufacturing or foodservice industry (7). The strategy employed by the group is multistaged and based on a three-pronged approach (education, voluntary reduction of sodium levels [in processed foods and foods sold by foodservice operations], and research). The preparatory stage allowed the group to gather baseline data on sodium levels from sources of sodium in Canadian diets. Next, the group moved into the assessment stage, which focused on gathering data on the following: (1) current efforts to educate/inform consumers and health professionals about sodium consumption and health-related consequences; (2) voluntary efforts to reduce sodium in foods; (3) consumers' perspectives on sodium and its relation to hypertension; (4) sodium, taste, and food choices; (5) functional uses of sodium; and (6) regulatory barriers or disincentives to reduce sodium in foods. During the third stage—development of a strategic framework—the working group used input from the wider stakeholder community to set goals and develop action plans and time lines for the implementation and assessment process. Currently, the working group is in the implementation stage (which began in April 2009) and is overseeing implementation of its strategies and monitoring progress.[1]

As the working group proceeds, it is expected to use input from several stakeholders, as well as data from sources such as the Total Diet Study (an ongoing research program that has provided Canadian dietary intake data since 1969) and the Canadian Community Health Survey.

In the interim, Health Canada's revised *Eating Well with Canada's Food Guide* advises Canadians to use the Nutrition Facts table on prepackaged food to choose foods that are lower in sodium.[2]

THE EUROPEAN UNION[3]

In 2008 a common framework was developed by the European Union (EU) to advance reduction in salt intake at the population level.[4] A goal of this initiative is to achieve WHO's strategies for a 16 percent reduction in salt intake during the next 4 years (against individual country baseline levels in 2008). The framework focuses on 12 categories of food that have been identified as priorities, of which each member state will choose at least 5 for its national plans. The first monitoring report is due in 2010.

FINLAND

Finland's National Nutrition Council first initiated a salt reduction campaign in the late 1970s, when salt intake was estimated to be approximately 12 g/d (4,800 mg/d sodium), making it one of the first countries to attempt to systematically reduce the sodium intake of its population (He and MacGregor, 2009; Laatikainen et al., 2006). From 1979 to 1982, a community-based intervention called the North Karelia project was conducted to reduce mortality associated with cardiovascular disease by reducing population-wide sodium intake. Several stakeholders were involved with the project (health service organizations, schools, non-governmental organizations, media outlets, and the food industry) (European Commission, 2008). After 3 years, the project was expanded to include the entire

[1] Available online: http://www.hc-sc.gc.ca/fn-an/nutrition/sodium/sodium_report_rapport_20080722-eng.php (accessed March 24, 2010).

[2] Available online: http://www.hc-sc.gc.ca/fn-an/food-guide-aliment/index-eng.php (accessed October 15, 2009).

[3] The European Union consists of 27 sovereign member states: Austria, Belgium, Bulgaria, Cyprus, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, The Netherlands, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom.

[4] Available online: http://ec.europa.eu/health/ph_determinants/life_style/nutrition/nutrition_salt_en.htm (accessed October 14, 2009).

country. Soon after, Finnish media, particularly the leading newspaper *Helsingin Sanomat*, began releasing numerous reports on the harmful health effects of salt and helped to raise public (and government) awareness of salt and salt alternatives (Karppanen and Mervaala, 2006).

In 1993, salt-labeling legislation was implemented by the Ministry of Trade and Industry and the Ministry of Social Affairs and Health for food categories that contribute high amounts of sodium to the diet, such as manufactured food items and meals, requiring that such foods be labeled with the percentage of "salt (NaCl) by fresh weight of the product" (Pietinen et al., 2007). The legislation also requires a "high salt content" label on foods that contain high levels of sodium and allows foods low in sodium to carry a "low salt" label (see Table C-1). Other labels in use include the Pansalt logo (used on products with sodium-reduced, potassium- and magnesium-enriched mineral salts) and the "Better Choice" label that was put in use by the Finnish Heart Association in 2000 (He and MacGregor, 2009; Karppanen and Mervaala, 2006).

Monitoring of salt intake is conducted as part of FINRISK, a survey conducted every 5 years that includes an assessment of urinary sodium excretion. A study conducted between 1997 and 1999, using FINRISK surveys, estimated that 21 percent of sodium intake in households came from table salt (down from 30 percent in 1980) and about 70 percent came from processed foods (Reinivuo et al., 2006). By 2002, mean sodium intake was 3,900 mg/d for men and 2,700 mg/d for women. At that time, the most significant sources of sodium in Finnish diets (> 40 percent of intake) were meat dishes and bread. Fish, sausage dishes, and savory baked goods were

TABLE C-1 "High Salt Content" and "Low Salt" Label Requirements in Finland

	NaCl Content of Food Item (%)	
Food Category	High Salt Content Label Required	Low Salt Label Allowed
Bread	> 1.3	≤ 0.7
Sausages	> 1.8	≤ 1.2
Cheese	> 1.4	≤ 0.7
Butter (voluntary)	> 2.0	≤ 1.0
Breakfast cereals	> 1.7	≤ 1.0
Crisp bread	> 1.7	≤ 1.2
Fish products	—	≤ 1.0
Soups, sauces, ready-made dishes	—	≤ 0.5

SOURCE: Karppanen and Mervaala, 2006.

also high contributors for men, as were fish, vegetable dishes, and savory baked goods for women (Reinivuo et al., 2006).

More recently a Finnish study (*n* = 2,007) estimated that if the entire Finnish adult population chose only products labeled as low salt (as determined by the requirements in Table C-1) as opposed to highly salted products, the mean salt intake could be reduced by 1.8 g (720 mg/d sodium) in men and 1.0 g (400 mg/d sodium) in women, whereas choosing only high-salt products could increase mean salt intake by 2.1 g (840 mg/d sodium) and 1.4 g (560 mg/d sodium), respectively (Pietinen et al., 2007).

During the time the initiative has been in place, sodium excretion levels, as well as blood pressure levels, have decreased. It has been reported that food companies either dropped products (to avoid selling products with a high-salt label) or began to reduce the sodium content of their foods by using alternatives such as mineral salts (European Commission, 2008; He and MacGregor, 2009).

FRANCE

In 2001 the Ministry of Health implemented the National Nutrition and Health Program (Programme National Nutrition Santé [PNNS]) with the goal of improving the health of the entire French population through nutrition interventions informed by input from several stakeholders in public and private sectors. One of the nine priority nutrition objectives of the program was to reduce the systolic blood pressure among adults (general population) by 10 mm Hg, which could partly be achieved by one of the 10 specific nutrition objectives to reduce the average consumption of sodium chloride to less than 8 g/d (3,200 mg/d sodium), which is equivalent to a 4 percent reduction in salt intake per year by the entire population over 5 years (Hercberg et al., 2008). The program implemented several strategies that were targeted to occur during a given year or over a period of time. The first set of activities included providing and promoting comprehensive nutrition communication for all consumers, which was done by disseminating information about the program and its objectives and publishing dietary reference guidelines and physical activity guidelines for the public, as well as food-based guides that offered advice on meeting PNNS recommendations (Hercberg et al., 2008). Mass media campaigns were launched to support the guides.

The next phase of action included ensuring a more healthful food supply and involving the food industry. One way of achieving this was to engage the food industry in formal commitments to improve the nutritional composition and quality of existing food products and to develop new products with higher nutritional standards, particularly in the areas of salt, sugar, and fat. The program also worked toward developing public health measures targeted at specific population groups; orienting actions toward health-care professionals and health services; mobilizing local authorities; establishing surveillance systems that monitor food consumption and the nutritional situation of the population; and developing epidemiological, behavioral, and clinical research in human nutrition (Hercberg et al., 2008). A national study to be released in 2010 will review the PNNS and report on the success of the program.

In addition, a working group convened by the French Food Standard Agency (AFSSA) released a report in 2002 that recommended a 20 percent reduction in the average salt intake over a 5-year period, which would bring the average intake from 10 g/d (4,000 mg/d sodium) to 7–8 g/d (2,800–3,200 mg/d sodium). To achieve this intake level, the working group developed initiatives for consumers, the food and catering industry, and medical professionals. Efforts were also initiated to encourage the food industry to adopt optional food labeling. Such labels, which are still in development, include listing sodium content in grams per 100 g or 100 mL and per serving (if necessary) and including the statement, "The salt (sodium) content of this product has been carefully studied; there is no need to add salt."[5] To date, no significant changes have been reported in the salt content of processed food or food labeling efforts.

IRELAND

The Food Safety Authority of Ireland (FSAI) began efforts in 2003 to reduce salt consumption by issuing a set of seven main objectives. The Salt Reduction Programme's objectives included the goal of raising the food industry's awareness about salt and health issues, working with manufacturers to gradually reduce the salt content of foods, and working on voluntary universal labeling of salt in packaged foods.[6] The long-term goal of the program was to "reduce the average population intake of salt from 10 g/d to 6 g/d (from 4,000 to 2,400 mg/d sodium) by 2010 through partnership with the food industry and State bodies charged with communicating the salt and health message to consumers."[7]

Further, in a 2005 report entitled "Salt and Health: Review of the Scientific Evidence and Recommendation for Public Policy in Ireland," subcommittees of the FSAI concluded that there was a scientific link between salt consumption and high blood pressure and that reducing the average in-

[5] Available online: http://www.worldactiononsalt.com/action/france.doc (accessed October 26, 2009).

[6] Available online: http://www.fsai.ie/science_and_health/salt_and_health/objectives_of_salt_programme.html (accessed October 13, 2009).

[7] Available online: http://www.fsai.ie/science_and_health/salt_and_health.html (accessed October 13, 2009).

take to 6 g/d (2,400 mg/d sodium) could result in significantly fewer deaths from stroke and heart disease (He and MacGregor, 2009).

To track progress, the FSAI chronicles salt reduction commitments by food manufacturers, retailers, foodservice suppliers, and caterers on its website.[8] At present, 63 companies and trade associations have registered with the FSAI's Salt Reduction Programme. As reported by the FSAI, the program has resulted in large bread bakers' reducing salt in all bread to levels below 1.14 g/100 g, representing a minimum 10 percent reduction in 5 years. Further, the agency reports that large and small meat product manufacturers have reduced salt in key products such as burgers and sausages and states that they are on course to meet FSAI targets for meat products by 2010. In addition, campaigns by the Irish Heart Foundation and the Food Safety Promotion Board are targeting the public to raise awareness about the health effects of a high salt intake.

THE UNITED KINGDOM

In 2003, the UK Scientific Advisory Committee on Nutrition (SACN) recommended that the public reduce salt intake to an average of 6 g/d (2,400 mg/d sodium) (SACN, 2003). The SACN used data from three national surveys to establish the 6 g target: (1) a 1990 24-hour urine collection reporting average daily salt intake of 9 g by adults; (2) a 1997 dietary intake survey of people 4–18 years of age that reported daily salt intake ranging from 4.7 to 8.3 g; and (3) a 1994–1995 dietary assessment survey of people 65-plus years of age with average daily salt intake of 6 g (SACN, 2003).

To help consumers reach the 6 g target, the UK government undertook a salt reduction program focused on three areas:

(1) cooperation with the food industry to voluntarily reduce salt in foods;
(2) a public campaign to raise awareness of why a high salt intake is detrimental to health and what the public can do to reduce intake; and
(3) voluntary nutrition labeling placed on the front of food packages to provide information on the amount of salt and other nutrients in foods.

[8] Available online: http://www.fsai.ie/science_and_health/salt_commitments_and_updates.html (accessed October 13, 2009).

The following pages provide information on the three components of the UK salt reduction initiative as reported by the Food Standard Agency (FSA).[9]

Salt Reduction Program: Focus Areas

Involvement with the Food Industry

Recognizing that approximately three-quarters of dietary salt intake comes from processed food, FSA established voluntary targets for salt in a number of processed food categories.[10] The targets are a means to track and report progress toward salt intake reductions and to provide guidance to industry. Starting with discussions that began in 2003, FSA developed a set of calculations to look at the potential impact of salt reductions in different food categories on population salt intake. The calculations were based on average sodium levels in foods within categories, weighted to account for varying consumption levels of different foods. The calculations were used to forecast how changes in the average salt content of various food categories can help the population reach the daily target of 6 g salt.[11] After soliciting and considering public comments, the final calculation spreadsheet was published in February 2005.[12]

Also in 2005, FSA Strategic Plan 2005–2010 was completed, which aimed to reduce the average population salt intake to 6 g/d (2,400 mg/d) by 2010 and to establish targets for salt content of key food categories by 2006. FSA consulted with the public and stakeholders to develop the final, voluntary salt targets for 2010, which were published in March 2006.[12] Eighty-five processed food categories including bread, bacon, breakfast cereals, and cheese were included among the target foods. FSA reported that it aimed to set challenging levels that would have a meaningful impact on consumer salt intake, while being mindful of food safety and technical issues and acknowledging that major processing changes would be necessary for certain foods to meet the targets.[13]

FSA reports that all sectors of the food industry have responded posi-

[9] Available online: http://www.food.gov.uk/consultations/ukwideconsults/2008/saltreductiontargets (accessed October 5, 2009).

[10] Available online: http://www.food.gov.uk/multimedia/spreadsheets/saltcommitmentsum.xls (accessed October 15, 2009).

[11] Available online: http://www.food.gov.uk/consultations/ukwideconsults/2003/saltmodellingconsult (accessed October 15, 2009).

[12] Available online: http://www.food.gov.uk/healthiereating/salt/salttimeline (accessed March 24, 2010).

[13] Available online: http://www.food.gov.uk/multimedia/pdfs/saltreductioninitiatives.pdf (accessed March 24, 2010).

tively to the appeals to reduce salt in foods. To gauge progress, FSA uses a Processed Food Databank, a reference tool that provides information about the levels of sodium (and other nutrients) in processed foods based on data collected from product labels. The agency also purchases proprietary data listing sales figures and sodium levels in more than 130,000 products sold in the United Kingdom, using them to inform its review of salt targets.[14] In addition, FSA maintains commitment documents from companies in the catering industry, such as restaurants, coffee shops, and workplace caterers. The commitment documents are updated annually and provide an overview of the company's actions to support the Agency's nutrition priorities, including sections on procurement, menu planning, kitchen practices, and customer information.[15]

FSA conducted a review in 2008 to gauge progress toward the 2010 salt targets and used the information it gathered to aid the process of setting revised targets for a limited range of food categories by 2010 and new targets for most foods by 2012. The review process included consultation by way of sector-specific meetings during which industry representatives reported on their progress, challenges, and potential future efforts to further reduce salt. FSA considered this industry input and other public comments as well as technical and safety issues, current salt intake, and public acceptance when proposing revised targets. Sixty responses were received from a range of stakeholders and were considered by the agency in revising the 2010 targets and establishing new targets for 2012. In May 2009, FSA published revised, voluntary salt reduction targets for 80 categories of food, for the industry to meet by 2012 (see Table C-2 at the end of this appendix). A small number of revisions were made for the 2010 targets (set forth in 2006) for foods that had already achieved the target or were close to doing so. The revised 2012 targets reflect the progress made thus far and are considered by FSA to serve as a continued challenge to industry to achieve salt levels that will help attain population salt intake of 6 g.[16] In March 2010, the agency published documents listing commitments from a range of retailers, manufacturers, trade associations, and caterers highlighting progress made on salt reduction; these documents will be updated regularly to show progress.[17]

[14] Ibid.

[15] Available online: http://www.food.gov.uk/healthiereating/healthycatering/cateringbusiness/commitments (accesed March 25, 2010).

[16] Available online: http://www.food.gov.uk/healthiereating/salt/saltreduction (accessed October 5, 2009).

[17] Available online: http://www.food.gov.uk/news/newsarchive/2010/mar/saltcommitments (accessed March 25, 2010).

FSA-Sponsored Awareness Campaign

Concurrent with the food industry plan, FSA launched a media campaign as part of the government salt reduction initiative.[18] The first phase aimed to raise consumers' awareness of the adverse health consequences of excessive salt consumption and ran from September to November 2004. It featured a character called "Sid the Slug" in poster, web, and print ads, with tag lines such as, "I've always known it: Too much salt is bad for your heart." The second phase ran from October to November 2005; its key messages were to raise awareness of the goal to eat no more than 6 g salt per day and to encourage consumers to check the salt content on food labels. A series of short TV ads ran during the following summer to maintain awareness of the key messages.[19] The third phase of the campaign commenced in March 2007, with the intent to inform consumers that most of the salt they eat is in everyday foods and to encourage them to chose lower-salt products. The fourth phase of consumer messaging began in October 2009 and highlighted the positive changes consumers could make to reduce salt intake, such as checking food labels to compare products and choosing the lower-salt option. The messages from the campaign have been disseminated through television and radio, print media, and on the web.[17] In addition, the British Heart Foundation contributed to the awareness campaign by producing a booklet on the salt content of foods and the effect of a high salt intake on heart health (British Heart Foundation, 2007).

Voluntary Front-of-Package Nutrition Labeling

During the implementation of the salt reduction campaign, there have also been efforts to improve nutrition labeling for packaged foods. Salt content has been one area of focus for voluntary changes in labeling. Some supermarkets and manufacturers are voluntarily displaying front-of-package labeling of individual nutrients with a traffic light color system. The labeling scheme shows red, amber, or green colors to indicate that a product contains high, medium, or low levels of total fat, saturated fat, sugar, and salt.[20] Other supermarkets and manufacturers are using front-of-package labeling that provides the percentage of the Guideline Daily Amount (GDA) (an established recommended amount similar to the U.S.

[18] Available online: http://www.food.gov.uk/healthiereating/salt/campaign (accessed March 22, 2010).

[19] Available online: http://www.food.gov.uk/healthiereating/salt/salttimeline (accessed March 24, 2010).

[20] Available online: http://www.eatwell.gov.uk/foodlabels/trafficlights/ (accessed October 15, 2009).

Daily Value) for selected nutrients, but without the traffic light color system (Malam et al., 2009).

Manufacturers and retailers may vary the label format, but certain core elements must be retained. The nutritional criteria determining the color coding for these voluntary labeling schemes were set by the government's independent scientific advisory committees on nutrition. To qualify for a green light, a product must have ≤ 300 mg sodium per 100 g or 100 mL. A sodium content > 1,500 mg per 100 g or 100 mL receives a red light, and anything between 300 and 1,500 mg sodium per 100 g or 100 mL receives an amber light.[21] This system was adopted based on consumer research showing that multiple traffic light colors were preferred over a single traffic light color, which would indicate only overall product healthfulness rather than amounts of a number of specific nutrients, such as sodium.[22]

Recently, a study was conducted to determine how these labels are understood and used by consumers (Malam et al., 2009). The results of this study indicate that the use of different labeling formats by different retailers and manufacturers is confusing to consumers, suggesting that a uniform format may be preferable. It was also found that consumers interpret colors differently, and some did not realize that the colors had meaning. Overall, labels combining the words high, medium, and low in addition to traffic light colors and percentage of GDAs were found to be the easiest for consumers to understand, with approximately 70 percent of consumers comprehending the label meaning.

There is also some evidence to suggest that manufacturers have reformulated products to make their products qualify for a better traffic light profile (British Retail Consortium, 2009).

Impact of the Salt Reduction Program

Thus far, FSA has reported decreases in the average daily salt consumption of the UK population. A 2008 UK survey[23] indicated that average daily sodium consumption decreased by almost 360 mg since the 2000–2001 National Diet and Nutrition Survey. The decrease was from an average of 9.5 g/d to 8.6 g/d salt (3,800 mg/d to 3,440 mg/d sodium) for both genders combined (National Centre for Social Research, 2008). This suggests that the United Kingdom's estimated consumption of sodium is now very similar to that reported for the U.S. population, which is 3,435 mg per day

[21] Available online: http://www.food.gov.uk/multimedia/pdfs/frontofpackguidance2.pdf (accessed December 8, 2009).

[22] Available online: http://www.food.gov.uk/foodlabelling/signposting/devfop/siognpostlabel research/ (accessed December 8, 2009).

[23] Available online: http://www.food.gov.uk/science/dietarysurveys/urinary (accessed October 13, 2009).

for persons 2 or more years of age (USDA/ARS, 2008). Whether consumption will continue to decrease below U.S. levels of intake is of considerable interest.

FSA plans to review progress toward the 6 g target in early 2011 and then again every 2 years. The 2011 review will look for "continuing trends of gradual salt reductions in foods and progress across the whole industry in a way that maintains consumer acceptability as people's palates adjust to less salty foods."[24] FSA will also examine the costs involved with the program.

