Public Health Implications of Raising the Minimum Age of Legal Access to Tobacco Products

ISBN
978-0-309-31624-8

360 pages
6 x 9
PAPERBACK (2015)

Richard J. Bonnie, Kathleen Stratton, and Leslie Y. Kwan, Editors; Committee on the Public Health Implications of Raising the Minimum Age for Purchasing Tobacco Products; Board on Population Health and Public Health Practice; Institute of Medicine

Public Health Implications of Raising the Minimum Age of Legal Access to Tobacco Products

Committee on the Public Health Implications of
Raising the Minimum Age for Purchasing Tobacco Products

Board on Population Health and Public Health Practice

Richard J. Bonnie, Kathleen Stratton, and Leslie Y. Kwan, *Editors*

INSTITUTE OF MEDICINE
OF THE NATIONAL ACADEMIES

THE NATIONAL ACADEMIES PRESS
Washington, D.C.
www.nap.edu

THE NATIONAL ACADEMIES PRESS 500 Fifth Street, NW Washington, DC 20001

This study was supported by Contract/Grant No. HHSF22301031T between the National Academy of Sciences and the Department of Health and Human Services: Food and Drug Administration. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the views of the organizations or agencies that provided support for the project.

International Standard Book Number 13: 978-0-309-31624-8
International Standard Book Number-10: 0-309-31624-3
Library of Congress Catalog Card Number: 2015942038

Additional copies of this report are available for sale from the National Academies Press, 500 Fifth Street, NW, Keck 360, Washington, DC 20001; (800) 624-6242 or (202) 334-3313; http://www.nap.edu.

For more information about the Institute of Medicine, visit the IOM home page at: **www.iom.edu.**

Printed in the United States of America

The serpent has been a symbol of long life, healing, and knowledge among almost all cultures and religions since the beginning of recorded history. The serpent adopted as a logotype by the Institute of Medicine is a relief carving from ancient Greece, now held by the Staatliche Museen in Berlin.

Suggested citation: IOM (Institute of Medicine). 2015. *Public health implications of raising the minimum age of legal access to tobacco products*. Washington, DC: The National Academies Press.

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

INSTITUTE OF MEDICINE
OF THE NATIONAL ACADEMIES

Advising the Nation. Improving Health.

THE NATIONAL ACADEMIES

Advisers to the Nation on Science, Engineering, and Medicine

The **National Academy of Sciences** is a private, nonprofit, self-perpetuating society of distinguished scholars engaged in scientific and engineering research, dedicated to the furtherance of science and technology and to their use for the general welfare. Upon the authority of the charter granted to it by the Congress in 1863, the Academy has a mandate that requires it to advise the federal government on scientific and technical matters. Dr. Ralph J. Cicerone is president of the National Academy of Sciences.

The **National Academy of Engineering** was established in 1964, under the charter of the National Academy of Sciences, as a parallel organization of outstanding engineers. It is autonomous in its administration and in the selection of its members, sharing with the National Academy of Sciences the responsibility for advising the federal government. The National Academy of Engineering also sponsors engineering programs aimed at meeting national needs, encourages education and research, and recognizes the superior achievements of engineers. Dr. C. D. Mote, Jr., is president of the National Academy of Engineering.

The **Institute of Medicine** was established in 1970 by the National Academy of Sciences to secure the services of eminent members of appropriate professions in the examination of policy matters pertaining to the health of the public. The Institute acts under the responsibility given to the National Academy of Sciences by its congressional charter to be an adviser to the federal government and, upon its own initiative, to identify issues of medical care, research, and education. Dr. Victor J. Dzau is president of the Institute of Medicine.

The **National Research Council** was organized by the National Academy of Sciences in 1916 to associate the broad community of science and technology with the Academy's purposes of furthering knowledge and advising the federal government. Functioning in accordance with general policies determined by the Academy, the Council has become the principal operating agency of both the National Academy of Sciences and the National Academy of Engineering in providing services to the government, the public, and the scientific and engineering communities. The Council is administered jointly by both Academies and the Institute of Medicine. Dr. Ralph J. Cicerone and Dr. C. D. Mote, Jr., are chair and vice chair, respectively, of the National Research Council.

www.national-academies.org

COMMITTEE ON THE PUBLIC HEALTH IMPLICATIONS OF RAISING THE MINIMUM AGE FOR PURCHASING TOBACCO PRODUCTS

RICHARD J. BONNIE (*Chair*), Harrison Foundation Professor of Medicine and Law, Professor of Psychiatry and Neurobehavioral Sciences, Director of the Institute of Law, Psychiatry, and Public Policy, University of Virginia

ANTHONY J. ALBERG, Blatt Ness Distinguished Endowed Chair in Oncology, Professor, Public Health Sciences, Interim Director of Hollings Cancer Center, Medical University of South Carolina

REGINA BENJAMIN, NOLA.com/Times Picayune Endowed Chair in Public Health Sciences, Xavier University, New Orleans

JONATHAN CAULKINS, Professor, Operations Research and Public Health Policy, Heinz College of Public Policy and Management, Operations Research Department, Carnegie Mellon University

BONNIE HALPERN-FELSHER, Professor, Department of Pediatrics, Director of Research, Associate Director of Adolescent Medicine Fellowship Program, Division of Adolescent Medicine, Stanford University

SWANNIE JETT, Executive Director, Florida Department of Health in Seminole County

HARLAN JUSTER, Director, Bureau of Tobacco Control, New York State Department of Health

JONATHAN D. KLEIN, Associate Executive Director, Julius B. Richmond Center of Excellence for Children and Secondhand Smoke, American Academy of Pediatrics

PAULA M. LANTZ, Professor and Chair, Department of Health Policy and Management, Milken Institute School of Public Health, George Washington University

ROBIN MERMELSTEIN, Director of the Institute for Health Research and Policy, Professor of Psychology, Clinical Professor of Community Health Sciences, School of Public Health, University of Illinois, Chicago

RAFAEL MEZA, Assistant Professor, Department of Epidemiology, University of Michigan

PATRICK O'MALLEY, Research Professor, Institute for Social Research, University of Michigan

KIMBERLY THOMPSON, Professor of Preventive Medicine and Global Health, University of Central Florida College of Medicine, President, Kid Risk, Inc.

Consultants

THEODORE R. HOLFORD, Susan Dwight Bliss Professor of Public Health (Biostatistics) and Professor of Statistics, Yale School of Medicine, Yale University

DAVID T. LEVY, Professor, Lombardi Comprehensive Cancer Center, Georgetown University Medical Center

MARIA RODITIS, Postdoctoral Research Fellow, Adolescent Medicine, Division of Adolescent Medicine, Department of Pediatrics, Stanford University

IOM Staff

KATHLEEN STRATTON, Study Director
LESLIE Y. KWAN, Research Associate
BETTINA RITTER, Research Assistant
ANNA MARTIN, Senior Program Assistant
DORIS ROMERO, Financial Associate
ROSE MARIE MARTINEZ, Senior Board Director, Board on Population Health and Public Health Practice

Reviewers

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:

ANNETTE M. BACHAND, Colorado State University
SANJAY BASU, Stanford Prevention Research Center
CHRISTINE DELNEVO, Rutgers School of Public Health
EDWARD EHLINGER, Minnesota Department of Health
MICHAEL P. ERIKSEN, Georgia State University
THOMAS J. GLYNN, Stanford University and American Cancer Society
STEVEN A. SCHROEDER, University of California, San Francisco
JOSHUA M. SHARFSTEIN, Maryland Department of Health and Mental Hygiene
LAURENCE STEINBERG, Temple University
JENNIFER IRVIN VIDRINE, University of Texas MD Anderson Cancer Center

KENNETH W. WACHTER, University of California, Berkeley
ALEXANDER C. WAGENAAR, University of Florida

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the conclusions or recommendations, nor did they see the final draft of the report before its release. The review of this report was overseen by **SUSAN J. CURRY,** University of Iowa, and **RONALD S. BROOKMEYER,** University of California, Los Angeles. Appointed by the National Research Council and 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 authoring committee and the institution.

Preface

The Surgeon General's clarion call in 1964 for "appropriate remedial action" to address the hazards of smoking is often credited with having launched the nation's public health campaign against cigarettes. Effective federal action was impeded for more than three decades by a symbolic congressional action in 1965 mandating weak package warnings and then by the regressive decision by Congress in 1969 to preempt the states from regulating tobacco advertising "based on smoking and health." The 1969 legislation also banned tobacco advertising on television and thereby erased the country's first major tobacco control initiative—the hugely significant ruling by the Federal Communications Commission that broadcasters who aired tobacco advertisements were required by the agency's fairness doctrine to make time available for antismoking messages.

Attention then shifted to the states, largely driven by a grassroots movement for public smoking restrictions. The campaign was given major boosts by an important Surgeon General report emphasizing the addictive properties of nicotine (1988) and an Environmental Protection Agency report on the environmental hazards of tobacco smoke (1992). Another key building block of contemporary tobacco control was the initiative aiming to reduce youth smoking spearheaded by Congressman Mike Synar in 1992. The Synar Amendment requires states to enact and enforce youth access restrictions or else forfeit 40 percent of their block grants for substance abuse prevention and treatment. Within 2 years, the Synar Amendment was followed by two major reports by the Surgeon General and by the Institute of Medicine (IOM) on preventing the onset of nicotine addiction in adolescents and by a rhetorically and politically important initiative by Food and

Drug Administration (FDA) Commissioner David Kessler characterizing nicotine addiction as a "pediatric disease." Despite some dissension within the ranks of tobacco control advocacy, preventing youth initiation took its place as one of the core strategic components of tobacco control.