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TABLE C-2 Food Standards Agency Salt Reduction Targets for 2010 and 2012

Main Product Category and Sub Categories (where relevant)	Current 2010 Targets (g salt or mg sodium per 100 g)*	Revised 2010 Targets (g salt or mg sodium per 100 g)*	Targets for 2012 (g salt or mg sodium per 100 g)*	Comments
1. MEAT PRODUCTS				
1.1 Bacon Includes all types of injection cured bacon, e.g., sliced back, streaky, smoked and unsmoked bacon, bacon joints, etc. Excludes all dry and immersion cured bacon.	3.5 g salt or 1,400 mg sodium (average)	3.13 g salt or 1,250 mg sodium (average)	2.88 g salt or 1,150 mg sodium (average p)	The FSA recognizes the difficulties in attaining an even dispersal of salt in bacon and the impact of legislation restricting the addition of nitrates and has set an average range target. Consultation comments indicate that the revised proposed level is achievable whilst maintaining a safe product. However it remains the responsibility of individual manufacturers to ensure the safety of any reformulated product throughout the shelf life it is allocated.
1.2 Ham/other cured meats Includes hams, cured pork loin and shoulder etc. Excludes “Protected Designation of Origin” and traditional specialty guaranteed products, e.g., Parma ham. Also excludes specialty products produced using traditional methods such as immersion and dry cured processes including cured tongue.	2.5 g salt or 1,000 mg sodium (average)	2.0 g salt or 800 mg sodium (average)	1.63 g salt or 650 mg sodium (average p)	The FSA recognizes that attaining an even dispersal of salt in ham causes similar problems as in bacon. An average target is set to reflect this. Many companies have however met or exceeded the current target for cured meats and the Agency expects industry to aim for the lowest level possible whilst maintaining product safety. Category now excludes cured tongue.

1.3 Sausages				
1.3.1 Sausages Includes all fresh, chilled and frozen meat sausages, e.g., pork, beef, chicken, turkey, etc.	1.4 g salt or 550 mg sodium (maximum)		1.13 g salt or 450 mg sodium (maximum)	Maintaining product binding and succulence in sausages has proved challenging whilst reducing levels of sodium. However, levels of 500 mg sodium per 100 g have already been achieved across a range of products.
1.3.2 Cooked sausages and sausage meat products Includes all cooked sausages and sausage meat products, e.g., stuffing, turkey roll with stuffing, etc. Excludes Scotch eggs (see category 22.1).	1.8 g salt or 700 mg sodium (maximum)	1.63 g salt or 650 mg sodium (maximum)	1.5 g salt or 600 mg sodium (maximum)	As above, product binding and succulence is recognized as an issue; however, product data shows that levels at or below 600 mg sodium per 100 g are achievable. The Agency recognizes concerns around problems with end extrusion and will monitor progress toward the 2012 target.
1.4 Meat Pies				
1.4.1 Delicatessen, pork pies and sausage rolls Includes all delicatessen pies, pork pies and sausage rolls, e.g., game pie, cranberry topped pork pie, Melton Mowbray pork pie, etc.	1.5 g salt or 600 mg sodium (maximum)	1.38 g salt or 550 mg sodium (maximum)	1.13 g salt or 450 mg sodium (maximum)	
1.4.2 Cornish and meat-based pasties Includes all Cornish and meat-based pasties only.	1.3 g salt or 500 mg sodium (maximum)	1.13 g salt or 450 mg sodium (maximum)	1.0 g salt or 400 mg sodium (maximum)	

continued

TABLE C-2 Continued

Main Product Category and Sub Categories (where relevant)	Current 2010 Targets (g salt or mg sodium per 100 g)*	Revised 2010 Targets (g salt or mg sodium per 100 g)*	Targets for 2012 (g salt or mg sodium per 100 g)*	Comments
1.4.3 Other meat-based pastry products including pies and slices, canned and frozen products Includes all meat-based pastry products, pies, slices, etc. whether chilled, canned, frozen etc. Excludes pork pies and sausage rolls (see category 1.4.1) and Cornish and meat-based pasties (see category 1.4.2)	1.1 g salt or 450 mg sodium (maximum)	1.0 g salt or 400 mg sodium (maximum)	0.75 g salt or 300 mg sodium (maximum)	
1.5 Cooked uncured meat Includes all roast meat, sliced meat, etc. Excludes ham (see category 1.2 above)				
1.5.1 Whole muscle Includes all chilled, frozen and canned whole muscle, e.g., beef, lamb, chicken, turkey, etc. Also includes rotisserie and roasted products.			0.75 g salt or 300 mg sodium (maximum)	Target is believed to be achievable for the majority of products, the Agency understands that it may be more difficult to achieve for some flavored products. We expect industry to aim for the lowest possible levels whilst maintaining food safety.

1.5.2 Reformed whole muscle Includes all reformed whole muscle, e.g., beef, lamb, chicken, turkey, etc.		1.0 g salt or 400 mg sodium (maximum)	A new sub-category has been set with a salt level appropriate for binding and tenderizing reformed whole muscle.
1.5.3 Comminuted or chopped reformed meat Includes all comminuted or chopped reformed and shaped uncured meats, e.g., beef, lamb, chicken, turkey, etc.		1.5 g salt or 600 mg sodium (maximum)	
1.6 Burgers, grillsteaks, etc.			
1.6.1 Standard fresh and frozen burgers and grillsteak products Includes beef burgers, hamburgers, pork/bacon burgers, chicken burgers, turkey burgers and all kebabs. Excludes canned burgers (see category 1.7.1)	1.0 g salt or 400 mg sodium (maximum)	0.75 g salt or 300 mg sodium (maximum)	The Agency recognizes that sodium plays a role in binding in thick burgers. However, it is also aware that for thin burgers and frozen burgers far lower levels of sodium are required. We are aware that the 2012 target levels are currently being trialed and we will review this target in 2010 based on any information that has identified as being achievable for these products.
1.6.2 Specialty and topped burgers and grillsteaks Includes all flavored products.	1.3 g salt or 500 mg sodium (maximum)	0.88 g salt or 350 mg sodium (maximum)	We are aware that the 2012 target levels are currently being trialed and we will review this target in 2010 based on any information that has identified as being achievable for these products.

continued

TABLE C-2 Continued

Main Product Category and Sub Categories (where relevant)	Current 2010 Targets (g salt or mg sodium per 100 g)*	Revised 2010 Targets (g salt or mg sodium per 100 g)*	Targets for 2012 (g salt or mg sodium per 100 g)*	Comments
1.7 Frankfurters, hotdogs, and burgers				
1.7.1 Canned frankfurters, canned hotdogs and canned burgers only. Excludes fresh and frozen burgers (see category 1.6), sausages (see category 1.3) and chilled frankfurters (see category 1.7.2)	1.4 g salt or 550 mg sodium (maximum)		1.38 g salt or 550 mg sodium (maximum)	
1.7.2 Fresh chilled frankfurters	None		1.63 g salt or 650 mg sodium (maximum)	A new category has been included for fresh chilled frankfurters. These products require higher levels of salt than canned products for food safety and technological reasons.

2. BREAD			
2.1 Bread and rolls Includes all bread and rolls: pre-packed, part-baked and freshly baked (including retailer in-store bakery) white, brown, malted grain and whole meal bread or rolls including seeded products, French bread, ciabatta, focaccia, pitta, naan, chappattis, tortillas etc. without additions (e.g., cheese, olives, sundried tomatoes, etc., see category 2.2)	1.1 g salt or 430 mg sodium (average)	1.0 g salt or 400 mg sodium (average r)	The Agency welcomes the commitment that the industry has shown to reducing levels, including the major retailers who have been particularly successful with achieving levels of between 300 and 400 mg sodium per 100 g. However the Agency also notes that premium breads have levels above this although manufacturers have reduced levels of salt on a sales weighted basis by 16% over the last 4 years. Plant bakers are committed to meeting the 2010 target but responses to the consultation on revised targets indicate that reducing to 370 mg/100 g by 2012 would not be achievable. The Agency will continue to work closely with the bread sector to ensure that salt reductions are made as quickly as is practicable as bread contributes around one-fifth of sodium to dietary intake and it is important to maintain and improve on reductions in this area.
2.2 Bread and rolls with additions Includes all bread and rolls (as listed at category 2.1 above) with “high salt” additions, e.g., cheese, olives, sundried tomatoes, etc. Also includes cheese scones.	1.3 g salt or 500 mg sodium (average)	1.2 g salt or 480 mg sodium (average)	See comments above.

continued

TABLE C-2 Continued

Main Product Category and Sub Categories (where relevant)	Current 2010 Targets (g salt or mg sodium per 100 g)*	Revised 2010 Targets (g salt or mg sodium per 100 g)*	Targets for 2012 (g salt or mg sodium per 100 g)*	Comments
2.3 Morning goods Includes plain and fruit scones, crumpets, pikelets, English muffins, Scotch pancakes, bagels, croissants, brioche, soda farls and waffles, etc. Also includes all buns, e.g., hot cross, teacakes, etc., except iced finger buns (see category 12.1 Cakes). Excludes cheese scones (see category 2.2)	1.3 g salt or 500 mg sodium (average)		0.75 g salt or 300 mg sodium (average r) 1.0 g salt or 400 mg sodium (maximum)	The Agency is aware that much of the sodium in some of these products comes from sodium bicarbonate. We are also aware of developments in processing allowing lower levels of raising agents to be used without using replacers. We recognize the diverse range of products included in this category and that some companies will make only a limited number of these so may find the average difficult to achieve across their individual ranges. However, the target has been set at a level that will give companies a level to work toward. As a guide for those companies making a small range of these type of products the lowest levels of sodium on the market (2007) were crumpets 320 mg; scones 320 mg; pancakes 280 mg; croissants 360 mg; teacakes 120 mg; English muffins 300 mg; potato cakes/soda farls 400 mg; pain au chocolate 200 mg; waffles 300 mg. Buns have now been moved to this category with the exception of iced finger buns as these can achieve lower levels and are included in the category for Cakes (12.1). As a guide: hotcross buns were available (2007) at 200 mg; other fruited buns 170 mg and other unfruited buns at 300 mg.

3. BREAKFAST CEREALS			
3.1 Breakfast cereals Includes all breakfast cereals, e.g., muesli, cornflakes, hot oat cereals, etc.	0.8 g salt or 300 mg sodium (average)		0.68 g salt or 270 mg sodium (average) 1.0 g salt or 400 mg sodium (maximum)

continued

TABLE C-2 Continued

Main Product Category and Sub Categories (where relevant)	Current 2010 Targets (g salt or mg sodium per 100 g)*	Revised 2010 Targets (g salt or mg sodium per 100 g)*	Targets for 2012 (g salt or mg sodium per 100 g)*	Comments
4. CHEESE				
4.1 Natural cheese Cheddar and other similar "hard pressed" cheeses, e.g., Cheshire, Lancashire, Wensleydale, Caerphilly, Double Gloucester, Leicester, Derby, etc.	Mild: 1.7 g salt or 670 mg sodium (average) Mature: 1.95 g salt or 750 mg sodium (average)		1.8 g salt or 720 mg sodium (average r)	There is now just one target for mild and mature cheeses, as a range average. The Agency has been advised that for cheddar, which is the biggest selling cheese in the United Kingdom, there are problems with the structure and texture of the cheese once levels of sodium start to fall below 720 mg per 100 g. This may not be the case for some other hard cheeses. Cheese contributes significantly to sodium intake and manufacturers are encouraged to reduce the sodium in their cheeses both by making absolute reductions, where possible, and by improving their process control to minimize variation in sodium content. The Agency will be looking further into the technical issues associated with salt reduction in these products and the issues raised in consultation responses. We will be funding research in this area and will review progress in 2010. However, label data indicates that products are currently available at and below the level of the 2012 target for both mature and mild cheddars—which should make a range average achievable.

4.2 "Fresh" cheeses Excludes fromage frais as no salt is added to this product. Also excludes Brie, Camembert, and other similar soft rinded cheeses.			In addition, the Agency recognizes the difficulties small cheesemakers face in reducing salt levels in their products, and is aware that some producers are looking at the ways they can reduce the variation in salt levels in their products. We encourage this work as a way of minimizing salt levels, and would like to hear from producers about their experiences and the opportunities for salt reduction.
4.2.1 Soft white cheese, e.g., Philadelphia. Includes all soft white cheese, flavored or unflavored, including reduced fat products. Excludes cottage cheese (see categories 4.2.2 and 4.2.3)	0.8 g salt or 320 mg sodium (maximum)	0.55 g salt or 220 mg sodium (average r) 0.75 g salt or 300 mg sodium (maximum)	
4.2.2 Cottage cheese, plain. Includes all unflavored cottage cheese. Excludes flavored products (see category 4.2.3)	0.54 g salt or 215 mg sodium (average)	0.55 g salt or 220 mg sodium (average r) 0.63 g salt or 250 mg sodium (maximum)	
4.2.3 Cottage cheese, flavored. Includes all flavored cottage cheese (onion and chive, pineapple)	0.64 g salt or 250 mg sodium (average)		

continued

TABLE C-2 Continued

Main Product Category and Sub Categories (where relevant)	Current 2010 Targets (g salt or mg sodium per 100 g)*	Revised 2010 Targets (g salt or mg sodium per 100 g)*	Targets for 2012 (g salt or mg sodium per 100 g)*	Comments
4.3 Mozzarella (used in food products). Includes mozzarella products for food industry use only. Excludes fresh mozzarella sold in retail outlets.	1.8 g salt or 700 mg sodium (average)		1.5 g salt or 600 mg sodium (average p)	This target is for hard block type mozzarellas used in the food industry to manufacture pizzas, ready meals, etc. Fresh mozzarella sold in retail outlets has higher water content and much lower levels of sodium should be attainable. The Agency will review progress in 2010.
4.4 Blue cheese UK produced blue cheeses only	No target		2.1 g of salt or 840 mg sodium (average p)	The Agency recognizes that the Stilton Cheese Makers Association has undertaken a program of work in the past 4 years to better understand the salt levels in their product, to reduce the standard deviation of levels within and between products and to reduce overall levels. The Agency commends this approach to other cheese manufacturers. In addition to working toward the 2012 target the SCMA has committed to working toward a further 20% reduction in the standard deviation in the levels of sodium in their products and to go further if possible.

4.5 Processed Cheese				
4.5.1 Cheese spreads	2.0 g salt or 800 mg sodium (average)		1.63 g salt or 650 mg sodium (average r) 2.25 g salt or 900 mg sodium (maximum)	The level of sodium in cheese spreads is largely influenced by the amount of cheese present which inturn dictates the amount of emulsifiers used (which are currently sodium-based).
4.5.2 Other processed cheese (e.g., slices, strings, etc.)	2.9 g salt or 1,170 mg sodium (average)	2.13 g salt or 850 mg sodium (average)	2.0 g salt or 800 mg sodium (average r)	This category covers a wide range of products from cheese that has been processed with nothing added, to cheese which has been processed with sodium based emulsifiers. As above those products with more cheese and therefore more emulsifiers will find it more difficult to reduce sodium content. In addition the types of packaging used will have an impact on the levels of salt reduction that can be achieved for example cheese slices packaged slice on slice may not be able to reach the same levels as those hot filled into individual packages. The Agency is aware that there is significant research in this are and will review progress in 2012.
5. BUTTER				
5.1 Butter				
5.1.1 Welsh and other regional butter Includes all Welsh and other regional UK butters, e.g., Cornish	3.0 g salt or 1,200 mg sodium (average)		2.0 g salt or 800 mg sodium (average r)	

continued

TABLE C-2 Continued

Main Product Category and Sub Categories (where relevant)	Current 2010 Targets (g salt or mg sodium per 100 g)*	Revised 2010 Targets (g salt or mg sodium per 100 g)*	Targets for 2012 (g salt or mg sodium per 100 g)*	Comments
5.1.2 Salted butter Includes all other "standard" salted butters	1.7 g salt or 670 mg sodium (average)		1.68 g salt or 670 mg sodium (average p)	Salt is the main controlling factor for microbial growth in this product which may also be subject to a considerable amount of cross contamination in the home. The Agency will review this target in the light of any future research.
5.1.3 Lightly salted butter Includes all lightly salted butters (made using different processes to that used for salted butters at 5.1.2, e.g., Lurpak)	1.2 g salt or 470 mg sodium (average)		1.13 g salt or 450 mg sodium (average p)	
5.1.4 Unsalted butter Includes all unsalted butters apart from whey butters.	0.1 g salt or 40 mg sodium (average)		0.1 g salt or 40 mg sodium (average p)	
6. FAT SPREADS				
6.1 Margarines/other spreads Includes all margarines and spreadable butters which include an oil element and spreads, e.g., sunflower, olive oil, buttermilk enriched, sterol/stanol containing, etc.	1.5 g salt or 600 mg sodium (average)	1.25 g salt or 500 mg sodium (average) 1.88 g salt or 750 mg sodium (maximum)	1.13 g salt or 450 mg sodium (average r) 1.63 g salt or 650 mg sodium (maximum)	The Agency is aware of industry concerns that margarines should not be put at a disadvantage to butter in terms of salt content. However, products which blend butter with oil to give a spreadable product are likely to be the products in direct competition to margarines, and data shows they are currently on the market at levels of around 400 mg.

7. BAKED BEANS				
7.1 Baked beans in tomato sauce without accompaniments	0.8 g salt or 300 mg sodium (maximum)		0.63 g salt or 250 mg sodium (maximum)	The Agency recognizes the significant reductions that have already been achieved in these products and the difficulties with achieving the 2012 target within the timeframe set. We will therefore review progress in both 2010 and 2012.
7.2 Baked beans and canned pasta with accompaniments Includes baked beans or canned pasta in tomato sauce with sausages, meatballs, other meats and cheese, macaroni cheese, etc.	1.0 g salt or 400 mg sodium (maximum)		0.75 g salt or 300 mg sodium (maximum)	

continued

TABLE C-2 Continued

Main Product Category and Sub Categories (where relevant)	Current 2010 Targets (g salt or mg sodium per 100 g)*	Revised 2010 Targets (g salt or mg sodium per 100 g)*	Targets for 2012 (g salt or mg sodium per 100 g)*	Comments
8. READY MEALS AND MEAL CENTERS				
8.1 Chinese/Thai/Indian—ready meals Includes all Chinese, Thai, and Indian ready meals with accompaniment (potato, rice, noodles, etc.) made from meat, poultry, fish or vegetables, e.g., sweet and sour chicken with rice, thai green curry with noodles, chicken tikka massala, etc.	0.8 g salt or 300 mg sodium (average)		0.63 g salt or 250 mg Sodium (average) 1.13 salt or 450 mg sodium (maximum)	The revised category also now includes all coated poultry products, as well as coated fish products, and all non-meat pies (e.g., cheese and onion pasties). Some vegetarian products based on meat analogue products, e.g., Quorn, tofu, etc., are included in category 25, although meal centers and ready meals remain in category 8. We recognize that some manufacturers will make a small range of products that are naturally high in sodium, for example, those based on cheese and pastry. In these circumstances the Agency would expect companies to achieve the lowest salt levels possible and as a minimum to fall within the maximum target. The Agency also recognizes that the maximum target will be challenging for some specific products and some ranges of ready meals. However at this level a meal will deliver approximately 4.5 g salt per 400 g portion which equates to 75% of the recommended maximum daily intake.
8.2 Chinese/Thai/Indian—meal centers Includes all Chinese, Thai, and Indian meal centers without accompaniment (potato, rice, noodles, etc.) made with meat, poultry, fish or vegetables, e.g., sweet and sour chicken, Thai green curry, chicken tikka massala, etc.	1.0 g salt or 400 mg sodium (average)			

8.3 Italian/Traditional/other—ready meals Includes all Italian, traditional, and other ready meals with accompaniment (potato, rice, noodles, etc.) not covered in 8.1, made with meat, poultry, fish, or vegetables, e.g., lasagne, chili con carne with rice, coq au vin with potato, cottage pie. Includes fresh stuffed pasta with sauce.	0.6 g salt or 250 mg sodium (average)
8.4 Italian/Traditional/other—meal centers Includes all Italian, traditional, and other ready meals without accompaniment (potato, rice, noodles, etc.) not covered in 8.1, made with meat, poultry, fish, or vegetables, e.g., chili con carne, coq au vin, beef stew. Also includes fresh stuffed pasta without sauce.	0.8 g salt or 300 mg sodium (average)

continued

TABLE C-2 Continued

Main Product Category and Sub Categories (where relevant)	Current 2010 Targets (g salt or mg sodium per 100 g)*	Revised 2010 Targets (g salt or mg sodium per 100 g)*	Targets for 2012 (g salt or mg sodium per 100 g)*	Comments
9. SOUPS				
9.1 Dried soups (as consumed) Includes all soups in a cup and other dried soups as consumed, i.e., once rehydrated.	0.6 g salt or 250 mg sodium (average)		0.58 g salt or 230 mg sodium (average r) 0.73 g salt or 290 mg sodium (maximum)	It is proposed that just one target is set for soups. This would continue to apply to dried soups as consumed (made up according to manufacturers instructions). The Agency is aware that a number of manufacturers are looking at the feasibility of this target for dried soup and we will review progress in 2010.
9.2 "Wet" soups Includes all canned, condensed (as consumed), ambient packed and fresh (chilled) soups.	0.6 g salt or 250 mg sodium (average)			
10. PIZZAS				
10.1 Pizzas with higher salt toppings, e.g., cured meat (ham, bacon, pastrami, chorizo, salt beef), olives, anchovies and smoked fish, hard cheese, prawns, crayfish, crab, tuna, and "Cheese Feast" or similar toppings.	1.2 g salt or 470 mg sodium (average)		1.0 g salt or 400 mg sodium (average r) 1.25 g salt or 500 mg sodium (maximum)	
10.2 Without high salt toppings, e.g., chicken, vegetables, etc.	1.0 g salt or 400 mg sodium (maximum)			