The campaign against secondhand tobacco smoke and the new focus on child protection and the prevention of addiction played pivotal roles in the gradual evolution of public support for aggressive tobacco control in the 1990s. The cause of tobacco control was also fundamentally accelerated by the emerging evidence that cigarettes have been engineered to be addictive and by the public distaste for industry advertising campaigns that seemed so obviously targeted at children and adolescents. In 1995, as the policy context for tobacco control rapidly evolved, FDA announced its innovative initiative to declare jurisdiction over cigarettes as "nicotine delivery devices" and its intention to develop a new rule aiming to reduce youth smoking. FDA's proposed rule included limitations on advertising and promotion as well as federal restrictions on youth access. Although the age of access in FDA's regulation was 18, the agency considered setting the minimum age at 21. Whatever the reasoning within FDA may have been, the consensus within the IOM committee that authored the 1994 report on youth smoking was that setting the age at 21 was too large a leap for reform in a political and social context in which existing youth access restrictions were largely unenforced and cigarettes were easily available to children old enough to put coins in a vending machine.

FDA's Tobacco Rule was proposed in 1995, promulgated in 1996, and invalidated by the Supreme Court in 2000. However, momentum for aggressive tobacco control continued to build throughout this period. The state attorney generals' lawsuits against the tobacco companies to recover Medicaid costs attributable to smoking—and the accompanying disclosures of industry documents—led to the Master Settlement Agreement in 1998 and to aborted negotiations regarding federal tobacco regulation. Meanwhile, social norms toward smoking have been transformed, prevalence has gradually declined, more reports on tobacco have been issued by the IOM and by Surgeons General, and the Family Smoking Prevention and Tobacco Control Act was enacted in 2009. Tobacco advocates have begun to focus on the "end game" for cigarette smoking.

It is in this context that Congress directed FDA in the Tobacco Control Act to commission a report on the public health implications of raising the minimum age of legal access to tobacco products. Many states and localities are considering proposals to raise the age, and some have already done so. In light of the extraordinary momentum achieved by tobacco control advocacy over the past three decades, talking about raising the age of youth access may seem anticlimactic. However, cigarette smoking is a stubborn and costly public health problem, and the tobacco industry is resourceful and creative. Adult prevalence remains about 18 percent, and smoking-related deaths approach 480,000 per year.

Although initiation rates have been dropping in recent years, history shows that they can reverse course just as easily. And investments in tobacco control tend to erode whenever the economy weakens. The development and marketing of new products is a wild card in the epidemiology of tobacco use. E-cigarettes and modified-risk tobacco products may eventually reduce the prevalence of cigarette smoking, but it is also possible that these products could serve as starter products for people who would not otherwise have begun smoking cigarettes and could also reduce incentives for cessation by addicted smokers who otherwise would have quit. Bringing these products within FDA's regulatory jurisdiction is imperative.

Vigilance is always advisable in tobacco control. It is prudent for federal policy makers and state and local authorities to strengthen all policies aimed at reducing the initiation of smoking, including the design and enforcement of youth access restrictions. The minimum age of legal access to tobacco products was set at 18 by the states more than two decades ago in response to federal incentives and is now required by federal law. However, states and localities remain free to raise the age. By assessing the public health implications of raising the minimum age, this report aims to provide the scientific guidance the states and localities need. In return, I urge states and localities that decide to raise the age to make sure that the necessary data are collected to evaluate the new policy in achieving its ultimate goal—the reduction and eventual elimination of tobacco use by children and youth.

Richard J. Bonnie, *Chair*
Committee on the Public Health
Implications of Raising the Minimum
Age for Purchasing Tobacco Products

Acknowledgments

The committee would like to express its sincere gratitude to the many people who contributed time and expertise in the development of this report. The work would not have been possible without the support of our sponsor, the Center for Tobacco Products of the Food and Drug Administration.

The committee would also like to acknowledge several consultants who contributed to this study. First and foremost, the committee extends its immense gratitude to Theodore R. Holford (Yale University) and David T. Levy (Georgetown University Medical Center), whose development, knowledge, and application of the Yale Lung Cancer/Cancer Intervention and Surveillance Modeling Network and SimSmoke models were integral to the deliberations of the committee and contributed significantly to the quality of the report. We thank them for their patience, expertise, and many hours of hard work. The committee is also grateful to Maria Roditis (Stanford University), who provided consultation and editorial support on draft materials on adolescent and young adult development, and Robert Pool for his assistance in editing the report.

Many individuals volunteered significant time and effort to address and educate the committee during our information-gathering meetings (see Appendix E for the names of these speakers). We are grateful to each of them for sharing their expertise and responding to our questions. The committee would like to add special thanks to Neal Benowitz (University of California, San Francisco) for his additional consultation and technical review of material on developmental neurobiology and neurological response to nicotine.

The committee also expresses its deep appreciation to the staff of the

Institute of Medicine and the National Academies for their invaluable assistance on this study. We thank the National Academies Research Center staff for their diligent help with research and references. We are grateful for the leadership of Rose Marie Martinez, senior board director of the Board on Population Health and Public Health Practice, and for the energetic and resourceful contributions of research associate Leslie Kwan, research assistant Bettina Ritter, and senior program assistant Anna Martin. Finally, we extend special thanks to study director Kathleen Stratton, whose wisdom and guidance throughout the study process were indispensable.

Contents

Summary

Smoking rates in the United States have declined substantially since the release of *Smoking and Health: Report of the Advisory Committee to the Surgeon General of the Public Health Service* in 1964, when the prevalence of current cigarette smoking was around 42 percent. Recent estimates reveal that since 1964, tobacco control in the United States has led to 8 million fewer premature deaths and has extended the mean life span at age 40 by about 2 years (Holford et al., 2014). However, tobacco use continues to have major public health implications; while the prevalence of current cigarette smoking among U.S. adults has declined to around 18 percent (Schiller et al., 2014), more than 42 million American adults still smoke (HHS, 2014).

STATEMENT OF TASK

The Family Smoking Prevention and Tobacco Control Act of 2009 (hereafter referred to as the Tobacco Control Act) amended the Federal Food, Drug, and Cosmetic Act, granting the Food and Drug Administration (FDA) broad authorities over tobacco products. The Tobacco Control Act directed FDA to, among other things, issue regulations to restrict cigarette and smokeless tobacco retail sales to youth and to restrict tobacco product advertising and marketing to youth. The act, however, prohibits FDA from taking several specific steps, including establishing a minimum age of sale of tobacco products to persons over 18 years of age.[1] On the other hand, the Tobacco Control Act directed FDA to convene a panel of experts to conduct a study on "the public health implications of raising the minimum age to purchase tobacco products" and to submit a report to Congress on the issue.

In August 2013 FDA contracted with the Institute of Medicine (IOM) to convene a committee to:

1. Examine existing literature on tobacco use initiation, and
2. Use modeling and other methods, as appropriate, to predict the likely public health outcomes of raising the minimum age for purchase of tobacco products to 21 years and 25 years.

The resulting IOM Committee on the Public Health Implications of Raising the Minimum Age for Purchasing Tobacco Products, assembled to address these issues, was composed of experts in public health law, the epidemiology of tobacco use and tobacco risks, adolescent and young adult development, risk behaviors and perceptions, public health policy and practice, and public policy modeling.

Interpreting the Statement of Task

During a discussion at the first public meeting of the committee, a representative of the Center for Tobacco Products of FDA urged the committee to include in its analysis the impact of raising the minimum age of legal access to tobacco products (MLA) to 19 years of age. The public health impacts examined in this report include tobacco initiation, prevalence, morbidity, and mortality. The committee uses the term "tobacco product" to mean any product covered by FDA regulatory authority, although most of the literature and the modeling focus on cigarettes. The committee did not consider the economic impact of raising the MLA, nor did it compare the effects of raising the MLA with other youth-oriented tobacco control policies.

The Tobacco Control Act refers to both minimum age for purchase[2] and minimum age for sale.[3] The committee focused on the implications of raising the MLA in the context of the body of youth access laws and enforcement policies currently in place across the country. These laws and policies vary considerably, not only in the scope of conduct that is prohib-

[1] Family Smoking Prevention and Tobacco Control Act of 2009, Public Law 111-31 § 906. 111th Cong. (June 22, 2009).
[2] Id. § 104.
[3] Id. § 906.

ited but also in the prescribed penalties for violations. What they all have in common, however, is a focus on curtailing retail access to tobacco products by underage persons, with little, if any, emphasis on punishing the underage users of tobacco products. The committee's charge requests conclusions regarding the public health implications of raising the MLA without any recommendations regarding whether the MLA should be raised.