11. CRISPS AND SNACKS				
11.1 Standard potato crisps All standard potato crisps, all flavors except salt and vinegar. Includes products aimed at the adult market.	1.5 g salt or 600 mg sodium (average)		1.38 g salt or 550 mg sodium (average r) 1.63 g salt or 650 mg sodium (maximum)	The Agency recognizes that the snack sector has removed a considerable amount of salt from their products and has been removing artificial additives, monosodium glutamate and working on reducing saturated fat. Predict further progress on salt reduction is difficult over the next 4 years, but the revised targets have been set at levels that should be achievable in that time frame. The Agency will review progress towards these targets in 2010.
11.2 Extruded snacks All extruded snacks, e.g., cheese flavor corn puffs, potato hoops, all flavors except salt and vinegar	2.8 g salt or 1,100 mg sodium (average)	2.25 g salt or 900 mg sodium (average)	1.88 g salt or 750 mg sodium (average r) 2.5 g salt or 1,000 mg sodium (maximum)	The target set appears achievable but the Agency recognizes that companies work will be dependant on consumer acceptance of lower salt products.
11.3 Pelleted snacks All snacks made from pellets, e.g., prawn cocktail flavor shell, crispy bacon flavor corn snacks, curly cheese snacks, all flavors except salt and vinegar.	3.4 g salt or 1,400 mg sodium (average)	2.5 g salt or 1,000 mg sodium (average)	2.25 g salt or 900 mg sodium (average r)	The Agency will keep progress towards achieving this target under close review following the technical issues raised during the consultation.

continued

TABLE C-2 Continued

Main Product Category and Sub Categories (where relevant)	Current 2010 Targets (g salt or mg sodium per 100 g)*	Revised 2010 Targets (g salt or mg sodium per 100 g)*	Targets for 2012 (g salt or mg sodium per 100 g)*	Comments
11.4 Salt and Vinegar products All crisps, snacks, etc. salt and vinegar flavour only.	3.1 g salt or 1,200 mg sodium (average)	2.38 g salt or 950 mg sodium (average)	2.13 g salt or 850 mg sodium (average r) 3 g salt or 1,200 mg sodium (maximum)	The Agency will keep progress towards achieving this target under close review following the technical issues raised during the consultation.
12. Cakes, pastries, fruit pies and other pastry-based desserts. NB Buns have now moved to categories 12.1 Cakes or 2.3 Morning goods.				
12.1 Cakes includes all sponge cakes, cake bars, malt loaf, American muffins, doughnuts, flapjacks, brownies, etc. Also includes iced finger buns. All other buns are now included in Morning goods (category 2.3).	0.6 g salt or 240 mg sodium (average)		0.5 g salt or 200 mg sodium (average r) 1 g salt or 400 mg sodium (maximum)	Cakes include all chemically raised products. This category also now includes iced finger buns which are yeast-raised but can achieve similarly low levels. All other buns are now included in category 2.3 Morning goods.

12.2 Pastries Includes all puff pastry based and laminated pastries, such as Danish pastries, maple and pecan plait, etc. Excludes all sweet shortcrust and choux pastry-based products (see category 12.3).	0.5 g salt or 185 mg sodium (average)		0.5 g salt or 200 mg sodium (average r)	The Agency is aware that pastries that are based on puff pastry, and/or laminated, will require higher levels of salt than those that are based on shortcrust pastry. For this reason, the Agency has redefined categories 12.2 and 12.3. 12.2 includes all puff and laminated products whilst all shortcrust-based products are now covered by 12.3.
12.3 Fruit pies and other shortcrust and choux pastry-based desserts Includes all fruit pies and other desserts made with shortcrust and choux pastry, e.g., apple pie, tarte au citron, tarte au chocolate, treacle tart, lemon meringue pie, custard tart, banoffee pie, eclairs, profiteroles, choux buns, etc. Excludes all puff pastry and laminated pastries (see category 12.2).	0.4 g salt or 130 mg sodium (average)		0.33 g salt or 130 mg sodium (maximum)	Some products now included here have moved from category 20.4. The Agency is aware that there is a wide range of products in this category and that the target may be more challenging for some products such as treacle tart. However, the target is already being met by many products on the market and we will review progress again in 2010 and 2012.

continued

TABLE C-2 Continued

Main Product Category and Sub Categories (where relevant)	Current 2010 Targets (g salt or mg sodium per 100 g)*	Revised 2010 Targets (g salt or mg sodium per 100 g)*	Targets for 2012 (g salt or mg sodium per 100 g)*	Comments
13. BOUGHT SANDWICHES				
13.1 With high salt fillings Includes sandwiches where the filling includes cured meat (ham, bacon, pastrami, chorizo, salt beef), olives, anchovies and smoked fish, hard cheese, prawns, crayfish, crab, and tuna.	1.3 g salt or 500 mg sodium (average)		1.0 g salt or 400 mg sodium (average r)	The average set is a range average, which means it applies across the product range made by each producer. It is used to allow for variety in the types of products on offer in this category. Individual products do not, therefore, need to meet the target set.
13.2 Without high salt fillings Sandwiches including all lower salt fillings, e.g., chicken, vegetables, egg, etc.—e.g., where ingredients are other than those specified in category 13.1 (see above).	1.0 g salt or 400 mg sodium (average)		0.75 g salt or 300 mg sodium (average r)	The average set is a range average, which means it applies across the product range made by each producer. It is used to allow for variety in the types of products on offer in this category.
14. TABLE SAUCES				
14.1 Tomato ketchup	2.4 g salt or 1,000 mg sodium (maximum)	2.25 g salt or 900 mg sodium (maximum)	1.83 g salt or 730 mg sodium (maximum)	
14.2 Brown sauce Includes all brown, BBQ, curry-flavored, etc.	1.5 g salt or 600 mg sodium (maximum)		1.5 g salt or 600 mg sodium (maximum)	

14.3 Salad cream	1.8 g salt or 700 mg sodium (maximum)		1.75 g salt or 700 mg sodium (maximum)	
14.4.1 Mayonnaise (not reduced fat/calorie)	1.5 g salt or 600 mg sodium (maximum)		1.25 g salt or 500 mg sodium (maximum)	
14.4.1 Mayonnaise (reduced fat/calorie only)	2.5 g salt or 1,000 mg sodium (maximum)	2.13 g salt or 850 mg sodium (maximum)	1.88 g salt or 750 mg sodium (maximum)	We are aware that the 2012 target is considered achievable but that this level may be difficult to reach within the required timescale due to microbiological and technical (stability) issues raised. We will review progress in view of these comments in 2010 and 2012.
14.5 Salad dressing Includes all oil and vinegar based dressings.	2.5 g salt or 1,000 mg sodium (maximum)		1.75 g salt or 700 mg sodium (maximum)	
15. COOK-IN AND PASTA SAUCES, THICK SAUCES AND PASTES				
15.1 All cook in and pasta sauces (except pesto and other thick sauces and pastes) Includes all cooking sauces, e.g., pasta sauce, curry, Mexican, etc. Excludes thick varieties—for pesto and other thick sauces see category 15.2; for thick pastes see category 15.3)	1.1 g salt or 430 mg sodium (average)		0.83 g salt or 330 mg sodium (average r)	

continued

TABLE C-2 Continued

Main Product Category and Sub Categories (where relevant)	Current 2010 Targets (g salt or mg sodium per 100 g)*	Revised 2010 Targets (g salt or mg sodium per 100 g)*	Targets for 2012 (g salt or mg sodium per 100 g)*	Comments
15.2 Pesto and other thick sauces Includes thick cooking sauces intended to be used in smaller quantities, e.g., pesto, stir fry sauces, etc. (e.g., a portion size of under 90 g)	3.0 g salt or 1,200 mg sodium (average)		1.5 g salt or 600 mg sodium (average r), 2.0 g salt or 800 mg sodium (maximum)	
15.3 Thick pastes Includes all thick pastes used in very small quantities (e.g., 15–20 g) such as curry and Thai.	n/a		5.0 g salt or 2,000 mg sodium (maximum)	
16. BISCUITS				
16.1 Sweet biscuits—unfilled Includes all unfilled sweet biscuits.	1.1 g salt or 416 mg sodium (average)		0.68 g salt or 270 mg sodium (average) 1.13 g salt or 450 mg sodium (maximum)	We are aware that it may be difficult for some products to meet the 2012 target within the required timescale and will review progress in 2010 and 2012.
16.2 Sweet biscuits—filled Includes all sweet biscuits with fillings, e.g., fig rolls, custard creams, etc.	0.5 g salt or 205 mg sodium (average)			

16.3 Savory biscuits—unfilled Includes all unfilled savory biscuits, e.g., cream crackers, oatcakes, water biscuits, breadsticks, melba toast, etc.	2.2 g salt or 860 mg sodium (average)		1.38 g salt or 550 mg sodium (average) 2.0 g salt or 800 mg sodium (maximum)	This category includes bagged savory snacks (e.g., cheesy biscuits and flavored crisp breads). We are aware that some bagged snacks have higher salt contents than their larger packeted equivalents because of the method of manufacture. Whilst we recognize that it may be difficult for some products to meet the 2012 target within the required timescale and will review progress in 2010.
16.4 Savory biscuits—filled Includes all savory biscuits with fillings.	1.9 g salt or 740 mg sodium (average)		1.25 g salt or 500 mg sodium (maximum)	There are very few filled savory biscuits—these have been retained in a separate category to savory biscuits, unfilled. We are aware that it may be difficult for some products to meet the 2012 target within the required timescale and will review progress in 2010 and 2012.

continued

TABLE C-2 Continued

Main Product Category and Sub Categories (where relevant)	Current 2010 Targets (g salt or mg sodium per 100 g)*	Revised 2010 Targets (g salt or mg sodium per 100 g)*	Targets for 2012 (g salt or mg sodium per 100 g)*	Comments
17. PASTA				
17.1 Pasta and noodles, plain and flavored Includes dried, fresh, canned, frozen pasta (including spaghetti/hoops in tomato sauce) and noodles. Also includes dry flavored noodles and pasta with flavor or sauce sold as a snack or meal—in these circumstances, the target is for the products as consumed (made up according to manufacturers instructions) and not as sold. Excludes stuffed pasta and pasta ready meals (see category 8) and canned pasta in tomato sauce with accompaniments (see category 7.2)	0.5 g salt or 200 mg sodium (maximum)		0.38 g salt or 150 mg sodium (maximum)	This category now includes flavored noodles and dry pasta sold as a snack or meal (made up according to manufacturers instructions).

18. RICE			
18.1 Rice (unflavored), as consumed Includes all unflavored rice (dried, cooked, frozen cooked, pouched, etc.), as consumed (made up according to manufacturers instructions, where appropriate).	0.2 g salt or 87 mg sodium (maximum)	0.2 g salt or 80 mg sodium (maximum)	
18.2 Flavored rice, as consumed Includes all pouched flavored rice, including ambient and dried products, as consumed (made up according to manufacturers instructions, where appropriate).	0.8 g salt or 300 mg sodium (average)	0.45 g salt or 180 mg sodium (average r) 0.63 g salt or 250 mg sodium (maximum)	We appreciate that it may be difficult for some products to meet the 2012 target within the required timescale and will review progress in 2010 and 2012.
19. OTHER CEREALS			
19.1 Other cereals Includes ready made Yorkshire pudding, ready made pastry, batter and pancake mix, etc.	0.8 g salt or 300 mg sodium (maximum)	0.63 g salt or 250 mg sodium (maximum)	

continued

TABLE C-2 Continued

Main Product Category and Sub Categories (where relevant)	Current 2010 Targets (g salt or mg sodium per 100 g)*	Revised 2010 Targets (g salt or mg sodium per 100 g)*	Targets for 2012 (g salt or mg sodium per 100 g)*	Comments
20. Processed puddings, Mousses, crème caramel, jelly, rice pudding, ready to eat custard, and custard powder are not included as these contain no added salt. Sodium present is that naturally occurring in the ingredients. Jelly crystals are also excluded for technical reasons.				
20.1 Dessert mixes, as consumed Includes dehydrated dessert mixes (made up according to manufacturers instructions). Excludes custard powder and jelly crystals.	0.5 g salt or 200 mg sodium (maximum)		0.5 g salt or 200 mg sodium (maximum)	
20.2 Cheesecake Includes ambient, chilled, frozen and dehydrated (as consumed, made up according to manufacturers instructions).	0.5 g salt or 200 mg sodium (maximum)		0.35 g salt or 140 mg sodium (maximum)	

20.3 Sponge-based processed puddings Includes jam roly-poly, spotted dick, sticky toffee pudding, etc. Excludes canned versions	1.0 g salt or 400 mg sodium (maximum)	0.5 g salt or 200 mg sodium (average), 0.75 g salt or 300 mg sodium (maximum)	
20.4 All other processed puddings Includes all other processed and pre-prepared puddings, e.g., bread and butter pudding, brownie desserts, crumbles, trifle etc. Excludes fruit pies and all other desserts made with shortcrust and choux pastry (see category 12.4).	0.3 g salt or 120 mg sodium (maximum)	0.18 g salt or 70 mg sodium (average) 0.3 g salt or 120 mg sodium (maximum)	Category 12.4 now includes all shortcrust and choux pastry based desserts, so these are no longer included in category 20.4.
21. QUICHE			
21.1 Quiches Includes all quiches and flans	0.8 g salt or 300 mg sodium (maximum)	0.75 g salt or 300 mg sodium (maximum)	
22. SCOTCH EGGS			
22.1 Scotch eggs	1.0 g salt or 400 mg sodium (maximum)	0.88 g salt or 350 mg sodium (maximum)	

continued

TABLE C-2 Continued

Main Product Category and Sub Categories (where relevant)	Current 2010 Targets (g salt or mg sodium per 100 g)*	Revised 2010 Targets (g salt or mg sodium per 100 g)*	Targets for 2012 (g salt or mg sodium per 100 g)*	Comments
23. CANNED FISH				
23.1 Canned tuna Includes all tuna canned in oil, brine, spring water, etc. Excludes fish with sauce products (see category 23.3).	1.0 g salt or 400 mg sodium (average)		1.0 g salt or 400 mg sodium (average p)	
23.2 Canned salmon Includes all standard canned salmon. Excludes fish with sauce products (excludes category 23.3).	1.2 g salt or 470 mg sodium (average)		0.93 g salt or 370 mg sodium (average p)	The Agency recognizes that the salt levels in these products are largely within the control of the U.S. and Canadian canneries and any reduction will depend on influencing them.
23.3 Other canned fish Includes sardines, mackerel, pilchards in brine, oil etc and canned fish with sauces, e.g., tomato, barbeque, mustard, etc. Also includes canned shellfish, e.g., prawns, crab, mussels, etc. Excludes anchovies, smoked fish, lumpfish caviar and fish roe.	1.5 g salt or 600 mg sodium (average)		0.93 g salt or 370 mg sodium (average r)	The range of products covered by this target makes it difficult to set a meaningful maximum target. The Agency has therefore set a range average target.

24. CANNED VEGETABLES		
24.1 Canned vegetables Includes all canned vegetables and pulses. Excludes processed/ marrowfat/mushy peas (see category 24.2) and sauerkraut.	0.13 g salt or 50 mg sodium (maximum)	0.13 g salt or 50 mg sodium (maximum)
24.2 Canned processed/ marrowfat/ mushy peas. Includes these products only.	0.5 g salt or 200 mg sodium (maximum)	0.45 g salt or 180 mg sodium (maximum)
25. MEAT ALTERNATIVES (PREVIOUSLY PROCESSED VEGETABLE-BASED PRODUCTS)		
25.1 Plain meat alternatives Includes plain tofu, Quorn ingredients (e.g., mince, plain pieces and fillets), meat free mince and other similar products	0.7 g salt or 280 mg sodium (maximum)	0.7 g salt or 280 mg sodium (maximum)

continued

TABLE C-2 Continued

Main Product Category and Sub Categories (where relevant)	Current 2010 Targets (g salt or mg sodium per 100 g)*	Revised 2010 Targets (g salt or mg sodium per 100 g)*	Targets for 2012 (g salt or mg sodium per 100 g)*	Comments
25.2 Meat free products Includes all meat and fish alternative products, e.g., sausages, burgers, bites, pies, en croute products, sausage rolls, nut cutlets, falafel, flavored “meat” pieces, e.g., chicken fillets, “meatballs,” all meat-free “meats,” e.g., ham, turkey, etc., including “beanburgers,” “veggieburgers,” and other similar products. Excludes bacon (see category 25.3), baked beans (category 7), canned vegetables (category 24), ready meals and meal centers (category 8) and takeaways.			0.93 g salt or 370 mg sodium (average r) 1.5 g salt or 600 mg sodium (maximum)	
25.3 Meat-free bacon. Includes all meat-free bacon type products, whether made from soya, Quorn, or other ingredients.	n/a		2.13 g salt or 850 mg sodium (average r)	

26. OTHER PROCESSED POTATOES			
26.1 Dehydrated instant mashed potato, as consumed Includes all instant mashed potato products, as consumed (as made up according to manufacturers instructions).	0.25 g salt or 100 mg sodium (maximum)	0.2 g salt or 80 mg sodium (maximum)	0.18 g salt or 70 mg sodium (maximum)
26.2 Other processed potato products Includes all other processed potato products, including frozen and chilled chips with coatings, potato waffles, shaped potato, wedges, etc. Excludes oven chips with no added salt.	0.5 g salt or 195 mg sodium (maximum)	0.49 g salt or 195 mg sodium (average) 0.88 g salt or 350 mg sodium (maximum)	0.49 g salt or 195 mg sodium (average r) 0.75 g salt or 300 mg sodium (maximum)

continued

TABLE C-2 Continued

Main Product Category and Sub Categories (where relevant)	Current 2010 Targets (g salt or mg sodium per 100 g)*	Revised 2010 Targets (g salt or mg sodium per 100 g)*	Targets for 2012 (g salt or mg sodium per 100 g)*	Comments
27. BEVERAGES				
27.1 Dried beverages, as consumed Includes drinking chocolate, instant chocolate drinks, instant malted drinks, instant cappuccino drinks, etc., as consumed (made up according to manufacturers instructions). Excludes tea and coffee.	0.25 g salt or 100 mg sodium (maximum)		0.15 g salt or 60 mg sodium (maximum)	The 2012 target for dried beverages has been maintained at a maximum of 60 mg sodium per 100 g, as consumed. An analysis of the dried beverage products on the market indicates that this is an achievable target.
28. TAKEAWAY, MEAT BASED				
28.1 Take away, meat based Includes curries, Chinese dishes, etc. Does not include beef burgers, pies.	0.6 g salt or 250 mg sodium (maximum)		0.63 g salt or 250 mg sodium (maximum)	The targets for takeaway foods have been maintained at their 2006 levels. The Agency has a separate program of engagement with the catering sector underway to promote salt reduction in these foods.
29. TAKEAWAY, FISH BASED				
29.1 Take away, fish based Includes curries, Chinese dishes, etc.	0.5 g salt or 200 mg sodium (maximum)		0.5 g salt or 200 mg sodium (maximum)	

30. TAKEAWAY, VEGETABLE AND POTATO BASED		
30.1 Take away, vegetable and potato based Includes takeaway chips, curries, Chinese dishes, etc.	0.5 g salt or 200 mg sodium (maximum)	0.5 g salt or 200 mg sodium (maximum)

NOTES: Some categories have been revised and there is no equivalent 2010 target. As a result, the "Current 2010 targets" column has been left blank. There are two types of average used within the targets table. The first is a processing average (average p) and is used to account for ranges of salt levels that occur in a single product, e.g., bacon and tuna. The second is a range average (average r), which is used to take into account a range of differing flavors (e.g., standard potato crisps) or products (e.g., morning goods) covered by a single target. All range averages should be calculated on a sales weighted basis.

*Revised targets for 2010 and 2012 have been set according to mg sodium that should be present. This figure has then been multiplied by 2.5 to give the salt equivalent. The targets that were published in 2006 have not changed in this way as this is currently the method proposed in the draft Food Information Regulation for labeling salt content.

SOURCE: Food Standards Agency. Available online: http://www.food.gov.uk/healthiereating/salt/saltreduction (accessed October 14, 2009).