ADOLESCENT AND YOUNG ADULT DEVELOPMENTAL TRAJECTORIES AND PATTERNS OF TOBACCO USE

Brain development continues until about age 25. While the development of some cognitive abilities is achieved by age 16, the parts of the brain most responsible for decision making, impulse control, sensation seeking, future perspective taking, and peer susceptibility and conformity continue to develop and change through young adulthood. Adolescent brains are uniquely vulnerable to the effects of nicotine and nicotine addiction. Adolescent and young adult developmental trajectories may be altered by social and environmental contextual influences, including normative developmental transitions into and out of school or work or changes in living arrangements or relationships.

According to the most recent results from an annual survey of adolescents in grades 8, 10, and 12, American teens are smoking less than ever before (Johnston et al., 2014b). Cigarette smoking in this age group peaked in 1996–1997 before beginning a fairly steady and substantial decline that continued through the mid-2000s. This decline in adolescent smoking has continued since then, but at a slower rate (HHS, 2014). Data from 2012 show that 34.1 percent of Americans between 21 and 25 were current cigarette users, making that the age group with the highest prevalence of cigarette smoking (SAMHSA, 2013). While almost 90 percent of people who have ever smoked daily first tried a cigarette before 19 years of age, the fact that nearly all others who ever smoked daily tried their first cigarette before the age of 26 should not be overlooked (see Table 2-8 in Chapter 2). Additionally, only 54 percent of daily smokers are smoking daily before age 18, but 85 percent are doing so by age 21 and 94 percent before age 25. These data strongly suggest that if someone is not a regular tobacco user by 25 years of age, it is highly unlikely they will become one.

CURRENT PRACTICES REGARDING YOUTH ACCESS RESTRICTIONS

Although most states currently set the minimum age of legal access to tobacco at 18, four states set it at 19, and New York City and several other localities around the country have raised the MLA to 21. All 50 states and the District of Columbia prohibit commercial transfers to underage persons, while 48 states and the District of Columbia also prohibit noncommercial transfers (e.g., giving, exchanging, bartering, furnishing, or otherwise distributing tobacco). Based on random, unannounced compliance inspections of tobacco retailers, the national average rate of tobacco sales to underage individuals (i.e., noncompliance) in 2013 was 9.6 percent.

Active enforcement of tobacco minimum age restrictions, including meaningful penalties for violations, increases retailer compliance and decreases the availability of retail tobacco to underage persons. However, it is difficult to know precisely how much increasing retailer compliance reduces the availability of retail tobacco to underage persons or how much the decreased retail availability of tobacco affects underage tobacco use because of the continued availability of tobacco from noncommercial sources. Underage users rely primarily on "social sources" (friends and relatives) to get tobacco, and there is little evidence that underage individuals are obtaining tobacco from the illegal commercial market. Bans on the noncommercial distribution of tobacco by friends, proxy purchasers, and other social sources are not well-enforced.

EFFECTS OF RAISING THE MLA ON TOBACCO USE

Through an iterative and consensus-driven process, the committee considered how these age-related effects would translate into potential changes in the rates of initiation across different age segments through adolescence and young adulthood for each of the three policy options (raising the MLA to 19, 21, or 25 years of age). The committee assigned ordered, categorical labels to its estimates as small, medium, or large. The committee attached numeric ranges to each of the magnitude estimate descriptors for use in the modeling. The committee used increments of 5 percent, ranging from 5 to 30 percent, to quantify the range of possible changes in initiation rates for use in the models. The committee has more confidence in its estimates pertaining to raising the MLA to 19 or 21 than in its estimates pertaining to raising the MLA to 25 because of the greater level of extrapolation needed for estimating change and also other factors that appear with increased age.

Conclusion 7-1: Increasing the minimum age of legal access to tobacco products will likely prevent or delay initiation of tobacco use by adolescents and young adults.

The definition of "initiation" used in this report, including in the modeling, is having smoked 100 cigarettes. This definition is based on data obtained from the National Health Interview Survey. Smoking at least 100 cigarettes in one's lifetime goes beyond occasional trying or "experimentation." To achieve the benchmark of 100 cigarettes, one must have access to cigarettes over a period of time and have developed symptoms of dependence and stronger motives for use beyond perceived peer or social group pressure (Dierker and Mermelstein, 2010).

A critical component in the development of dependence and continued tobacco use is the reinforcing effects of nicotine. Adolescent brains have a heightened sensitivity to the rewarding effects of nicotine, and this sensitivity diminishes with age (Adriani et al., 2006; Jamner et al., 2003). Thus, the probability that a user escalates to dependence after the first few trials is likely to decrease the further one moves away from adolescence.

Changes in the initiation of tobacco use would not necessarily be linear with increases in the MLA or be equal for all segments of underage individuals. Changing the MLA has an indirect effect of helping to change norms about the acceptability of tobacco use, but this effect may take time to build. In addition, the norms about acceptability of tobacco use are also likely to vary by age, with greater perceived unacceptability for those the farther away from the MLA. If the MLA increases to 21, the social unacceptability of smoking will be greater for a 16-year-old than for a 20-year-old.