Appendix D

Salt Substitutes and Enhancers

TABLE D-1 Selected Examples of Proposed Salt Substitutes

Substitute	Applications	Comments
Potassium chloride (KCl)	Many foods, including cheeses,[a] breads,[b] and meats;[c] may be mixed with NaCl in up to a 50:50 ratio[c]	Bitter to many people;[c] many patents to reduce KCl bitterness exist;[d] because potassium intake of the U.S. population is low, increased intake of potassium may benefit some[e] but could harm certain subpopulations (e.g., those with certain medical conditions or taking certain medications)[f]
Lithium chloride (LiCl)	None: toxic although almost perfectly salty	
Calcium chloride ($CaCl_2$), magnesium chloride ($MgCl_2$), and magnesium sulfate ($MgSO_4$)	Few foods	Somewhat salty but with many off-tastes;[g] bitter tastes of $MgSO_4$ are usually perceived only at high levels;[h] $CaCl_2$ can cause irritations on the tongue[h]
Sea salt	Many foods, also used in salt shakers	Usually contains substantial amounts of sodium chloride; benefits of use in reducing sodium consumption are unclear
Salts with altered crystal structure	Some foods	Porous and star-shaped structures, created by manipulating the salt drying process, allow greater salty taste with smaller amounts of salt;[i] particularly useful in applications where salt is used on the surface of food products[j]

[a] Guinee and O'Kennedy, 2007.
[b] Cauvain, 2007.
[c] Desmond, 2007
[d] Porzio, 2007.
[e] Anthony, 2007.
[f] Dietary Guidelines Advisory Committee, 2005.
[g] Murphy et al., 1981.
[h] Kilcast and den Ridder, 2007.
[i] Desmond, 2006.
[j] Pszczola, 2007.

TABLE D-2 Selected Examples of Proposed Salt Enhancers

Ingredient	Applications	Comments
Monosodium glutamate (MSG) and other glutamates	Many foods; can replace some salt[a]	No pleasant taste in itself, but enhances salty tastes; imparts the taste of umami; MSG contains sodium; other glutamate salts such as monopotassium glutamate or calcium diglutamate may further reduce sodium; synergizes with 5′-ribonucleotides;[b] may replace bitter blocking[c] and oral thickening[d] characteristics; often contained in hydrolyzed vegetable protein and yeast extracts[a]
Yeast extracts and hydrolyzed vegetable protein	Some foods	Often contains MSG, but is seen as a "natural" alternative to MSG use; meaty and brothy tastes limit potential uses[d,e]
Nucleotides including inosine-5′-monophosphate (IMP) and guanosine-5′-monophosphate	Some foods	Imparts the taste of umami; found to act synergistically with glutamates to enhance salty tastes in some foods[d,f]
Amino acids, especially arginine and related compounds	Not known	L-Arginine is reported to enhance the saltiness of foods with low to moderate levels of salt; practical uses are not clear[g]
Dairy concentrates	Many foods	Reported to allow moderate sodium reductions in a variety of products[e,h]
Lactates (potassium lactate, calcium lactate, and sodium lactate)	Few foods	May enhance the saltiness of NaCl, but not widely used; calcium lactate can impart a sour taste[b]
Herbs and spices	Many foods	Herbs and spices provide other flavoring characteristics and may, for some people, help alleviate blandness following salt removal[e,i,j]
Compounds that reduce bitterness including adenosine-5′-monophosphate, DHB (2,4-dihydroxybenzoic acid), lactose, sodium gluconate, and mixtures for use in combination with potassium chloride	Many foods	Designed to mask bitterness of potassium chloride or reduce bitterness from other food components that are usually masked by salt; allow partial reduction of total sodium content[b,e,k,l]

TABLE D-2 Continued

Ingredient	Applications	Comments
Mixtures of NaCl substitutes and enhancers	Many foods	Proprietary mixtures are produced by many companies; mixtures consist of a number of ingredients such as non-sodium salts, yeast extracts, potassium chloride, sodium, and sodium gluconate[e,m,n,o]

[a] Yamaguchi, 1987.
[b] Kilcast and den Ridder, 2007.
[c] Keast et al., 2004.
[d] Brandsma, 2006.
[e] Pszczola, 2007.
[f] Ajinomoto Food Ingredients LLC, 2008.
[g] Breslin and Beauchamp, 1995.
[h] Armor Proteines, 2007.
[i] Kilcast, 2007.
[j] Ainsworth and Plunkett, 2007.
[k] Ndabikunze and Lahtinen, 1989.
[l] Desmond, 2007.
[m] DSM Food Specialties, 2004.
[n] Pszczola, 2006.
[o] Jungbunzlauer, 2007.

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Appendix E

Background on the National Health and Nutrition Examination Surveys and Data Analysis Methods

OVERVIEW

In the 1960s, the National Health Examination Survey began to assess the health status of individuals ages 6 months through 74 years, including measures of hypertension, elevated serum cholesterol, and overweight. Nutritional intake was added as a survey component in the 1970s. Therefore, the 1970s mark the time during which information on sodium intake became available from this survey, beginning with the first National Health and Nutrition Examination Survey, known as NHANES I (1971–1974).[1] The U.S. Department of Agriculture's (USDA's) food composition database has provided the sources of information that allow the estimates of food intake collected in the NHANES to be translated into quantitative nutrient intake (Bodner-Montville et al., 2006; Briefel, 2006). The NHANES and related food intake surveys conducted by USDA were integrated in 2002, and at that time the dietary reports from the integrated survey became known as What We Eat in America (WWEIA).

The NHANES reflects a continuous and standardized data collection based on a representative sample of the U.S. population and major subgroups (including those related to race/ethnicity and income) and provides critical diet and health measures for federal program planning and policy

[1]The U.S. Department of Agriculture (USDA) Household Food Consumption Surveys conducted in 1977–1978 and 1987–1988 provide a snapshot of food sources of sodium in the 1970s and the 1980s at the household-level. More recent data have not been collected, although USDA plans to collect similar household food acquisition and food cost data in 2010 or 2011.

making. The survey relies on the gold standard for dietary measures, two or more 24-hour dietary recalls per person (IOM, 2000). NHANES is unique in that it collects and tracks both dietary intake and health measures in a nationally representative sample of Americans. Dietary intake estimates are limited by survey respondents' abilities to accurately report foods and amounts consumed and by the accuracy, specificity, and currentness of the food composition databases used to code foods reported in the survey. They are also prone to underreporting intake (IOM, 2000). Issues related to estimation of usual intake related to WWEIA-NHANES have been carefully reviewed by others (Dwyer et al., 2003).

During the four decades that dietary intake has been tracked in nationally representative cross-sectional surveys of the population, there have been changes in the data collection methods and protocols used to estimate dietary intake. The quality of data has improved, but of course some bias and measurement error still exist given that the estimates must rely on self-reported data. Beginning with NHANES III (1988–1994), improvements were made in dietary data collection to produce population-level estimates of total sodium intake to track progress in meeting Healthy People objectives for the dietary guidelines for sodium.[2] These improvements included the collection of more than 1 day of intake on at least a subsample of the population and questions about tap water consumption and water softening, dietary supplement use, and salt added at the table, including the type of salt. These additional survey questions were intended to produce more complete estimates of dietary sodium intake.

Beginning in 2003–2004, two 24-hour diet recalls were collected and released for each person, allowing for estimates of usual nutrient (sodium) intake in the population using statistical software to account for the large day-to-day variations in individual intake (Dodd, 1996). The improvements in dietary data collection and the availability of statistical techniques to assess dietary intake allow for estimates of the population's usual sodium intake from food sources. When the available statistical software is not applicable to the measure(s) of interest, data on the basis of a 1-day mean are reported. This applies to analyses focused on food categories, sodium intake from earlier studies, and measures of sodium density.

ESTIMATION OF CURRENT SODIUM INTAKE FROM NHANES 2003–2006

Current estimates of intake are derived from information available from two recently completed NHANES: 2003–2004 and 2005–2006. Those data sets were combined for this report to provide larger sample sizes for

[2] Available online: http://www.healthypeople.gov/document/pdf/tracking/od19.pdf (accessed November 14, 2009).

subgroup analysis. Analysis weights were appropriately revised following the recommended procedures for combining NHANES survey data.[3] Data are weighted to reflect population estimates. Unweighted sample size is shown in the data tables in Appendix F.

Sodium from Foods

Estimates of food intake are derived from two 24-hour dietary recalls.[4] The day 1 interview was conducted in person in the Mobile Examination Center of NHANES. The day 2 interview was conducted by telephone 3–10 days later. As part of the NHANES 24-hour recall interview on day 1, respondents are probed to provide details of the food consumed. These probes elicit information such as brand names, preparation method, the form of the food (such as frozen, canned, or fresh), and the type of food to assist in clarifying levels of sodium in the food consumed, as well as fat, calories, and other components and where the foods were obtained. Questions are not asked about salt used in cooking, recipes, or food preparation as part of the 24-hour recall. Rather, a set of health-related questions is administered separately and includes questions about salt use. Respondents are asked how often salt is used in cooking inside the home; this question refers only to ordinary or seasoned salt and not "lite" salt or salt substitutes. Response options include "never," "rarely," "occasionally," and "very often." This information is applied to algorithms for recipes and sodium absorbed in cooking (Moshfegh, 2009).

A statistical method for estimating usual intake distributions and the proportion below or above defined cutoff values has been developed at Iowa State University and makes use of the second-day dietary recall for this purpose (Carriquiry, 2003). This method was applied to estimates of sodium intake for this study, where possible. Certain measures of interest were not applicable to use of this software and were reported as 1-day means; these include estimates of sodium intake from other sources such as tap water.

Sodium from Other Sources

Other sources of sodium include salt added at the table, tap water, and dietary supplements. The approach used to estimate this intake was developed for the Healthy People 2010 Progress Review, Focus Area 19,

[3] Available online: http://www.cdc.gov/nchs/data/nhanes/nhanes_03_04/nhanes_analytic_guidelines_dec_2005.pdf (accessed March 25, 2010).

[4] Available online: http://www.ars.usda.gov/Services/docs.htm?docid=13793 (accessed October 26, 2009).

presented April 2008[5,6] and described as part of the Healthy People 2010 tracking system.[7]

Accurate reporting of salt used at the table relies on subjects' ability to estimate the quantity and frequency with which salt is added to foods. For NHANES, respondents are asked to indicate how often salt is added at the table.[8] Response options include "never," "rarely," "occasionally," and "very often." Sea salt, flavored salts (such as garlic or onion salt), and seasoning salts were counted as ordinary salts. So-called lite salt was recorded as such and has a reduced sodium content. Salt substitutes do not contain sodium. When an analysis incorporates use of salt at the table in the estimation of sodium intake, the amount of sodium depending on salt type is multiplied by the frequency value (i.e., sodium in type of salt multiplied by frequency amount of sodium from table salt added per day) to obtain a daily amount for each person. Regarding type of salt, a zero sodium value is assigned for reports of "none" and "salt substitute." When "very often" was reported for use, ordinary salt is assigned as 290 mg sodium for persons ages 2–19 years, and 580 mg for persons over 20 years of age. If salt use was reported as "occasionally," the value for "very often" was multiplied by one-half; for reports of use as "rarely," the value for "very often" was multiplied by one-fourth.

When an analysis incorporates sodium from drinking water, water derived from a water softening or conditioning system is identified as containing 3 mg of sodium per fluid ounce. Otherwise, water is counted as unsoftened. One mg sodium per fluid ounce is used for "regular" municipal water based on the USDA food composition database. In WWEIA 2003–2004, only sweetened bottled waters were captured in the 24-hour recall. Information on plain water, tap water (and source), and plain carbonated water was captured in survey questions following the 24-hour recall. For the analysis in this report, waters were categorized as tap water (for the tap water contribution), and other bottled and sweetened waters were categorized as foods in the beverage category.

Finally, data on dietary supplements are collected as part of NHANES, but the incorporation of sodium from dietary supplements requires additional data permutations to link the dietary supplement data set to the foods intake data set. To make this calculation, the content of each dietary supplement reported by the respondent and the frequency of use in the past

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[5] Available online: http://www.healthypeople.gov/data/2010prog/focus19/Default.htm (accessed November 14, 2009).

[6] Available online: http://www.cdc.gov/nchs/healthy_people/hp2010/focus_areas/fa19_nutrition2.htm (accessed November 14, 2009).

[7] Available online: http://www.healthypeople.gov/Document/html/tracking/od19.htm (accessed November 14, 2009).

[8] Available online: http://www.healthypeople.gov/document/pdf/tracking/od19.pdf (accessed November 14, 2009).

month are combined to estimate a daily amount of sodium from supplements per person. Antacids are included in the estimates of sodium intake from dietary supplements.

Usual Sodium Intake Comparison to Dietary Reference Intakes

As part of describing current sodium intake, means and distributions of usual intake from foods and from all dietary sources in NHANES 2003–2006 were compared to the Dietary Reference Intakes (DRIs) (IOM, 2005)—that is, the Adequate Intake (AI) and the Tolerable Upper Intake Level (UL) for sodium. If the usual mean intake exceeds the AI, the group is assumed to have adequate intake levels (Murphy, 2003). The proportion of the population that exceeds the UL is determined to be at risk of adverse effects from an excessive intake (Murphy, 2003). The statistical method for estimating the proportion below or above defined DRI cutoff values developed at Iowa State University was used (Carriquiry and Camano-Garcia, 2006).

Special Subgroups

The NHANES collects information on race/ethnicity on the basis of self-reported categories as follows: non-Hispanic whites, non-Hispanic African Americans, and Mexican Americans. Income for the survey is also reported on a category basis and is analyzed consistent with standards for reporting nutrition and statistical data for the evaluation of nutrition assistance programs: low-income is defined as an annual household income level of 130 percent of poverty or less, the income eligibility for the Supplemental Nutrition Assistance Program, formerly called the food stamp program; higher-income is defined as an annual household income above 185 percent of poverty, the eligibility cut-off for free- or reduced-price school meals and the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC); and intermediate income is between 130 and 185 percent of the poverty line. Mean sodium intake from foods is highest among low- and higher-income adults ages 19–30 years and higher-income adults ages 31–50 years (Appendix F, Table F-6). Hypertension was defined as an elevated blood pressure (systolic pressure ≥ 140 mm Hg and diastolic pressure ≥ 90 mm Hg) and/or the taking of antihypertensive medications at the time of the individual's medical examination in the NHANES Medical Examination Center (NCHS, 2009).

ESTIMATION OF TIME TRENDS FOR SODIUM INTAKE FROM NHANES

Trends in mean sodium intake have been reported for age/gender subgroups from age 1 year through 74 years from 1971–1974 to 1999–2000 (Briefel and Johnson, 2004). NHANES collected single 24-hour dietary recalls in 1971–1974 and estimated mean sodium intake from foods by age group and gender for the household-based population ages 1 year through 74 years. The age range was expanded to 2 months and older with no upper age cutoff in NHANES III (1988–1994), and from birth on starting in NHANES 1999. Nutrient intake is not reported for breastfeeding infants.

To update the Briefel and Johnson analysis (2004) and allow for comparison to current estimates of intake, estimated 1-day mean sodium intake from foods[9] in NHANES 2003–2006 was derived using analytic techniques comparable to those used in the earlier analysis. A table was then generated to compare intake estimates from NHANES 2003–2006 to the existing time trend analysis (Briefel and Johnson, 2004).

APPROACH TO CHARACTERIZING SOURCES OF SODIUM IN NHANES 2003–2006

The food category analysis used data from NHANES 2003–2006 and relied on the food categorization scheme used in a previous NHANES analysis by Cole and Fox (2008). In brief, all foods reported in the 24-hour dietary recalls are grouped into 11 major categories and into 154 food groups. Nearly 4,000 unique food codes were used to code foods reported in NHANES 2003–2004 (n = 3,894 foods). The estimates of sodium from foods include salt used in cooking and food preparation, but not salt added at the table. Further, foods are not disaggregated at the ingredient level, and salt that was used in recipes is also included in the sodium content of the food "as prepared." Foods are recorded as reported by consumers, for example, as an apple, a mixed dish, or a sandwich. In some cases, individual components were reported, and it was not always possible to aggregate or disaggregate all reported foods at the same level.

One-day dietary recall data were used to estimate food sources of sodium and mean daily sodium and sodium density by home versus away food source using the population proportion method as described by Krebs-Smith and colleagues (1989). For this report, the committee classified food sources as "Home," "Away," and "Other" based on the food source categories listed in Box E-1. "Home" sources are those foods obtained from the store and assumed to be consumed at home. "Away" sources include restaurants (which include those with waiter service, fast food and pizza

[9] This estimate includes salt used in cooking and in food preparation.

BOX E-1
Food Source Categories

Home includes:
- Foods prepared at home
- Foods purchased from the store

Away includes:
- Restaurant with wait staff
- Restaurant fast food/pizza
- Bar/tavern/lounge
- Restaurant, no additional information
- Cafeteria not at school
- Cafeteria at school

Other includes:
- Child care center
- Family/adult day care center
- Meals on Wheels
- Community food programs
- Vending machine
- Common coffee pot or snack tray
- From someone else/gift
- Mail order purchase
- Residential dining facility
- Grown or caught by you or someone you know
- Fish caught by you or someone you know
- Sport, recreation, or entertainment
- Street vendor, vending truck
- Fundraiser sales

places, and bar, tavern, or lounge categories) and cafeterias (school and non-school). "Other" sources for purposes of this analysis represent an average of 22 percent of the daily sodium in 2003–2006 and include sources such as child care centers, vending machines, street vendors, sports events, and community food programs.

The data used to characterize sodium intake by contributing source are largely obtained from self-reported intake surveys coded using composition databases. As such, they are subject to the same limitations described for estimating intake by self-report. As discussed earlier, the constantly evolving food supply and increasing globalization make it a challenge to maintain updated food composition databases or databases for supplements that may also undergo formulation changes. Furthermore, new technologies for analyzing samples may change established values for the nutrient content of certain foods. Each food item listed in self-reported intake surveys has a code that corresponds to an entry in the database. However, foods may not have unique food codes; they are often grouped with similar foods within a food group and assigned an aggregate nutrient content based on the market share of the items in the food code.

The categorization of foods in the database can affect the ability to track the contribution of individual food items to sodium intake over time. How researchers decide to categorize and report foods can also have a major influence on the rank ordering of which foods are the greatest contributors to sodium intake and can make data comparisons across studies difficult (Cole and Fox, 2008; Cotton et al., 2004; Subar et al., 1998).

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Appendix F

Sodium Intake Tables

This appendix includes the following tables on sodium intake:

- Table F-1: Mean 1-Day Sodium Intake by Dietary Source by Age or Gender for Persons 2 or More Years of Age
- Table F-2: Usual Sodium Intake Distributions from All Dietary Sources by Age or Gender for Persons 2 or More Years of Age
- Table F-3: Usual Sodium Intake Distributions from Foods by Age or Gender for Persons 2 or More Years of Age
- Table F-4: Mean Sodium Intake, Mean Energy Intake, and Mean Sodium Density Values for Persons 2 or More Years of Age
- Table F-5: Usual Mean Sodium Intake Distributions from Foods by Age and Race or Ethnicity for Persons 2 or More Years of Age
- Table F-6: Usual Sodium (mg/d) Intake Distributions from Foods by Income Level for Persons 2 or More Years of Age
- Table F-7: Usual Sodium Intake Distributions from Foods Among Adults with Hypertension
- Table F-8: Top 20 Sources of Sodium Intake Within Food Categories for Persons 2 or More Years of Age
- Table F-9: Top 10 Food Sources of Sodium Intake by Age or Gender for Persons 2 or More Years of Age
- Table F-10: Top 10 Sources of Sodium Intake by Home Versus Away for Persons 2 or More Years of Age

TABLE F-1 Mean 1-Day Sodium Intake by Dietary Source by Age or Gender for Persons 2 or More Years of Age

	Mean Intake (mg/d)				
	n	Food[a]	SE	Table Salt[b]	SE
All Ages 2+ Yrs	16,822	3,407	13.8	178	1.4
Children					
2–3 yrs	921	2,201	31.4	28	1.9
4–8 yrs	1,680	2,795	29.6	49	1.7
Males					
9–13 yrs	1,009	3,513	48.9	93	2.6
14–18 yrs	1,351	4,339	65.6	105	2.3
19–30 yrs	1,097	4,490	64.2	217	5.8
31–50 yrs	1,439	4,448	55.4	237	5.5
51–70 yrs	1,215	3,738	50.4	230	6.0
> 70 yrs	808	3,000	47.0	189	7.1
Females[c]					
9–13 yrs	1,039	3,019	43.9	85	2.5
14–18 yrs	1,250	2,980	42.0	112	2.4
19–30 yrs	914	3,062	46.6	207	6.2
31–50 yrs	1,350	3,021	40.4	215	5.4
51–70 yrs	1,251	2,773	35.8	197	5.5
> 70 yrs	787	2,397	38.3	127	5.5
Pregnant and lactating females[d]	711	3,465	55.2	220	6.9
Pregnant females	623	3,541	62.2	201	7.1
Lactating females	99	3,236	121.8	270	19.4

NOTES: d = day; mg = milligram; *n* = unweighted sample size; SE = standard error.

[a] Includes salt added in food preparation and cooking.

[b] Salt added by the consumer at the table.

[c] Excludes pregnant and lactating females (shown separately).

[d] Includes 11 females who were pregnant and lactating.

SOURCE: NHANES 2003–2006.

Tap Water	SE	Supplements	SE	All Sources	SE
27	0.3	2	0.2	3,614	14.1
9	0.4	1	0.1	2,239	31.4
12	0.4	1	0.1	2,857	29.8
17	0.7	0	0.1	3,624	48.9
27	1.0	4	0.7	4,474	65.9
32	1.3	2	2.2	4,741	65.1
32	1.1	1	0.2	4,719	56.0
28	1.0	2	0.3	3,999	51.1
25	1.0	3	0.5	3,217	48.5
16	0.6	1	0.1	3,121	44.1
20	0.8	1	0.2	3,113	42.1
29	1.2	1	0.2	3,298	47.8
31	1.1	1	0.2	3,268	41.3
32	1.0	3	0.3	3,005	36.5
26	1.0	4	1.0	2,554	39.1
24	1.4	1	0.2	3,710	55.4
22	1.4	1	0.2	3,765	63.1
28	4.3	0	0.1	3,534	119.0

TABLE F-2 Usual Sodium Intake Distributions from All Dietary Sources by Age or Gender for Persons 2 or More Years of Age

	Usual Intake Percentiles (mg/d)					
	n	AI	UL	5th	10th	25th
All ages 2+ yrs	16,822			2,007	2,283	2,799
Children						
2–3 yrs	921	1,000	1,500	1,378	1,532	1,819
4–8 yrs	1,680	1,200	1,900	1,876	2,054	2,382
Males						
9–13 yrs	1,009	1,500	2,200	2,572	2,770	3,122
14–18 yrs	1,351	1,500	2,300	2,543	2,883	3,509
19–30 yrs	1,097	1,500	2,300	2,960	3,293	3,903
31–50 yrs	1,439	1,500	2,300	2,895	3,235	3,850
51–70 yrs	1,215	1,300	2,300	2,373	2,668	3,214
> 70 yrs	808	1,200	2,300	1,963	2,191	2,612
Females[a]						
9–13 yrs	1,039	1,500	2,200	2,001	2,212	2,591
14–18 yrs	1,250	1,500	2,300	1,960	2,172	2,561
19–30 yrs	914	1,500	2,300	1,994	2,245	2,691
31–50 yrs	1,350	1,500	2,300	1,978	2,217	2,647
51–70 yrs	1,251	1,300	2,300	1,860	2,072	2,454
> 70 yrs	787	1,200	2,300	1,623	1,801	2,118
Pregnant and lactating females[b]	711	1,500	2,300	2,344	2,612	3,088
Pregnant females	623	1,500	2,300	2,327	2,592	3,081
Lactating females	99	1,500	2,300	2,387	2,638	3,054

NOTES: AI = Adequate Intake; d = day; mg = milligram; *n* = unweighted sample size; includes sodium from foods, salt added at the table, tap water, and supplements; SE = standard error; UL = Tolerable Upper Intake Level.

[a] Excludes pregnant and lactating females (shown separately).

[b] Includes 11 females who were pregnant and lactating.

SOURCE: NHANES 2003–2006.

						Excessive Usual Intake (mg/d)	
Median	Mean	SE	75th	90th	95th	% > UL	SE
3,471	3,615	8.9	4,270	5,126	5,713	92	0.5
2,182	2,239	19.4	2,597	3,017	3,292	91	2.1
2,797	2,857	16.3	3,267	3,739	4,045	94	1.6
3,556	3,622	22.4	4,052	4,558	4,892	99	0.9
4,310	4,479	37.6	5,259	6,282	6,992	97	1.1
4,652	4,744	36.0	5,475	6,301	6,849	99	0.5
4,609	4,720	32.7	5,467	6,344	6,927	99	0.5
3,900	3,998	31.5	4,676	5,454	5,957	96	1.3
3,141	3,217	29.9	3,740	4,342	4,732	87	2.7
3,061	3,127	23.6	3,592	4,124	4,471	90	2.7
3,051	3,117	22.1	3,598	4,142	4,499	86	2.7
3,231	3,298	28.8	3,831	4,435	4,832	89	2.6
3,181	3,274	24.5	3,795	4,441	4,884	88	2.3
2,934	3,006	22.1	3,480	4,032	4,396	82	2.3
2,505	2,554	22.2	2,936	3,370	3,654	64	2.7
3,657	3,710	33.4	4,275	4,876	5,258	96	1.9
3,693	3,764	38.4	4,369	5,029	5,450	95	2.0
3,507	3,497	66.4	3,949	4,338	4,567	96	5.8

TABLE F-3 Usual Sodium Intake Distributions from Foods by Age or Gender for Persons 2 or More Years of Age

	Usual Intake Percentiles (mg/d)					
	n	AI	UL	5th	10th	25th
All ages 2+ yrs	16,822			1,846	2,114	2,615
Children						
2–3 yrs	921	1,000	1,500	1,344	1,498	1,783
4–8 yrs	1,680	1,200	1,900	1,830	2,004	2,327
Males						
9–13 yrs	1,009	1,500	2,200	2,474	2,669	3,016
14–18 yrs	1,351	1,500	2,300	2,417	2,755	3,377
19–30 yrs	1,097	1,500	2,300	2,737	3,066	3,659
31–50 yrs	1,439	1,500	2,300	2,648	2,981	3,585
51–70 yrs	1,215	1,300	2,300	2,161	2,446	2,974
> 70 yrs	808	1,200	2,300	1,784	2,004	2,413
Females[a]						
9–13 yrs	1,039	1,500	2,200	1,907	2,117	2,492
14–18 yrs	1,250	1,500	2,300	1,840	2,047	2,431
19–30 yrs	914	1,500	2,300	1,841	2,076	2,496
31–50 yrs	1,350	1,500	2,300	1,774	2,003	2,417
51–70 yrs	1,251	1,300	2,300	1,659	1,864	2,236
> 70 yrs	787	1,200	2,300	1,491	1,663	1,971
Pregnant and lactating females[b]	711	1,500	2,300	2,112	2,378	2,841
Pregnant females	623	1,500	2,300	2,131	2,392	2,865
Lactating females	99	1,500	2,300	2,147	2,383	2,785

NOTES: AI = Adequate Intake; d = day; mg = milligram; *n* = unweighted sample size; food sources include salt added in cooking and food preparation; SE = standard error; UL = Tolerable Upper Intake Level.

[a] Excludes pregnant and lactating females (shown separately).

[b] Includes 11 females who were pregnant and lactating.

SOURCE: NHANES 2003–2006.

						Excessive Usual Intake (mg/d)	
Median	Mean	SE	75th	90th	95th	% > UL	SE
3,268	3,409	8.7	4,044	4,879	5,454	88	0.6
2,144	2,201	19.3	2,557	2,977	3,251	90	2.2
2,736	2,796	16.0	3,199	3,664	3,966	93	1.8
3,446	3,511	22.2	3,936	4,438	4,769	99	1.2
4,175	4,344	37.5	5,120	6,141	6,851	96	1.3
4,388	4,494	35.9	5,212	6,053	6,611	98	0.9
4,335	4,451	32.4	5,189	6,066	6,649	98	0.9
3,640	3,738	30.7	4,396	5,157	5,650	93	1.7
2,927	3,001	29.0	3,509	4,094	4,474	80	2.9
2,960	3,026	23.5	3,489	4,019	4,365	87	2.9
2,916	2,984	22.0	3,460	4,004	4,360	81	2.8
3,006	3,069	27.1	3,571	4,137	4,510	83	3.0
2,932	3,027	23.8	3,530	4,164	4,600	80	2.5
2,704	2,775	21.6	3236	4,164	4,134	72	2.2
2,347	2,398	21.7	2,769	3,197	3,478	53	2.5
3,398	3,466	33.5	4,028	4,650	5,039	92	2.5
3,457	3,540	38.0	4,134	4,806	5,230	92	2.6
3,231	3,230	65.9	3,674	4,072	4,309	92	8.4

TABLE F-4 Mean Sodium Intake, Mean Energy Intake, and Mean Sodium Density Values for Persons 2 or More Years of Age

	Mean Intake (mg/d)					
	n	Sodium (mg)	SE	Energy (kcal)	SE	Sodium[a] Density (mg/1,000 kcal)
All ages 2+ yrs	16,822	3,407	13.8	2,176	7.8	1,566
Children						
2–3 yrs	921	2,201	31.4	1,525	17.9	1,443
4–8 yrs	1,680	2,795	29.6	1,879	15.5	1,488
Males						
9–13 yrs	1,009	3,513	48.9	2,267	26.7	1,550
14–18 yrs	1,351	4,339	65.6	2,812	36.5	1,543
19–30 yrs	1,097	4,490	64.2	2,907	36.8	1,545
31–50 yrs	1,439	4,448	55.4	2,860	29.9	1,555
51–70 yrs	1,215	3,738	50.4	2,321	25.3	1,610
> 70 yrs	808	3,000	47.0	1,909	24.0	1,571

Females[b]						
9–13 yrs	1,039	3,019	43.9	1,943	23.5	1,553
14–18 yrs	1,250	2,980	42.0	1,970	23.1	1,513
19–30 yrs	914	3,062	46.6	1,964	28.3	1,559
31–50 yrs	1,350	3,021	40.4	1,898	21.5	1,592
51–70 yrs	1,251	2,773	35.8	1,681	18.0	1,649
> 70 yrs	787	2,397	38.3	1,506	20.1	1,591
Pregnant and lactating females[c]	711	3,465	55.2	2,256	30.5	1,536
Pregnant females	623	3,541	62.2	2,321	34.1	1,526
Lactating females	99	3,236	121.8	2,078	67.8	1,557

NOTES: d = day; mg = milligram; kcal = calorie; *n* = unweighted sample size; SE = standard error.

[a] Includes salt added in food preparation and cooking.

[b] Excludes pregnant and lactating females (shown separately).

[c] Includes 11 females who were pregnant and lactating.

SOURCE: NHANES 2003–2006.

TABLE F-5 Usual Mean Sodium Intake Distributions from Foods by Age and Race or Ethnicity for Persons 2 or More Years of Age

				Usual Intake Percentiles (mg/d)		
	n	AI	UL	5th	10th	25th
All						
2–3 yrs	921	1,000	1,500	1,344	1,498	1,783
4–8 yrs	1,680	1,200	1,900	1,830	2,004	2,327
9–13 yrs	2,048	1,500	2,200	2,151	2,364	2,745
14–18 yrs	2,683	1,500	2,300	2,006	2,294	2,832
19–30 yrs	2,466	1,500	2,300	2,109	2,416	2,984
31–50 yrs	2,963	1,500	2,300	1,991	2,291	2,852
51–70 yrs	2,466	1,300	2,300	1,790	2,045	2,518
> 70 yrs	1,595	1,200	2,300	1,550	1,751	2,116
19+ yrs (all adults)	9,490		2,300	1,851	2,132	2,659
All ages 2+ yrs	16,822			1,846	2,114	2,615
Non-Hispanic White						
2–3 yrs	263	1,000	1,500	1,325	1,479	1,766
4–8 yrs	478	1,200	1,900	1,832	2,007	2,331
9–13 yrs	520	1,500	2,200	2,162	2,378	2,762
14–18 yrs	737	1,500	2,300	1,997	2,298	2,862
19–30 yrs	997	1,500	2,300	2,300	2,598	3,140
31–50 yrs	1,398	1,500	2,300	2,042	2,354	2,931
51–70 yrs	1,265	1,300	2,300	1,886	2,137	2,608
> 70 yrs	1,151	1,200	2,300	1,599	1,796	2,156
19+ yrs (all adults)	4,811		2,300	1,911	2,189	2,714
All ages 2+ yrs	6,809			1,879	2,148	2,655
Non-Hispanic African American						
2–3 yrs	243	1,000	1,500	1,492	1,661	1,971
4–8 yrs	513	1,200	1,900	1,959	2,138	2,454
9–13 yrs	690	1,500	2,200	2,119	2,344	2,745
14–18 yrs	944	1,500	2,300	1,869	2,140	2,658
19–30 yrs	609	1,500	2,300	1,960	2,241	2,759
31–50 yrs	692	1,500	2,300	1,841	2,137	2,679
51–70 yrs	555	1,300	2,300	1,542	1,774	2,205
> 70 yrs	206	1,200	2,300	1,459	1,625	1,929
19+ yrs (all adults)	2,062		2,300	1,692	1,964	2,472
All ages 2+ yrs	4,452			1,765	2,021	2,496
Mexican American						
2–3 yrs	303	1,000	1,500	1,202	1,350	1,624
4–8 yrs	524	1,200	1,900	1,725	1,892	2,203
9–13 yrs	670	1,500	2,200	2,052	2,276	2,684
14–18 yrs	819	1,500	2,300	2,021	2,284	2,766
19–30 yrs	664	1,500	2,300	1,769	2,098	2,709
31–50 yrs	612	1,500	2,300	2,074	2,350	2,857
51–70 yrs	489	1,300	2,300	1,341	1,586	2,049
> 70 yrs	185	1,200	2,300	1,155	1,336	1,690
≥ 19 yrs	1,950		2,300	1,704	1,999	2,555
All ages 2+ yrs	4,266			1,716	1,981	2,482

						Excessive Usual Intake (mg/d)	
Median	Mean	SE	75th	90th	95th	% > UL	SE
2,144	2,201	19.3	2,557	2,977	3,251	90	2.2
2,736	2,796	16.0	3,199	3,664	3,966	93	1.8
3,212	3,280	16.9	3,739	4,282	4,644	94	1.7
3,531	3,693	23.6	4,371	5,288	5,929	90	1.4
3,699	3,816	23.7	4,514	5,360	5,931	92	1.3
3,582	3,734	22.9	4,446	5,366	5,995	90	1.2
3,122	3,234	20.4	3,825	4,563	5,062	83	1.5
2,574	2,651	19.0	3,100	3,648	4,016	65	1.8
3,346	3,493	12.1	4,163	5,037	5,635	86	0.7
3,268	3,409	8.7	4,044	4,879	5,454	88	0.6
2,132	2,193	36.9	2,554	2,987	3,271	89	3.8
2,743	2,811	30.8	3,217	3,702	4,021	93	3.0
3,234	3,307	34.3	3,770	4,326	4,702	94	2.8
3,605	3,806	49.8	4,522	5,557	6,301	90	2.4
3,822	3,943	36.2	4,610	5,438	6,000	95	1.7
3,675	3,830	34.0	4,559	5,504	6,148	91	1.7
3,213	3,316	27.8	3,912	4,627	5,096	86	2.1
2,612	2,692	22.4	3,138	3,688	4,058	67	2.2
3,401	3,549	16.9	4,221	5,097	5,694	87	1.0
3,324	3,478	14.1	4,130	5,002	5,603	88	0.8
2,355	2,404	39.1	2,784	3,209	3,482	95	3.9
2,834	2,874	26.6	3,250	3,661	3,926	96	3.1
3,228	3,282	29.2	3,759	4,287	4,628	93	3.7
3,341	3,479	37.2	4,149	4,996	5,562	86	2.8
3,423	3,550	45.1	4,204	5,023	5,570	89	3.7
3,365	3,499	44.4	4,168	5,024	5,612	86	3.0
2,757	2,862	39.4	3,402	4,082	4,542	71	3.3
2,310	2,362	42.4	2,738	3,166	3,443	51	5.1
3,131	3,271	24.9	3,915	4,756	5,331	81	1.8
3,107	3,231	15.6	3,829	4,595	5,116	85	1.3
1,969	2,018	31.7	2,359	2,749	3,003	83	4.4
2,607	2,672	28.5	3,073	3,542	3,844	90	3.3
3,175	3,230	30.2	3,708	4,248	4,608	92	3.2
3,377	3,486	35.6	4,084	4,823	5,320	90	3.0
3,478	3,581	47.4	4,338	5,191	5,744	86	2.6
3,503	3,620	43.5	4,256	5,040	5,564	91	2.8
2,662	2,831	50.6	3,420	4,280	4,899	65	3.0
2,152	2,236	55.9	2,683	3,234	3,607	42	4.4
3,291	3,425	27.4	4,149	5,018	5,597	83	1.6
3,135	3,264	16.8	3,903	4,708	5,249	86	1.2

continued

TABLE F-5 Continued

				Usual Intake Percentiles (mg/d)		
	n	AI	UL	5th	10th	25th
Other Race or Ethnicity						
2–3 yrs	63	1,000	1,500	1,550	1,676	1,903
4–8 yrs	106	1,200	1,900	1,745	1,914	2,229
9–13 yrs	109	1,500	2,200	2,073	2,262	2,610
14–18 yrs	105	1,500	2,300	1,381	1,735	2,429
19–30 yrs	106	1,500	2,300	2,598	2,853	3,316
31–50 yrs	143	1,500	2,300	1,710	2,000	2,562
51–70 yrs	94	1,300	2,300	2,108	2,331	2,744
> 70 yrs	33	1,200	2,300	—	—	—
≥ 19 yrs	376		2,300	1,941	2,212	2,717
All ages 2+ yrs	759			1,782	2,044	2,535

NOTE: AI = Adequate Intake; d = day; mg = milligram; *n* = unweighted sample size; SE = standard error; UL = Tolerable Upper Intake Level.
SOURCE: NHANES 2003–2006.

						Excessive Usual Intake (mg/d)	
Median	Mean	SE	75th	90th	95th	% > UL	SE
2,189	2,260	65.7	2,535	2,927	3,211	96	9.8
2,624	2,670	59.5	3,062	3,486	3,750	91	8.1
3,057	3,158	75.2	3,591	4,177	4,589	92	9.2
3,309	3,462	143.3	4,286	5,329	6,084	78	6.7
3,887	3,974	90.3	4,543	5,215	5,650	98	3.9
3,344	3,580	118.7	4,350	5,477	6,252	83	6.0
3,269	3,353	88.1	3,871	4,485	4,888	91	8.8
2,366	2,419	130.3	—	—	—	54	11.0
3,382	3,542	60.0	4,197	5,084	5,690	88	3.9
3,190	3,371	43.2	4,009	4,928	5,576	87	2.8

TABLE F-6 Usual Sodium (mg/d) Intake Distributions from Foods by Income Level for Persons 2 or More Years of Age

	Usual Intake Percentiles					
	n	AI	UL	5th	10th	25th
Poverty: ≤ 130%						
2–3 yrs	457	1,000	1,500	1,363	1,534	1,841
4–8 yrs	737	1,200	1,900	1,854	2,027	2,349
9–13 yrs	775	1,500	2,200	1,924	2,165	2,600
14–18 yrs	1,025	1,500	2,300	1,984	2,261	2,776
19–30 yrs	903	1,500	2,300	2,008	2,324	2,908
31–50 yrs	719	1,500	2,300	1,667	1,949	2,485
51–70 yrs	544	1,300	2,300	1,467	1,711	2,168
> 70 yrs	441	1,200	2,300	1,412	1,602	1,951
All ages 2+ yrs	5,601			1,677	1,938	2,430
Poverty: 131%–185%						
2–3 yrs	108	1,000	1,500	1,402	1,555	1,834
4–8 yrs	217	1,200	1,900	1,797	1,963	2,280
9–13 yrs	278	1,500	2,200	2,192	2,400	2,778
14–18 yrs	313	1,500	2,300	1,901	2,185	2,736
19–30 yrs	324	1,500	2,300	2,010	2,277	2,770
31–50 yrs	325	1,500	2,300	1,763	2,085	2,686
51–70 yrs	247	1,300	2,300	1,811	2,062	2,513
> 70 yrs	277	1,200	2,300	1,558	1,726	2,042
All ages 2+ yrs	2,089			1,769	2,019	2,487
Poverty: > 185%						
2–3 yrs	313	1,000	1,500	1,311	1,450	1,711
4–8 yrs	663	1,200	1,900	1,829	2,004	2,326
9–13 yrs	920	1,500	2,200	2,291	2,485	2,832
14–18 yrs	1,212	1,500	2,300	2,025	2,318	2,869
19–30 yrs	1,106	1,500	2,300	2,197	2,514	3,082
31–50 yrs	1,822	1,500	2,300	2,157	2,447	2,989
51–70 yrs	1,545	1,300	2,300	1,858	2,112	2,585
> 70 yrs	771	1,200	2,300	1,650	1,855	2,224
All ages 2+ yrs	8,352			1,933	2,202	2,707

NOTES: AI = Adequate Intake; d = day; mg = milligram; *n* = unweighted sample size; income level is defined as a percentage of the poverty line based on annual household income and household size; 130% is the income eligibility cutoff for the Supplemental Nutrition Assistance Program and 185% is the income eligibility cutoff for free- and reduced-price school meals and WIC; SE = standard error; UL = Tolerable Upper Intake Level; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children.
SOURCE: NHANES 2003–2006.