Given the assumption that changes in the MLA could have differential effects on adolescents at different ages, the committee considered possible changes in initiation rates for three age divisions: (1) adolescents under age 15; (2) adolescents between the ages of 15 and 17; and (3) individuals at age 18 for estimates with an MLA of 19, or individuals at ages 18 to 20 or 21 to 24 for an MLA of 21 or 25, respectively. These age groupings reflect not just differences in years from the MLA but also several important developmental transitions that play a role in tobacco use.

Conclusion 7-2: Although changes in the minimum age of legal access to tobacco products will directly pertain to individuals who are age 18 or older, the largest proportionate reduction in the initiation of tobacco use will likely occur among adolescents 15 to 17 years old.

Conclusion 7-3: The impact on initiation of tobacco use of raising the minimum age of legal access to tobacco products (MLA) to 21 will likely be substantially higher than raising it to 19, but the added effect of raising the MLA beyond age 21 to age 25 will likely be considerably smaller.

Adolescents Less Than 18 Years of Age

Many adolescents under age 15 are not yet in high school or of driving age. Adolescents under age 15 are less likely to have coworkers or members of their peer networks who are over the MLA (with the likelihood decreasing as the MLA increases). Thus, social network sources and mobility are most restricted for adolescents under age 15. For adolescents under 15 years of age, raising the MLA from 18 to 19 may have only a modest impact on reducing social sources, given the small difference in age. Increasing the MLA to 21, however, would provide a greater distancing of social sources. Although 19-year-olds may still be in high schools and thus potentially influence those under 15, it is far less likely that 21-year-olds are in the same social networks. On the other hand, increasing the MLA from 21 to 25 will not be likely to achieve many additional notable reductions in social sources for those under 15 beyond what is achieved with an MLA of 21.

Although social sources play a central role in establishing adolescent tobacco use patterns, other factors that contribute to early adolescent tobacco use (for those who initiate before age 15) may limit the reductions that would be achieved with increases in the MLA. Adolescents who reach a level of 100 cigarettes before 15 may be those who are most susceptible to the reinforcing effects of nicotine, who have higher levels of psychological or substance use comorbidities, who have a combination of problem behaviors (of which tobacco use is one manifestation), and who have social networks within which tobacco and other substances are more readily available, regardless of age. Thus, the committee also expects that there may be limits to how much changes in the MLA will affect this subset of adolescents. Considering the balance of these factors, the committee estimates that for adolescents under age 15 reductions in initiation will be small for an MLA of 19 and medium for an MLA of 21 and an MLA of 25.

The committee expects that the greatest gains in reducing tobacco use will be achieved for adolescents between the ages of 15 and 17. Negative consequences for tobacco use, through parental or school controls, are still relevant, and changes in the MLA are likely to increase these negative consequences as social norms adjust. Adolescents in this age group are still most likely to get tobacco through social sources (committee analysis of Arrazola et al., 2014; Johnston et al., 2014a). Between the ages of 15 and 17 adolescent mobility increases with driving privileges. Social networks and potential social sources of tobacco start to increase as some adolescents take on formal, part-time jobs with coworkers who may be over the MLA. Changing the MLA to 19 may not change social sources substantially for these adolescents, but the committee expects that raising the MLA to 21 will substantially impact initiation. Raising the MLA to 25 may provide only a modest additional reduction in initiation over that achieved with an MLA of 21, given that changes to social network sources may not be substantially different.

Balancing these factors, the committee estimates that the reduction in initiation in this age group will likely exceed that seen in adolescents less than

15 years of age for all policy options. Furthermore, the committee estimates that the higher the MLA, the greater the effect on initiation rates will be.

Young Adults 18 to 20 Years of Age

By age 18, many adolescents graduate from high school and have numerous life transitions, including entering higher education, exposure to more adults in the workforce, leaving home, and significant changes in social networks. Patterns of initiation to date also show a tailing off of initiation by age 18 (committee analysis of Johnston et al., 2014a). Given that the social networks of 18-year-olds overlap more with 19-year-olds, the committee expects a small reduction in initiation for 18-year-olds for an MLA of 19. The committee expects similar effects on initiation rates for 19- and 20-year-olds as for 18-year-olds with an MLA of 21 or 25. This expectation of increased effect is due primarily to the increased social distancing expected when the MLA is raised to 21 or 25, but it also takes into account the benefit of the additional maturing of executive functions among young adults, the decreased sensitivity to the rewarding properties of nicotine, the additional social norms proscribing tobacco use, and tobacco's decreased social value and the decreased motives for use as individuals enter the workforce or parenthood.

Young Adults 21 to 24 Years of Age

Changes in initiation for young adults in the 21–24 age group were considered only for the case of raising the MLA to 25. Even under the current MLA of 18, the probability of initiation at these ages is substantially lower than for adolescents and younger adults. However, current patterns of tobacco marketing suggest that young adults are increasingly targeted in tobacco promotions (Ling and Glantz, 2002), and tobacco promotions are frequently linked with bar settings and alcohol consumption, which may also keep this age group susceptible to initiation (Ling and Glantz, 2002). In addition, the committee considered that there may be more lax enforcement for an MLA of 25. Considering the balance of factors, the committee expects that some reduction in initiation will still occur with an MLA of 25 but that this reduction will be small.

Conclusion 7-4: Based on the modeling, raising the minimum age of legal access to tobacco products, particularly to age 21 or 25, will likely lead to substantial reductions in smoking prevalence.

Two tobacco simulation models commissioned by the committee, SimSmoke and the Cancer Intervention and Surveillance Modeling Network (CISNET) smoking population model, suggest significant reductions in smoking prevalence from 2015 to 2100 in the United States, even under a status quo scenario with regard to the MLA; these declines reflect ongoing benefits from prior tobacco control policies. The models predict that raising the MLA would lead to considerable additional reductions in smoking prevalence based on the committee's conclusions about the likely reductions in smoking initiation described above. Specifically, both models estimate that raising the MLA will lead to approximately a 3 percent decrease in smoking prevalence for an MLA of 19, a 12 percent decrease for an MLA of 21, and a 16 percent decrease for an MLA of 25 above and beyond the decrease predicted in the status quo scenario.

HEALTH EFFECTS OF RAISING THE MLA

Given the likelihood that raising the MLA would decrease the rates of initiation of tobacco use by adolescents and young adults, it follows that tobacco-related disease and death would also decrease, generally in proportion to the decrease in tobacco use.

Conclusion 8-1: Based on the modeling, raising the minimum age of legal access to tobacco products will likely lead to substantial reductions in smoking-related mortality.

Conclusion 8-2: Based on a review of the literature, raising the minimum age of legal access to tobacco products (MLA) will likely immediately improve the health of adolescents and young adults by reducing the number of those with smoking-caused diminished health status. As the initial birth cohorts affected by the policy change age into adulthood, the benefits of the reductions of the intermediate and long-term adverse health effects will also begin to manifest. Raising the MLA will also likely reduce the prevalence of other tobacco products and exposure to secondhand smoke, further reducing tobacco-caused adverse health effects, both immediately and over time.

Adolescents and adults most commonly use tobacco in the form of cigarettes, and the adverse health effects of cigarettes are best documented among all the various forms of tobacco use. Cigarette smoking is causally associated with a broad spectrum of adverse health effects that begin soon after the onset of regular smoking and significantly diminish the health status of the smoker compared to nonsmokers. Cigarette smoking causes many adverse health effects with an intermediate latency, such as subclinical atherosclerosis, impaired lung development and function, diabetes, periodontitis, exacerbation of asthma, subclinical organ injury, and adverse surgical outcomes. Cigarette smoking is also causally associated with a broad spectrum of long-latency adverse health effects, such as chronic obstructive pulmonary disease, coronary heart disease, and numerous cancers, that cause suffering, impaired quality of life, and premature death. Results from both models suggest that reductions in smoking-related mortality following an increase in the MLA will be large but will not be observed for at least 30 years after the increased MLA takes effect. For example, if the MLA were raised now to age 21 nationwide, modeling suggests that for the cohort of people born between 2000 and 2019 there would be approximately 10 percent fewer lifetime premature deaths, lung cancer deaths, and years of life lost (YLL) from cigarette smoking. Given the status quo projections, this translates to approximately 249,000 fewer premature deaths, 45,000 fewer deaths from lung cancer, and 4.2 million fewer YLL.[4]

Smoking combustible tobacco products other than cigarettes, such as pipes and cigars, is causally associated with a broad spectrum of adverse health effects. The impact of raising the MLA on morbidity and mortality from these products would depend on the risk profile of each product and the degree to which that product is used in the population over time. Raising the MLA can also be expected to lessen exposure to secondhand smoke from cigarettes and other combustible tobacco products. Secondhand smoke exposure is causally associated with a number of adverse health effects.

Conclusion 8-3: Based on a review of the literature and on the modeling, an increase in the minimum age of legal access to tobacco products will likely improve maternal, fetal, and infant outcomes by reducing the likelihood of maternal and paternal smoking.