						Excessive Intake	
Median	Mean	SE	75th	90th	95th	% > UL	SE
2,219	2,285	29.8	2,655	3,114	3,428	91	3.0
2,756	2,807	23.5	3,211	3,655	3,934	94	2.7
3,143	3,239	32.7	3,772	4,433	4,880	89	2.9
3,450	3,610	36.9	4,271	5,164	5,779	89	2.4
3,657	3,814	42.7	4,547	5,509	6,168	90	2.4
3,201	3,393	48.1	4,083	5,072	5,776	81	2.9
2,764	2,896	44.1	3,476	4,245	4,776	70	3.1
2,397	2,474	35.3	2,908	3,434	3,793	56	3.0
3,079	3,244	15.5	3,873	4,755	5,376	84	1.1
2,181	2,225	53.0	2,568	2,953	3,200	92	6.4
2,689	2,733	42.3	3,136	3,555	3,820	92	6.0
3,247	3,317	46.1	3,774	4,319	4,687	95	4.8
3,477	3,651	72.0	4,376	5,341	5,997	87	5.7
3,387	3,469	54.4	4,078	4,767	5,209	89	4.9
3,476	3,649	74.6	4,434	5,450	6,124	85	4.0
3,074	3,186	61.8	3,731	4,444	4,943	83	5.3
2,453	2,532	41.1	2,935	3,438	3,775	59	4.7
3,098	3,231	22.9	3,832	4,616	5,147	85	1.9
2,048	2,109	31.5	2,440	2,847	3,117	88	4.0
2,733	2,796	25.7	3,197	3,669	3,979	93	2.7
3,254	3,297	21.8	3,715	4,162	4,447	97	2.2
3,588	3,761	36.5	4,454	5,408	6,083	90	1.9
3,781	3,895	35.1	4,579	5,415	5,983	94	1.6
3,692	3,832	27.9	4,520	5,393	5,984	93	1.4
3,191	3,302	25.7	3,897	4,633	5,126	85	1.9
2,676	2,746	26.9	3,190	3,722	4,080	71	2.7
3,362	3,498	12.2	4,135	4,963	5,532	90	0.7

TABLE F-7 Usual Sodium Intake Distributions from Foods Among Adults with Hypertension

	Usual Intake Percentiles (mg/d)					
	n	AI	UL	5th	10th	25th
All adults[a]						
19–30 yrs	78	1,500	2,300	3,641	3,869	4,272
31–50 yrs	569	1,500	2,300	2,015	2,303	2,849
51–70 yrs	1,386	1,300	2,300	1,790	2,034	2,486
> 70 yrs	1,127	1,200	2,300	1,479	1,679	2,049
All adults 19+ yrs	3,160		2,300	1,711	1,963	2,437
Males						
19–30 yrs	66	1,500	2,300	4,801	4,833	4,886
31–50 yrs	314	1,500	2,300	2,472	2,800	3,420
51–70 yrs	661	1,300	2,300	2,112	2,375	2,858
> 70 yrs	520	1,200	2,300	1,711	1,935	2,345
All males 19+ yrs	1,561		2,300	2,057	2,347	2,890
Females[a]						
19–30 yrs	11	1,500	2,300	3,059~	3,222~	3,498~
31–50 yrs	254	1,500	2,300	1,909	2,099	2,439
51–70 yrs	725	1,300	2,300	1,662	1,870	2,248
> 70 yrs	607	1,200	2,300	1,424	1,602	1,930
All females 19+ yrs	1,597		2,300	1,587	1,791	2,165

NOTES: AI = Adequate Intake; d = day; mg = milligram; *n* = unweighted sample size; hypertension is defined as a measurement of systolic blood pressure ≥ 140 mm Hg or diastolic blood pressure ≥ 90 mm Hg or current treatment with a prescription medication; SE = standard error; UL = Tolerable Upper Intake Level.

[a] Excludes pregnant and lactating females.

~ Unreliable due to small sample size.

SOURCE: NHANES 2003–2006.

Median	Mean	SE	75th	90th	95th	Excessive Usual Intake (mg/d) % > UL	SE
4,757	4,808	86.8	5,289	5,812	6,148	100	
3,581	3,734	51.4	4,459	5,375	5,980	90	3.0
3,064	3,179	26.4	3,746	4,469	4,961	82	2.1
2,519	2,589	22.5	3,053	3,591	3,941	62	2.0
3,064	3,215	19.5	3,827	4,661	5,237	80	1.3
4,947	4,947	11.1	5,007	5,063	5,096	100	
4,225	4,373	75.0	5,165	6,137	6,781	97	2.1
3,465	3,566	39.0	4,163	4,886	5,368	92	2.7
2,853	2,915	35.1	3,418	3,975	4,331	77	3.5
3,593	3,739	30.3	4,425	5,313	5,922	91	1.6
3,818~	3,845~	153.3	4,162~	4,501~	4,721~	100~	
2,860	2,917	42.4	3,337	3,813	4,118	82	8.4
2,744	2,838	30.8	3,328	3,928	4,329	73	2.8
2,340	2,395	26.5	2,800	3,259	3,554	52	2.6
2,642	2,731	20.0	3,199	3,783	4,177	68	1.9

TABLE F-8 Top 20 Sources of Sodium Intake Within Food Categories for Persons 2 or More Years of Age

Food Category	Food Item	Percentage of Sodium Contributed Within the Food Category
Mixed dishes = 44% of total daily sodium	Sandwiches (excl. burgers)	35.3
	Pizza with meat	12.2
	Hamburgers, cheeseburgers	8.5
	Mexican entrées	6.9
	Pasta dishes, Italian style	6.5
	Meat mixtures with red meat	3.7
	Rice dishes	3.4
	Macaroni and cheese	3.2
	Pizza (no meat)	3.1
	Meat mixtures with chicken or turkey	3.0
	Grain soups	3.0
	Vegetable mixtures (incl. soup)	2.9
	Other grain mixtures	2.8
	Meat soup	2.2
	Chili con carne	1.7
	Bean soup	0.8
	Meat mixtures with fish	0.7
	Tomato sauce and meat (no pasta)	0.2
Meat and meat alternates = 15.5% of total daily sodium	Chicken	25.0
	Cheese	15.3
	Eggs	12.1
	Bacon or sausage	10.6
	Beef	7.7
	Fish	6.4
	Cold cuts	5.0
	Pork	4.4
	Hot dogs	3.3
	Ham	3.3
	Shellfish	3.2
	Ground beef	2.2
	Turkey	0.8
	Lamb and misc. meats	0.8
	Organ meats	0.2

TABLE F-8 Continued

Food Category	Food Item	Percentage of Sodium Contributed Within the Food Category
Grains = 11.4% of total daily sodium	Bread	21.5
	Cold cereal	18.5
	Rice	10.9
	Pancakes, waffles, French toast	9.6
	Crackers	9.0
	Flour tortillas	6.3
	Biscuits, scones, croissants	5.8
	Hot cereal	4.2
	Bagels	4.2
	Cornbread	3.2
	Rolls	3.1
	Pasta	1.4
	Breakfast or granola bar	0.9
	English muffin	0.6
	Taco shells	0.5
	Corn tortillas	0.4
Vegetables = 9.3% of total daily sodium	Salad (greens)	30.0
	Cooked potatoes—not fried	16.7
	Cooked potatoes—fried	15.2
	Cooked tomatoes	9.2
	Cooked green beans	4.3
	Other cooked (low nutrients)	4.1
	Cooked corn	3.5
	Cooked mixed	2.8
	Vegetable juice	2.5
	Cooked broccoli	2.1
	Raw cabbage or coleslaw	2.1
	Other cooked (high nutrients)	1.5
	Other cooked dark green	1.4
	Other cooked deep yellow	1.0
	Cooked carrots	1.0
	Other fried	0.9
	Cooked peas	0.9
	Raw carrots	0.4
	Other raw (low nutrients)	0.3
	Other raw (high nutrients)	0.1

continued

TABLE F-8 Continued

Food Category	Food Item	Percentage of Sodium Contributed Within the Food Category
Sweets = 5.0% of total of total daily sodium	Cookies	22.0
	Cake or cupcakes	21.6
	Ice cream	10.5
	Pies or cobblers	9.3
	Doughnuts	7.8
	Candy	7.3
	Pastries	7.0
	Muffins	6.6
	Sweet rolls	3.8
	Pudding	3.3
	Jello	0.6
	Ices or popsicles	0.3
Condiments, oils, fats = 4.3% of total daily sodium	Catsup, mustard, relish, soy sauce	39.9
	Gravy	12.3
	Salad dressing	11.7
	Garnishes such as pickles or olives	10.6
	Margarine	7.4
	Butter	5.6
	Cream or sour cream	5.2
	Syrups or sweet toppings	2.7
	Cream cheese	2.0
	Other added fats or oil	1.3
	Mayonnaise	0.8
	Jelly	0.3
	Sugar	0.3
	Seasonings	0.1
	Other added oils	0.0
Salty snacks = 3.4% of total daily sodium	Corn-based salty snacks	32.1
	Popcorn	25.9
	Potato chips	23.0
	Pretzels or party mix	19.1
Milk = 2.9% of total daily sodium	Unflavored 2% milk	28.8
	Unflavored whole milk	19.2
	Unflavored skim milk	12.9
	Unflavored 1% milk	9.9
	Yogurt	5.8
	Flavored whole milk	5.4
	Flavored 2% milk	4.5
	Dry or evaporated milk	4.4
	Flavored milk—% not further specified	2.8
	Soymilk	2.1
	Flavored 1% milk	1.5
	Flavored skim milk	1.4
	Unflavored milk—% not further specified	1.3

TABLE F-8 Continued

Food Category	Food Item	Percentage of Sodium Contributed Within the Food Category
Beverages = 2.2% of total daily sodium	Non-carbonated sweetened drink	28.0
	Regular soda	25.2
	Sugar-free soda	12.8
	Coffee	11.7
	Beer	7.3
	Tea	6.7
	Liquor	6.6
	Wine	1.0
	Low-calorie or sugar-free drink	0.8
Beans, nuts, and seeds = 2.1% of total daily sodium	Baked or refried beans	37.6
	Nuts	18.7
	Beans	16.8
	Protein or meal enhancement	12.4
	Peanut or almond butter	6.9
	Soy products	5.9
	Seeds	1.8
Fruit = 0.1% of total daily sodium	Citrus juice	25.8
	Non-citrus juice	24.5
	Avocado or guacamole	13.8
	Fresh melon	12.4
	Other fresh fruit	4.5
	Other canned or frozen	3.2
	Fresh banana	3.0
	Fresh apple	2.6
	Fresh grapes	2.2
	Canned or frozen peaches	1.9
	Dried fruit	1.5
	Applesauce, canned or frozen apples	1.3
	Fresh watermelon	1.2
	Fresh berries	0.9
	Fresh pear	0.6
	Fresh other citrus	0.3
	Canned or frozen pineapple	0.2
	Lemon or lime—any form	0.0

SOURCE: NHANES 2003–2006.

TABLE F-9 Top 10 Food Sources of Sodium Intake by Age or Gender for Persons 2 or More Years of Age

Age or Gender Group	Food Source	Percentage of Sodium Contributed
Ages 2–3 yrs (males and females)	Sandwiches (excl. burgers)	11.6
	Pasta dishes, Italian style	5.9
	Cheese	4.3
	Cold cereal	4.2
	Chicken	4.0
	Hot dogs	3.6
	Macaroni and cheese	3.2
	Pizza with meat	3.0
	Unflavored whole milk	2.9
	Unflavored 2% milk	2.5
	Sum	*45.1*
Ages 4–8 yrs (males and females)	Sandwiches (excl. burgers)	11.7
	Chicken	5.9
	Pizza with meat	5.7
	Cold cereal	4.7
	Pasta dishes, Italian style	3.9
	Macaroni and cheese	3.5
	Hamburgers, cheeseburgers	3.2
	Cheese	3.1
	Pizza (no meat)	2.5
	Pancakes, waffles, French toast	2.2
	Sum	*46.3*
Males 9–13 yrs	Sandwiches (excl. burgers)	16.3
	Pizza with meat	7.3
	Hamburgers/cheeseburgers	4.8
	Mexican entrées	4.5
	Chicken	4.1
	Pasta dishes, Italian style	3.9
	Cold cereal	3.2
	Cheese	2.5
	Pizza (no meat)	2.3
	Grain soups	2.1
	Sum	*51.1*
Females 9–13 yrs	Sandwiches (excl. burgers)	15.2
	Pizza with meat	5.9
	Chicken	4.7
	Pasta dishes, Italian style	4.5
	Hamburgers, cheeseburgers	3.2
	Mexican entrées	3.1
	Cold cereal	2.7
	Cheese	2.5
	Macaroni and cheese	2.3
	Grain soups	2.2
	Sum	*46.3*

TABLE F-9 Continued

Age or Gender Group	Food Source	Percentage of Sodium Contributed
Males 14–18 yrs	Sandwiches (excl. burgers)	18.0
	Pizza with meat	10.9
	Hamburgers, cheeseburgers	7.0
	Chicken	4.9
	Mexican entrées	2.9
	Cold cereal	2.7
	Pizza (no meat)	2.5
	Pasta dishes, Italian style	2.5
	Catsup, mustard, relish, etc.	2.4
	Cooked potatoes—fried	1.9
	Sum	*55.7*
Females 14–18 yrs	Sandwiches (excl. burgers)	17.7
	Pizza with meat	8.0
	Chicken	4.5
	Hamburgers, cheeseburgers	4.4
	Mexican entrées	4.0
	Salad (greens)	3.4
	Cold cereal	2.7
	Pasta dishes, Italian style	2.6
	Cheese	2.5
	Macaroni and cheese	2.3
	Sum	*52.2*
Males 19–30 yrs	Sandwiches (excl. burgers)	17.3
	Pizza with meat	8.7
	Mexican entrées	5.7
	Hamburgers, cheeseburgers	4.9
	Chicken	3.7
	Pasta dishes, Italian style	2.9
	Catsup, mustard, relish, etc.	2.3
	Salad (greens)	2.1
	Cheese	2.0
	Rice dishes	1.9
	Sum	*51.6*
Females 19–30 yrs	Sandwiches (excl. burgers)	14.6
	Pizza with meat	4.7
	Mexican entrées	4.6
	Chicken	4.5
	Salad (greens)	3.9
	Hamburgers, cheeseburgers	3.8
	Pasta dishes, Italian style	3.1
	Cheese	2.9
	Bread	2.5
	Rice dishes	2.2
	Sum	*46.6*

continued

TABLE F-9 Continued

Age or Gender Group	Food Source	Percentage of Sodium Contributed
Males 31–50 yrs	Sandwiches (excl. burgers)	16.1
	Pizza with meat	6.1
	Hamburgers, cheeseburgers	4.2
	Chicken	3.7
	Mexican entrées	3.5
	Salad (greens)	2.7
	Pasta dishes, Italian style	2.7
	Bread	2.3
	Eggs	2.1
	Bacon or sausage	2.0
	Sum	*45.3*
Females 31–50 yrs	Sandwiches (excl. burgers)	14.7
	Salad (greens)	4.3
	Chicken	4.2
	Pizza with meat	4.0
	Hamburgers, cheeseburgers	3.2
	Mexican entrées	3.2
	Pasta dishes, Italian style	2.3
	Cheese	2.1
	Bread	2.0
	Vegetable mixtures (incl. soup)	2.0
	Sum	*41.9*
Males 51–70 yrs	Sandwiches (excl. burgers)	17.8
	Pizza with meat	3.6
	Hamburgers, cheeseburgers	3.2
	Bread	3.0
	Chicken	3.0
	Salad (greens)	2.9
	Bacon/sausage	2.5
	Eggs	2.4
	Pasta dishes, Italian style	2.4
	Cooked potatoes—not fried	2.3
	Sum	*43.0*
Females 51–70 yrs	Sandwiches (excl. burgers)	11.9
	Salad (greens)	4.5
	Bread	3.6
	Pasta dishes, Italian style	3.4
	Cheese	3.3
	Chicken	3.1
	Eggs	2.6
	Pizza with meat	2.5
	Vegetable mixtures (incl. soup)	2.4
	Hamburgers, cheeseburgers	2.4
	Sum	*39.7*

TABLE F-9 Continued

Age or Gender Group	Food Source	Percentage of Sodium Contributed
Males > 70 yrs	Sandwiches (excl. burgers)	17.5
	Bread	4.2
	Vegetable mixtures (incl. soup)	3.3
	Cold cereal	3.2
	Cooked potatoes—not fried	2.9
	Eggs	2.8
	Chicken	2.6
	Pasta dishes, Italian style	2.4
	Bacon or sausage	2.3
	Salad (greens)	2.3
	Sum	*43.7*
Females > 70 yrs	Sandwiches (excl. burgers)	15.4
	Bread	4.3
	Salad (greens)	3.5
	Cooked potatoes—not fried	3.3
	Vegetable mixtures (incl. soup)	3.1
	Cold cereal	2.9
	Meat mixtures with red meat	2.7
	Meat soup	2.4
	Chicken	2.3
	Cheese	2.1
	Sum	*41.8*
Pregnant and lactating females	Sandwiches (excl. burgers)	12.6
	Pizza with meat	5.1
	Salad (greens)	3.7
	Cheese	3.7
	Hamburgers, cheeseburgers	3.6
	Chicken	3.6
	Mexican entrées	3.2
	Macaroni and cheese	2.9
	Cold cereal	2.8
	Eggs	2.6
	Sum	*43.6*

SOURCE: NHANES 2003–2006.

TABLE F-10 Top 10 Sources of Sodium Intake by Home Versus Away for Persons 2 or More Years of Age

Location	Food Item	Percentage of Sodium Contributed
Store (home)	Sandwiches (excl. burgers)	16.0
	Pasta dishes, Italian style	3.8
	Cold cereal	3.3
	Bread	3.0
	Cheese	3.0
	Chicken	2.4
	Pizza with meat	2.3
	Salad (greens)	2.3
	Bacon or sausage	2.1
	Eggs	2.0
	Sum	*40.2*
Restaurant, cafeteria, dining facility	Sandwiches (excl. burgers)	15.3
	Pizza with meat	12.0
	Hamburgers, cheeseburgers	8.7
	Chicken	6.9
	Mexican entrées	6.7
	Salad (greens)	3.9
	Cooked potatoes—fried	3.2
	Pizza (no meat)	3.1
	Catsup, mustard, relish, etc.	2.9
	Rice dishes	2.3
	Sum	*65.0*
Other	Sandwiches (excl. burgers)	12.4
	Cake or cupcakes	4.3
	Chicken	2.8
	Fish	2.7
	Cooked potatoes—not fried	2.7
	Hamburgers/cheeseburgers	2.7
	Pasta dishes, Italian style	2.7
	Mexican entrées	2.6
	Other grain mixtures	2.5
	Cheese	2.5
	Sum	*37.8*

SOURCE: NHANES 2003–2006.

Appendix G

National Salt Reduction Initiative Coordinated by the New York City Health Department[1]

In 2008, a national partnership of city and state health departments and public health organizations responded to the need for population sodium intake reduction by convening food industry leaders to introduce a framework for voluntary reductions in food sodium content. The National Salt Reduction Initiative (NSRI), which includes the American Medical Association (AMA), American Heart Association (AHA), American Public Health Association (APHA), along with 45 national health organizations, cities, and states, is intended to promote gradual, achievable, substantive, and measurable reductions in the sodium content of packaged and restaurant foods. The NSRI goal is to reduce population sodium intake by 20 percent over 5 years, which would require an approximate 25 percent reduction in the sodium content of packaged and restaurant foods. The New York City (NYC) Health Department was instrumental in initiating the activities that have resulted in the NSRI.

Based upon the United Kingdom (UK) Salt Reduction Campaign model,[2] the NSRI sets targets by individual food category. The program intends the targets to be voluntary, substantive, achievable, gradual, and measurable. The framework includes meetings with major manufacturers and restaurant chains to discuss proposed targets by category, and a strategic plan for ongoing monitoring and evaluation to assess progress toward the targets. Throughout 2009, food category meetings were convened to

[1] This appendix was submitted by the New York City Department of Health and Mental Hygiene.

[2] Available online: http://www.food.gov.uk/healthiereating/salt/ (accessed April 5, 2010).

discuss proposed targets and get industry feedback. Based upon these consultations, proposed targets were developed and publicly released for final technical comment in early January 2010. Final targets were announced in Spring 2010.

APPROACH

The NSRI is conducting parallel sodium reduction approaches for packaged food and for restaurant food. The two are similar in terms of time line, metrics, reporting structure, and monitoring. However, differences in patterns of consumption and data sources require unique food categories and target setting approaches. In each case, the steps include defining and establishing food categories, proposing targets, reviewing industry feedback, announcing 2012 and 2014 targets, assessing progress toward food targets, and measuring changes in population sodium intake over time. Two unique databases were created to support this initiative, one specific to packaged food and a second tailored to restaurant food.

Packaged Food

Packaged Food Database

When the NSRI launched, no comprehensive national database existed that linked individual packaged food sales and nutrition information by Universal Product Code (UPC). To create this database, the NYC Health Department purchased sales data from the Nielsen Company (Nielsen), a market research company that aggregates packaged food sales data from major U.S. retailers. The time period for baseline sales data is the 52 weeks ending December 31, 2008; over 240 Nielsen categories were purchased. Nielsen sales and Guiding Stars Licensing Company nutrition data tables were merged by UPC. Product manufacturers' publicly available nutrition information was used to complete and verify nutrition data. Because sales data for private label products is included in Nielsen, private label market share could be determined; however, nutrition data for private label products could not be linked to Nielsen sales data. Private label sodium information was collected separately for comparison to the category mean and range. A recognized limitation of the database is that it does not include food sold to the foodservice market or retailers that do not submit data to Nielsen.

Packaged Food Categories

As demonstrated by the UK initiative, individual food categories must be sufficiently refined to assure that included products are similar with respect to sodium content in terms of functional requirements and food safety and with respect to the potential for reduction. In addition, categories should allow for feasible tracking and monitoring of reductions based on data availability.

In order to establish proposed food categories for packaged foods, the Health Department first compared those created by the UK Salt Reduction Campaign with Food and Drug Administration (FDA) categories defined for Reference Amounts Customarily Consumed (RACC)[3] and U.S. Department of Agriculture (USDA) food categories (Table G-1), and then reviewed Nielsen categories and categories defined by Information Resources, Inc. (IRI), another market research firm.

The NSRI Packaged Food Database was used to identify items that were outliers in sodium content within each proposed food category. These outliers were more closely assessed to consider category fit. A total of 46 potential food categories were initially proposed. Industry feedback was then solicited through conference calls, written requests, and food category meetings conducted in person, with an option for industry to participate by remote access. Based upon industry comments, changes included the elimination or addition of categories and the movement of select products between categories. Currently, there are more than 60 food categories, with limited further category refinement expected as the process comes to a conclusion.

Packaged Food Targets

Proposed targets by food category were developed first by analysis of the NSRI Packaged Food Database. In response to industry feedback, the metric sodium mg per 100 g of food is used as the unit for reported analysis, setting targets, and monitoring. This metric was preferred over sodium mg per serving size because serving size may vary within a range according to FDA and USDA regulations, preventing accurate comparisons across products.

In order to assess each food category and to set targets that would take into account differences in individual product sales—and therefore differences in contribution to population intake—the sales-weighted mean was calculated. A sales-weighted mean is calculated by weighting each product based on its relative sales before calculating the mean. The sales-weighted mean sodium is based on all branded products with available nutrition information in the top 80 percent of sales of each food category.

Additional summary statistics including the distribution and range of

[3] Available online: http://ecfr.gpoaccess.gov/cgi/t/text/text-idx?c=ecfr&sid=8c5344f04a8ae103e5b0ff5a17c7fa97&rgn=div8&view=text&node=21:2.0.1.1.2.1.1.8&idno=21 (accessed February 24, 2010).

TABLE G-1 Example of Aligning a Proposed Food Category

NSRI Proposed Food Category	FDA Product Category	UK Category
Vegetables	Vegetables	Canned vegetables
11.1 Frozen vegetables	All other vegetables with sauce: fresh, canned, or frozen	No corresponding UK category
11.2 Canned vegetables	All other vegetables without sauce: fresh, canned, or frozen (vacuum packed or canned in liquid)	24.1 Canned vegetables
11.3 Canned whole tomatoes	All other vegetables without sauce: fresh, canned, or frozen (vacuum packed or canned in liquid)	24.1 Canned vegetables
11.4 Diced, crushed, and stewed tomatoes	All other vegetables without sauce: fresh, canned, or frozen (vacuum packed or canned in liquid)	24.1 Canned vegetables
11.5 Vegetable Juice	Vegetable juice	No corresponding UK category

sodium content and the sales-weighted mean by manufacturer were calculated by category (Figures G-1 and G-2). This allowed for the identification of products in each category that were very low or high in sodium per 100 g. These products were carefully considered to better understand the potential opportunities and limitations of salt reduction in each category, and to understand individual manufacturer's products.

Using the sales-weighted mean sodium (mg/100 g) as a starting point, a 25 percent reduction was calculated to estimate an initial 2014 target. Adjustments were made based on comparisons to UK targets; examples of substantial sodium reductions achieved in the United Kingdom and United States; assessment of the range of standard products (e.g., the range of sodium per 100 grams of tomato soup or cornflakes produced by major manufacturers); and an examination of documented technical challenges including food safety and technical requirements. Based upon adjustments to the proposed 5-year 2014 target, an interim target was proposed for 2012. For a company to meet the category target, calculations will be based on the sales-weighted mean of all of a company's products in that category.

Once calculations were complete, the NSRI convened food category meetings to share the category analysis, discuss proposed targets, and get industry feedback on technical challenges and opportunities specific to the category. Invited meeting participants included food category manufacturers, private label manufacturers, retailers, industry trade associations, and food service establishments. Meetings were conducted in person

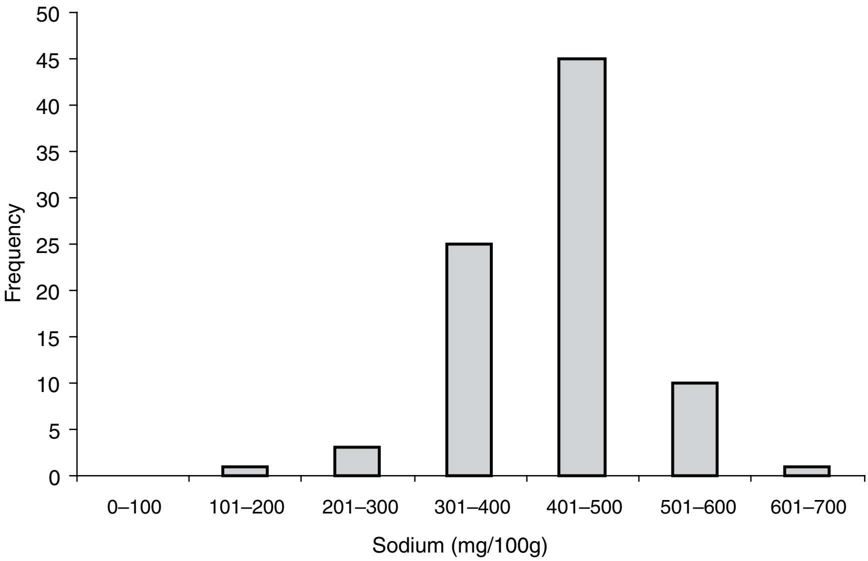

FIGURE G-1 Example: Sodium distribution and proposed targets in a category (sodium mg/100 g).
NOTE: Sales data exclude retailers that do not submit to Nielsen and food sold to foodservice; nutrition data from private label not included. Data based on products that represent top sellers of U.S. market. g = gram; mg = milligram.

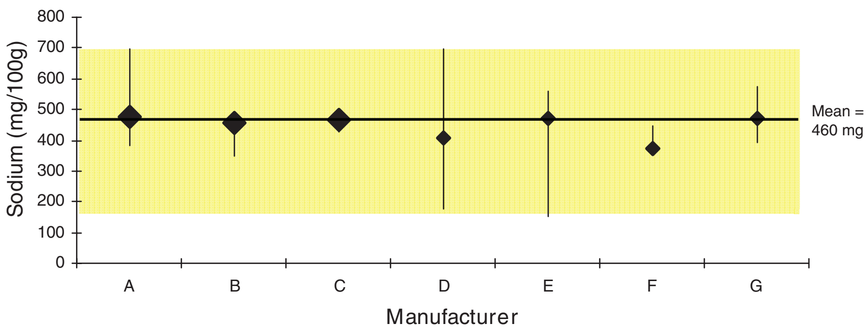

FIGURE G-2 Example: Sales-weighted mean sodium and range in category by manufacturer (sodium mg/100 g).
NOTE: Sales data exclude retailers that do not submit to Nielsen and food sold to foodservice; nutrition data from private label not included. Data based on products that represent top sellers of U.S. market. Large diamonds represent the sales-weighted mean of manufacturers that have at least 10 percent of the category market share. g = gram; mg = milligram.

with Internet-based conferencing available to accommodate those unable to attend. Industry attendees included more than 50 manufacturers and food service companies, 12 trade associations, and 2 food retailers. At these meetings, data charts were reviewed, including those that illustrate sales-weighted means and ranges by individual company (Figures G-1 and G-2). Further discussions with individual manufacturers followed the group meetings by phone, Internet-based conferencing, and email as requested. The opportunity to submit written feedback addressed concerns expressed by some industry participants about sharing sensitive data in group meetings.

Adjustments to the proposed targets have been made based on meeting feedback and the receipt of written documentation, with supporting data, from industry.

Restaurant Food

The restaurant portion of the initiative was launched in February 2009 at a private meeting with representatives from 14 food service companies, restaurant chains, and trade associations.

Restaurant Food Database

The basis of the NSRI Restaurant Food Database is publicly available nutrition data for all restaurants that are in the 2009 QSR 50,[4] a ranking of quick-service restaurants based on 2008 sales, and 2008 NPD Crest market share data. Forty-seven of the QSR 50 chains had at least some nutrition and serving weight data available; baseline nutrition data uses publicly available information from early 2009.

Restaurant/Food Service Categories

The first step to define restaurant categories was to identify key food categories that contribute to U.S. population sodium intake. An NYC Health Department food purchase receipt study and National Health and Nutrition Examination Survey (NHANES) analysis of 24-hour dietary intake data provided support for the identification of 25 menu item categories that are key contributors to sodium intake (Bassett et al., 2007).

Categories were defined to correspond to menu categories and items within categories were further reviewed to assess comparability with respect

[4] Available online: http://www.qsrmagazine.com/reports/qsr50/2009/charts/09rank.phtml (accessed August 3, 2009).

TABLE G-2 Example of Restaurant Key Food Categories for Hamburgers

Main NSRI Restaurant Food Category	Restaurant Key Food Category	Restaurant Key Food Category Description
Hamburgers	Hamburgers	Plain ground beef burgers and ground beef burgers with toppings other than cheese. Excludes turkey burgers, veggie burgers, and any ground beef burger with cheese.
	Cheeseburgers	Ground beef cheeseburgers and ground beef cheeseburgers with toppings. Excludes turkey burgers, veggie burgers, and any ground beef burger without cheese.

to sodium levels (Table G-2). As with packaged foods, once proposed key food categories were developed by NSRI, they were reviewed and modified based upon conference call discussions and meetings with restaurant chains, food service companies, and restaurant trade associations.

Restaurant/Food Service Targets

Proposed targets by food category were developed first by analysis of the NSRI Restaurant Food Database. Market share-weighted mean sodium content (mg/100 g) was calculated for each category.

Proposed key food category targets were set based on a percentage reduction from the mean. Initial 2012 and 2014 targets corresponded to a reduction of 10 percent and an additional reduction of 15 percent from the baseline sodium content. During individual meetings with restaurants, proposed targets for each key food category and a proposed maximum were discussed. Further adjustments were made to proposed targets following discussions at the meetings and receipt of written documentation with supporting data from industry.

Companies are encouraged to submit blinded sales information, so that the company's category mean is weighted by sales. In addition to a category-specific sodium target, an overall maximum for sodium content as served is proposed for any item for 2012 and 2014. For a restaurant to meet category-specific targets, either the mean sodium or the sales-weighted mean sodium of the restaurant's products in that category must be at or below the target. For a company to comply with a maximum, the sodium content of all individual items served must be below the defined threshold.

NEXT STEPS, MONITORING AND EVALUATION

All packaged food and restaurant category meetings were completed by the end of 2009. Proposed targets were publicly released in January 2010. Final targets were made public in Spring 2010. Final targets and industry commitments for 2012 and 2014 are available on the Health Department website.[5]

NSRI progress will be assessed through monitoring changes in the sodium content of food by category and through assessment of changes in population sodium intake. In 2012 and 2014, the NSRI will assess progress toward 2012 and 2014 food category targets, utilizing updated NSRI Packaged Food and Restaurant Food databases. To assure that the most recent reformulation achievements are captured, industry will also be asked to provide nutrition and unit sales data for target years, although analysis will not rely upon industry provision of this information.

In 2010, the NYC Health Department will conduct a 24-hour urinary sodium evaluation on a representative sample of NYC residents to assess current NYC population sodium intake. Plans are to repeat this study in 2014 for analysis of change in population sodium intake.

PARTICIPATING ORGANIZATIONS

As of February 2010, the undersigned agencies and organizations have expressed commitment to the NSRI and have agreed to work toward the goal of reducing population salt intake by at least 20 percent during the next 5 years by setting targets and monitoring progress through a transparent, public process.

Alaska Department of Health and Social Services
American College of Cardiology
American College of Epidemiology
American Heart Association
American Medical Association
American Public Health Association
American Society of Hypertension
Arizona Department of Health Services
Association of Black Cardiologists
Association of State and Territorial Health Officials
Baltimore City Health Department
Boston Public Health Commission
California Department of Public Health

[5] Available online: http://www.nyc.gov/health/salt (accessed March 3, 2010).

Chicago Department of Public Health
Consumers Union
Council of State and Territorial Epidemiologists
Delaware Department of Health and Social Services, Division of Public Health
District of Columbia Department of Health
InterAmerican Heart Foundation
International Society of Hypertension in Blacks
Joint Policy Committee, Societies of Epidemiology
Los Angeles County Department of Public Health
Maine Center for Disease Control and Prevention
Maryland Department of Health and Mental Hygiene
Massachusetts Department of Public Health
Michigan Department of Community Health
National Association of Chronic Disease Directors
National Association of County and City Health Officials
National Hispanic Medical Association
National Kidney Foundation
New York City Department of Health and Mental Hygiene
New York State Chapter, American College of Cardiology
New York State Department of Agriculture and Markets
New York State Department of Health
North Carolina Department of Health and Human Services, Division of Public Health
Northern Illinois Public Health Consortium
Oregon Department of Health and Human Services, Division of Public Health
Pennsylvania Department of Health
Philadelphia Department of Public Health
Preventive Cardiovascular Nurses Association
Public Health, Seattle and King County
Society for the Analysis of African-American Public Health Issues
Tennessee Department of Health
Washington State Department of Health
West Virginia Department of Health and Human Services, Bureau of Public Health
World Hypertension League

REFERENCE

Bassett, M. T., T. Dumanovsky, C. Huang, L. D. Silver, C. Young, C. Nonas, T. D. Matte, S. Chideya, and T. R. Frieden. 2008. Purchasing behavior and calorie information at fast-food chains in New York City, 2007. *American Journal of Public Health* 98(8): 1457-1459.

Appendix H

Federal Rulemaking Process[1]

INTRODUCTION

Federal regulation, like taxing and spending, is one of the basic tools of government used to implement public policy. In fact, the development and framing of a rule has been described as "the climactic act of the policy making process" (Driver, 1989). Another observer described the rulemaking process as "absolutely central to the definition and implementation of public policy in the United States," and said that "no significant attempt to alter the direction of a public program can succeed without effective management of the rulemaking process" (Kerwin, 1999). Regulations generally start with an act of Congress, and are the means by which statutes are implemented and specific requirements are established. Federal agencies issue more than 4,000 final rules each year on topics ranging from the timing of bridge openings to the permissible levels of arsenic and other contaminants in drinking water. The costs and benefits associated with all federal regulations have been a subject of great controversy, with the costs estimated in the hundreds of billions of dollars and the benefits estimates even higher. The costs federal regulations impose on regulated entities to accomplish policy goals are not reflected in the federal budget process, and some view these off-budget regulatory costs as greater than all federal domestic discretionary spending. Estimates of the benefits of federal regulations are even higher.

[1] This appendix and Figure H-1 are reprinted from Copeland, C. 2008. *The federal rulemaking process: An overview.* RL32240. Washington, DC: Congressional Research Service.

The terms "rule" or "regulation" are often used interchangeably in discussions of the federal regulatory process. The Administrative Procedure Act (APA) of 1946 defines a rule as "the whole or part of an agency statement of general or particular applicability and future effect designed to implement, interpret, or prescribe law or policy."[2] The process by which federal agencies develop, amend, or repeal rules is called "rulemaking," and is the subject of this report.

Figure H-1 illustrates in a general manner the process that most federal agencies are generally required to follow in writing or revising a significant rule. However, we should be quick to point out that some aspects of Figure H-1 do not apply to all rulemaking. For example, as discussed later in this report, an agency may, in certain circumstances, issue a final rule without issuing a notice of proposed rulemaking, thereby skipping several steps depicted in the figure. On the other hand, some rules may be published for public comment more than once. Also, independent regulatory agencies[3] are not required to submit their rules to the Office of Management and Budget's (OMB) Office of Information and Regulatory Affairs (OIRA) for review, and no agency is required to do so for rules that are not "significant."

Note at the top of Figure H-1 that the rulemaking process begins when Congress passes a statute either requiring or authorizing an agency to write and issue certain types of regulations. An initiating event (e.g., a recommendation from an outside body or a catastrophic accident) can prompt either legislation or regulation (where regulatory action has already been authorized). For example, in response to lethal chemical releases by plants in Bhopal, India, and West Virginia, Congress enacted section 313 of the Emergency Planning and Community Right-to-Know Act of 1986 (42 USC §§ 11001-11050, 11023). The act required the owners and operators of certain types of facilities to report the amounts of various toxic chemicals that the facilities release to the environment above certain thresholds, and requires the Environmental Protection Agency (EPA) to make this information available to the public. EPA subsequently issued detailed regulations implementing these requirements and, using the authority provided to it through the statute, has required reporting for more than 300 toxic substances in addition to those delineated in the law.

As this example illustrates, the authority to regulate rests with Congress, and is delegated, through law, to an agency. The statutory basis for

[2] 5 USC § 551(4).

[3] As used in this report, the term "independent regulatory agencies" refers to the boards and commissions identified as such in the Paperwork Reduction Act (44 USC § 3502(5)), including the Federal Communications Commission, the Federal Energy Regulatory Commission, the Nuclear Regulatory Commission, and the Securities and Exchange Commission. The term "independent agencies" refers to other agencies that answer directly to the President, but are not part of Cabinet departments.

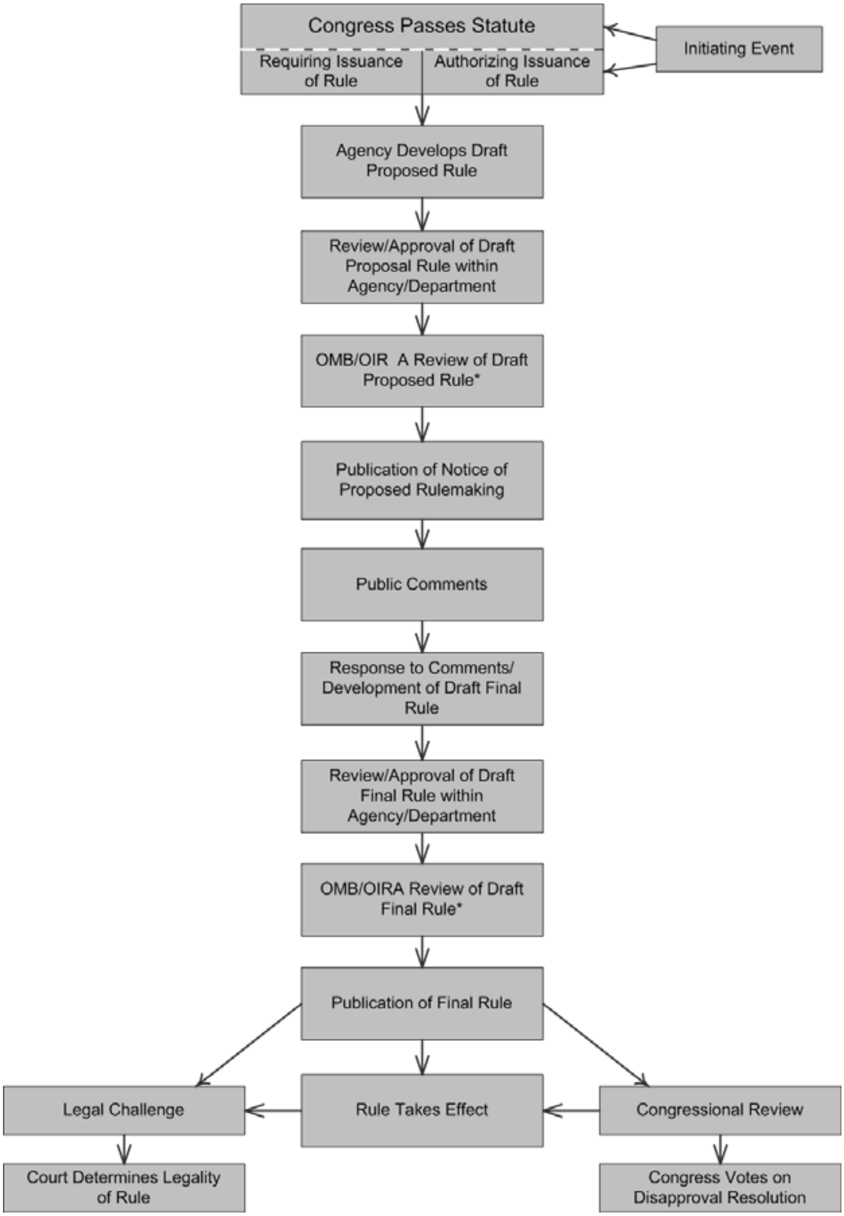

FIGURE H-1 The federal rulemaking process.
* = The Office of Management and Budget's (OMB) Office of Information and Regulatory Affairs (OIRA) reviews only significant rules and does not review any rules submitted by independent regulatory agencies.

a regulation can vary greatly in terms of its specificity, from (1) very broad grants of authority that state only the general intent of the legislation and leave agencies with a great deal of discretion as to how that intent should be implemented, to (2) very specific requirements delineating exactly what regulatory agencies should do and how they should take action. Note also in Figure H-1 the roles that Congress and the courts can play at the end of the rulemaking process, which may result in a rule being returned to an earlier point in the process or being vacated by the reviewing body. Congress may also play a role at other stages in the process through its oversight and appropriations responsibilities.

Implicit within the steps depicted in Figure H-1 is an elaborate set of procedures and requirements that Congress and various Presidents have developed during the past 60 to 65 years to guide the federal rulemaking process. Some of these rulemaking requirements apply to virtually all federal agencies, some apply only to certain types of agencies, and others are agency-specific. Collectively, these rulemaking provisions are voluminous and require a wide range of procedural, consultative, and analytical actions on the part of rulemaking agencies. Some observers contend that the requirements have resulted in the "ossification" of the rulemaking process, causing agencies to take years to develop final rules (McGarity, 1992; Pierce, Jr., 1995; Verkuil, 1995). For example, the National Advisory Committee on Occupational Safety and Health noted that it takes the Occupational Safety and Health Administration (OSHA) within the Department of Labor an average of 10 years to develop and promulgate a health or safety standard (National Advisory Committee on Occupational Safety and Health, 2000). On the other hand, while these congressional and presidential rulemaking requirements are numerous, it is not clear whether they or some other factors (e.g., lack of data, congressionally imposed delays, court challenges, etc.) are the primary cause of the long timeframes that are sometimes required to develop and publish final rules.

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Appendix I

Nutrition Facts Panel

Nutrition Facts

Serving Size 1 cup (228g)
Servings Per Container 2

Amount Per Serving

Calories 260	Calories from Fat 120
	% Daily Value*
Total Fat 13g	**20**%
Saturated Fat 5g	**25**%
Trans Fat 2g	
Cholesterol 30mg	**10**%
Sodium 660mg	**28**%
Total Carbohydrate 31g	**10**%
Dietary Fiber 0g	**0**%
Sugars 5g	
Protein 5g	

Vitamin A 4%	•	Vitamin C 2%
Calcium 15%	•	Iron 4%

* Percent Daily Values are based on a 2,000 calorie diet. Your Daily Values may be higher or lower depending on your calorie needs:

	Calories:	2,000	2,500
Total Fat	Less than	65g	80g
Sat Fat	Less than	20g	25g
Cholesterol	Less than	300mg	300mg
Sodium	Less than	2,400mg	2,400mg
Total Carbohydrate		300g	375g
Dietary Fiber		25g	30g

Calories per gram:
Fat 9 • Carbohydrate 4 • Protein 4

FIGURE I-1 Example of a Nutrition Facts panel.

Appendix J

State and Local Sodium Labeling Initiatives[1]

The *Patient Protection and Affordable Care Act*,[2] signed into law in March 2010, amends the *Federal Food, Drug, and Cosmetic Act* to require chain restaurants to provide access to nutrition information for standard menu items. Restaurants with 20 or more outlets are required to post calories on menus, menu boards (including drive-thrus) and food display tags, with additional information (fat, saturated fat, carbohydrates, sodium, protein, and fiber) available in writing upon request. This imposes national uniformity, ensuring consistency in information provided. Before passage of the *Patient Protection and Affordable Care Act*, some states and localities considered or passed into law proposals to provide customers with sodium information at the point of purchase. Examples of these activities are summarized in this Appendix.

IMPLEMENTED

King County (Seattle), Washington

- Requires chain restaurants with 15 or more outlets nationwide and $1 million in annual sales (collectively for the chain) to display

[1] Compiled and adapted from the Center for Science in the Public Interest's summary of 2009–2010 activities, available online: http://cspinet.org/new/pdf/ml_bill_summaries_09.pdf (accessed April 1, 2010).

[2] *Patient Protection and Affordable Care Act*, HR 3590, Title IV, Subtitle C, §4205; 111th Congress, 2nd session, March 2010.

calorie, saturated fat, **sodium**, and carbohydrate information for foods and beverages on menus (or approved methods at the point of ordering). If the restaurant uses a menu board, calories must be posted on the board, and other nutrition information (including **sodium**) must be provided in a plainly visible format at the point of ordering.

- Exemptions are provided for items on the menu for less than 90 days; unopened, prepackaged foods; foods in salad bars, buffet lines, cafeteria service, and other self-serve arrangements; and food served by weight or custom-ordered quantity. Grocery and convenience stores are also exempt.
- Required nutrition disclosure at fast food and other chain restaurants as of December 31, 2008. Labeling regulations for drive-through menu boards went into effect August 1, 2009.

Philadelphia

- Requires that calories, saturated fat, *trans* fat, **sodium**, and carbohydrates be displayed on menus and calories on menu boards and food tags in restaurants with 15 or more outlets nationwide. If a restaurant serves food in wrappers or boxes, it must display the nutrition information on the wrapper or box in a clear and conspicuous manner.
- The menu board provisions of the law went into effect on February 1, 2010, and the menu labeling requirement went into effect April 1, 2010.

PASSED INTO LAW

State of California

- Requires caloric content to be provided for standard menu items on menus, menu boards, and food display tags at chain restaurants with 20 or more outlets in California, and nutrition information to be provided in a brochure placed at point of sale.
- Implementation would be carried out in two phases:
    - Phase 1 (July 2009 to December 2010)—Restaurants must provide a brochure placed at the point of sale that includes at least calories, **sodium**, saturated fat, and carbohydrate information per menu item. For sit-down restaurants, the information must be provided at the table. Drive-thrus are required to have the brochures available upon request and to have a notice of the availability at the point of sale.

  - Phase 2 (would go into effect January 1, 2011)—Calories must be listed on menus, menu boards, and food display tags next to the menu item. Drive-thrus shall continue to have a brochure available upon request and must have a notice that the information is available.
- *Note:* San Mateo County, San Francisco City and County, and Santa Clara County had menu labeling ordinances that included **sodium**, but they were superseded by passage of the statewide legislation.

Montgomery County, Maryland

- Requires chain restaurants with 20 or more outlets nationwide to display calories on menus and menu boards, including drive-thrus, for standard menu items (on the menu for at least 60 days per year). Additional nutrition information (including total fat, saturated fat, **sodium**, fiber, and sugars) will be provided in writing on the premises upon request.
- The menu labeling requirement was planned to go into effect July 1, 2010.

Oregon

- Requires chain restaurants with 15 or more outlets nationwide to visibly post calorie information at the point of purchase for all regular menu items. The policy would require these restaurants to post the number of calories of each regular item in plain view on all of their menus, menu boards, and food tags; restaurants also were required to provide information about each regular menu item's **sodium**, saturated fat, *trans* fat, and carbohydrate levels available at the consumer's request in the restaurant.
- The point-of-purchase calorie information bill was planned to go into effect January 1, 2011; the provision of other nutrition information took effect January 1, 2010.
- *Note:* Multnomah County had an ordinance to disclose **sodium** information, and Lane County had introduced a similar proposal, but these were superseded by the passage of the state legislation.

INTRODUCED

Delaware
(Introduced April 2009)

- Would require a foodservice establishment with 10 or more outlets in Delaware or nationwide to post calories, saturated fat, carbohydrates, and **sodium** on menus (including carryout menus). Menu boards (including drive-thrus) and food tags would be allowed to post only calories, with additional nutrition information available upon request.
- Items on the menu less than 30 days would be exempt.
- The bill would require the Division of Public Health to conduct an education campaign and an evaluation of menu labeling. The bill would go into effect 1 year after enactment.

District of Columbia
(Introduced July 2009)

- Would require chain restaurants with 10 or more outlets nationwide to provide nutrition information for standard menu items; on printed menus the information would include calories, saturated plus *trans* fats, carbohydrates, and **sodium**. Nutrition information on menu boards (including drive-thrus) and food tags could be limited to calories, provided that the additional information be available in writing upon request of the customer.
- Items on the menu less than 30 days would be exempt.
- The policy would take effect 9 months after enactment.

Florida
(Introduced March 2009)

- Would require that chain restaurants with 19 or more outlets in Florida to provide nutrition information on menus, menu boards, and food tags.
- Alcoholic beverages, buffets, salad bars, and items on the menu for less than 180 days per year would be exempt.
- Implementation would be completed in two phases:
  - Phase I (from January 1, 2010, to June 30, 2010)—Restaurants with sit-down service would be required to provide nutrition information for each standard menu item on menus, in a menu insert, or on a brochure or menu tent at each table. Restaurants that use a drive-thru or indoor menu board would be required

to provide information in a brochure that is available upon request at the point of sale, with a notice indicating its availability. The nutrition information to be provided would include calories, carbohydrates, saturated fat, and **sodium**.
  - Phase II (after June 30, 2010)—Calorie information would be required to be posted.

Indiana
(Introduced January 2009)

- Would require chain restaurants of 20 or more outlets in Indiana to post calories and carbohydrates on menus and menu boards. Other information including calories, total fat, saturated fat, *trans* fat, cholesterol, **sodium**, carbohydrates, fiber, sugars, and protein would be required to be made available to customers in the restaurant.

Kentucky
(Introduced February 2009)

- Would require chain restaurants with 10 or more locations in Kentucky to provide calorie information for menu items on menus or menu boards, including drive-thrus. Additional information including calories, carbohydrates, saturated fat, and **sodium** would be required to be made available to customers.

Maryland
(Introduced February 2009)

- Would require chain restaurants with 15 or more outlets nationwide to post nutrition information for all standard menu items. Restaurants using printed menus would be required to list calories, carbohydrates, saturated plus *trans* fats, and **sodium**. Restaurants may list only calories on menu boards including drive-thrus, food tags, salad bars, buffets, and other displayed foods, as long as the other nutrition information is provided in writing at the point of ordering.
- The act would take effect October 1, 2010.

Oklahoma
(Introduced February 2009)

- Would require restaurants with 10 or more outlets in the state to provide nutrition information for standard menu items and post calorie content information next to menu item on menus, menu boards, and food tags.
- Implementation would be completed in two phases:
  - Phase I (from July 1, 2010, to December 31, 2011)—Restaurants with sit-down service would be required to provide calories, saturated fat, carbohydrates, and **sodium** content for each standard menu item on menus, in a menu insert, or on a brochure or menu tent on each table. Restaurants that use a drive-thru or indoor menu board would be required to provide information in a brochure that is available upon request at the point of sale under a notice indicating its availability.
  - Phase II (would take effect January 1, 2012)—Restaurants would be required to post calorie content information adjacent to each standard menu item on menus, indoor menu boards, and food tags.

Pennsylvania
(Introduced June 2009)

- Would require chain restaurants with an average of at least $500,000 in food sales over the past 3 years to post calories and provide nutrition information for standard menu items.
- Implementation would be completed in two phases:
  - Phase I (January 1, 2011, to June 30, 2012)—restaurants must provide a brochure at the point of sale listing calories, saturated fat, carbohydrates, and **sodium** content for each standard menu item. For sit-down restaurants, this information must be provided at the table and drive-thrus, in a brochure that is available upon request at the point of sale under a notice indicating its availability.
  - Phase II (by July 1, 2010)—Restaurants would be required to post calorie content information adjacent to each standard menu item on menus, indoor menu boards, and food tags.
- Within 60 days after enactment, the law would supersede and replace any existing or future local menu labeling ordinances in Pennsylvania.

Tennessee
(Introduced February 2009)

- Would require chain restaurants with 20 or more outlets nationwide to disclose calories (per serving) for each standard menu items. Additional nutrition information would be required to be located on the premises and available to customers upon request prior to the point of ordering. For each standard menu item, information required would include calories, calories from fat, total fat, saturated fat, cholesterol, **sodium**, total carbohydrates, complex carbohydrates, sugars, dietary fiber, and protein.
- Items on the menu for less than 90 days per year would be exempt.

Texas
(Introduced February 2009)

- Would require that chain restaurants with 19 or more locations in Texas to provide nutrition information on menus and menu boards.
- Implementation would be completed in two phases:
  - Phase I (January 1, 2010, to December 31, 2010)—Restaurants with sit-down service would be required to provide nutrition information for each standard menu item on menus, in a menu insert, or on a brochure or menu tent at each table. Restaurants that use a drive-through or indoor menu board would be required to provide information in a brochure that is available upon request at the point of sale with a notice indicating its availability. The nutrition information to be provided would include calories, carbohydrates, saturated fat, and **sodium**.
  - Phase II (after December 31, 2010)—Restaurants would be required to post calorie information adjacent to each menu item on menus, indoor menu boards, and food tags.

Vermont
(Introduced February 2009)

- Would require restaurants with 10 or more outlets nationwide to post nutrition information next to each item as offered for sale. If a restaurant uses a printed menu, it would be required to include calories, saturated fat, carbohydrates, protein, and **sodium** for each menu item. If a restaurant uses a menu board, it would be required

to post calories next to each item on the board and have additional nutrition information available in writing upon request.
- The Department of Health would have 12 months from enactment of the bill to adopt rules to implement the policy.

Appendix K

Approach to Linking Universal Product Code (UPC) Sales Data to the Nutrition Facts Panel

Research is needed to better track the sodium content of the food supply. Commercial operations provide universal product code (UPC) level data including weights that allow estimation of the total sales of each UPC level food during a specified time (e.g., weekly, quarterly, annually). In addition, such companies also maintain household panels that provide data on their purchases by rescanning all food purchases and transmitting the data on an ongoing basis. Purchase data from these household panels are projected to the U.S. population using a statistical weighting procedure. Detailed information on the characteristics of the households that participate in the panels is also available and could be used to analyze differences in the content of sodium purchases by different portions of the population. In turn, both the store scanner data and the household-based scanner data can be linked to nutrient information from the Nutrition Facts panel using data maintained by an outside vendor. The nutrient content data are provided at the UPC level and thus can be linked to the scanner data. Additional analyses may be required to add nutrient content for UPCs that are represented in the nutrient databases for one but not all package sizes for a particular brand name and product size. Developers may deem it necessary to select target food categories and focus on the top-selling products to facilitate periodic updates over time. For example, the tracking analysis could focus on the top brand representing some percentage of the sales for representative categories of foods.

The primary advantage of this approach is that it can be accomplished without requiring additional reporting or cooperation from food manufacturers or retailers. Furthermore, it can be an economical method of monitoring sources of sodium in large portions of the food supply and can be scaled based on the availability of resources for conducting the analysis. Once key targets are identified and the methodology is established, this method could provide data on trends over time by individual food categories. However, the analysis will have some limitations that may have to be addressed using other sources. In particular, private label products that are contract-manufactured for the major retail chains are included in the store scanner data, but it may be infeasible to link these foods to nutrient data. The analysis will likely need to focus on the top-selling products based on the availability of nutrient data at the UPC level from outside vendors. Foods that are prepared and packaged within a retail establishment are not currently required to include the Nutrition Facts panel; thus, the sodium content of these foods cannot be monitored without linking through other types of data sources that would require substantially more manual effort. Not all stores participate in store scanner data reporting (e.g., Wal-Mart), but product sales from these stores can be tracked using household-based scanner data because at least a portion of the household panel purchases items at stores not currently captured in store scanner data.

Appendix L

Public Information-Gathering Workshop Agenda

STRATEGIES TO REDUCE SODIUM INTAKE

Institute of Medicine
Food and Nutrition Board

Venable Conference Center, Room E11200 (8th floor)
575 7th Street, N.W.
Washington, DC 20004

March 30, 2009

8:30 a.m.	Welcome and Overview of Committee Tasks *Jane Henney, MD, Chair*
SESSION 1:	Sodium: Taste Perception and Technological Innovations *Moderator: Gary Beauchamp, Ph.D., Committee Member*
8:40	Sodium Taste Perception *Paul A.S. Breslin, Ph.D., Monell Chemical Senses Center and Rutgers University Department of Nutritional Sciences*
8:55	Technological Innovations for Reducing Sodium in Foods *Cindy Beeren, Ph.D., Sensory and Consumer Science, Leatherhead Food International*
9:10	Committee Discussion with Presenters

SESSION 2: Consumer Interface: Public Health Interventions Over Time and Current Consumer Perspectives
Moderator: Glorian Sorensen, Ph.D., M.P.H., Committee Member

9:30 Overview of U.S. Public Health Interventions to Reduce Sodium Intake and Hypertension
Ed Roccella, Ph.D., M.P.H., Program Coordinator, National Heart, Lung, and Blood Institute, National Institutes of Health (retired)

9:40 Consumer Perspectives on Sodium Intake and Reduced-Sodium Foods
Susan Borra, R.D., Executive Vice President, Managing Director for Nutrition, Food, and Wellness, Edelman

9:50 Committee Discussion with Presenters

10:10 Break

SESSION 3: Regulatory Options for Reducing Sodium Intake
Moderator: David Vladeck, J.D., LLM, Committee Member

10:25 Overview of Regulatory Options
Michael R. Taylor, J.D., Research Professor of Health Policy, School of Public Health, George Washington University

10:40 Reactions and Discussion Panel
Fred Degnan, J.D., Partner, King and Spalding
Philip Derfler, J.D., Assistant Administrator of the Office of Policy and Program Development, Food Safety and Inspection Service, U.S. Department of Agriculture
Michael R. Taylor, J.D., Research Professor of Health Policy, School of Public Health, George Washington University

10:55 Committee Discussion with Presenters

SESSION 4: Surveillance and Monitoring
Moderator: Ronette Briefel, Dr.P.H., R.D., Committee Member

11:20 Challenges in Biological Measures and Survey Methodologies
Cliff Johnson, M.S.P.H., Director of the Division of Health

	and Nutrition Examination Surveys, National Center for Health Statistics, Centers for Disease Control and Prevention
11:30	Challenges in Developing and Maintaining Food Composition Tables for Sodium *Alanna Moshfegh, M.S., R.D., Research Leader and Supervisory Nutritionist, Food Surveys Research Group, U.S. Department of Agriculture*
11:40	Contributions of Specific Food Categories to Current Sodium Intake *Eric Hentges, Ph.D., Executive Director, International Life Sciences Institute*
11:50	Committee Discussion with Presenters
12:00 p.m.	Lunch on Your Own
SESSION 5:	The United Kingdom Experience in Reducing Sodium Intake *Moderator: Beth Yetley, Ph.D., Committee Member*
1:00	Overview of Food Standards Agency Campaign to Reduce Salt Consumption *Corinne Vaughan, Deputy Head of Nutrition Division, Food Standards Agency*
1:20	Lessons Learned from the Salt Campaign—A Retailer's Perspective *Vanessa Hattersley, Company Nutritionist, ASDA*
1:30	Lessons Learned from the Salt Campaign—A Food Processor's Perspective *Ed Fern, Ph.D., Head of Corporate Nutrition, Nestlé*
1:40	Committee Discussion with Presenters
2:00	Break
SESSION 6:	Perspectives of the Food Industry and Food Service *Moderator: John Ruff, M.A., Committee Member*
2:10	Perspectives from the Food Processing Industry—Campbell Soup *Chor San Khoo, Ph.D., Vice President of Global Nutrition and Health, Campbell Soup Company*

2:25	Perspectives from the Food Processing Industry—Kraft Foods *Todd Abraham, Ph.D., Vice President of Global Nutrition, Kraft Foods*
2:35	Perspectives from the Food Processing Industry—Unilever *Douglas Balentine, Ph.D., Director of Nutrition Sciences for the Americas, Unilever*
2:45	Perspectives from the Food Service Industry—Compass Group *Deanne Brandstetter, M.B.A., R.D., Vice President of Nutrition and Wellness, Compass Group North America*
2:55	Perspectives from the Food Service Industry—Burger King *Stephanie Rohm Quirantes, M.S., R.D., L.D./N., Nutrition Manager, North America, Burger King*
3:05	Perspectives from the Food Service Industry—National Restaurant Association *Elizabeth Johnson, M.S., R.D., Executive Vice President for Public Affairs, National Restaurant Association*
3:15	Committee Discussion with Presenters
3:45	Break
SESSION 7:	Three-Minute Comments from Stakeholders *Moderator: Jane Henney, M.D., Committee Chair* Stakeholders Registered to Make Comments as of March 10, 2009: The Salt Institute (Morton Satin) The Truthful Labeling Coalition (Charles Hansen III) Center for Science in the Public Interest (Michael Jacobson) Grocery Manufacturers Association (Robert Earl) American Heart Association (Frank Sacks) Centers for Disease Control and Prevention (Darwin Labarthe) Institute of Food Technologists (Sara Olhourst)
5:00	Adjourn

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