Maternal smoking during pregnancy and secondhand smoke exposure during infancy are causally associated with many adverse health outcomes. Such exposures not only leave exposed infants prone to various short- and long-term health risks but can also result in death. The SimSmoke model projected the effects of raising the MLA on the incidence of select maternal–child outcomes. Relative to the status quo, if the MLA were raised now to age 21 nationwide, modeling projects that by 2100 there would be an estimated 286,000 fewer pre-term births, 438,000 fewer cases of low birth

[4] All absolute differences, including the numbers of premature deaths, lung cancer deaths, and YLL, are relative to underlying status quo projections. These status quo projections estimate decreases in smoking prevalence and thus smoking-attributable morbidity and mortality. As such, the committee encourages the reader to focus on the percentage reduction rather than on the absolute numerical estimates.

weight, and roughly 4,000 fewer sudden infant death syndrome (SIDS) cases among mothers age 15 to 49.[5]

CONSIDERATIONS FOR POLICY MAKERS

The Tobacco Control Act sets a "floor" of 18 on the MLA, while allowing states and localities to raise the age. Unless Congress acts to raise the age on a national basis or delegates authority to FDA to do so, one might expect a patchwork of different MLAs in different states and localities, as existed for alcohol for many decades, rather than a uniform MLA across all of the 51 jurisdictions. The simulations described in Chapters 7 and 8 model a situation in which increases in the MLA would be adopted and implemented on a nationwide basis. In the absence of a national MLA, the public health impact of raising the MLA for tobacco would be dependent, first and foremost, upon the degree to which local and state governments take up this policy. To the extent that states choose not to raise the MLA, the effects estimated in Chapters 7 and 8 are not likely to be realized.

The strength and efficacy of existing state and local tobacco control programs vary significantly, reflecting differences in the number and intensity of tobacco control activities and the resources allocated to support them. The modeling essentially aggregates each state's tobacco control activities, whether they are strong or weak. To the extent that policy makers in individual states want to derive state-based estimates from the findings of a national modeling exercise, they will have to take into account whether the existing levels of tobacco control activity in their states are comparable to the "average" state. If they are much weaker or stronger, extrapolation from the modeling used in this report may not be suitable.

The committee expects social sources, especially proxy purchases, to remain the primary sources of tobacco for underage persons, and it has been realistic about the high level of continuing availability to underage adolescents and young adults who are in the workforce or in college environments. Our estimates in this respect are predicated on relatively conservative assumptions. Although access to social sources could be reduced significantly if the laws prohibiting transfers to underage persons were aggressively enforced, the committee does not expect such a radical change in enforcement policy in the foreseeable future, especially under a higher MLA, because of likely public resistance. However, if a state or locality ramped up the threat of detection and punishment against social sources,

[5] All absolute differences, including the numbers of cases of pre-term births, low birth weight, and SIDS, are relative to underlying status quo projections. These status quo projections predict that there will be decreases in smoking prevalence, and thus smoking-attributable morbidity and mortality.

the impact on adolescent and young adult consumption could be greater than the committee has projected.

Concerns about adolescent vulnerability to addiction and immaturity of judgment support an underage access restriction, but they do not resolve the policy question about the specific age at which the line should be drawn. The argument against raising the MLA above 18 is predicated on the assumption that adolescents older than 17 are mature enough to make their own decisions about what is in their best interests. However, evidence suggests that capacities related to mature judgment, especially in emotionally charged situations or in situations in which peer influence plays a role, are still developing into the early 20s. Many young people in their late teens and early 20s may also still be at elevated risk, developmentally speaking, to becoming addicted to nicotine. A balance needs to be struck between the personal interest of young adults in making their own choices and society's legitimate concerns about protecting the public health and discouraging young people from making decisions they may later regret (IOM, 2007; IOM and NRC, 2004). Although some line is required, 18 is not the only developmentally plausible place to draw it. Every state sets the legal age for certain activities higher or lower for different policy purposes, and state legislators will likely continue to draw the line in different places in different policy contexts (Bonnie and Scott, 2013; Hamilton, 2010; Steinberg, 2012).

The committee assumes that the MLA will be increased for all tobacco products, including electronic nicotine delivery systems (ENDS), and that the intensity of enforcement will be the same for all products. The committee sees no reason to believe that the effects of the legal norm and its enforcement on retailer compliance, retail availability, or access to social sources would differ materially for ENDS as compared with other tobacco products. Given the evidence that adolescents who currently initiate tobacco use with ENDS rather than with conventional tobacco products are younger (Wills et al., 2014), the main effect of raising the MLA for ENDS will likely be to reduce the number of adolescents and young adults who initiate tobacco use with ENDS. However, recent trends suggest that ENDS initiation is already increasing and is likely to increase even if the MLA is raised. Increased initiation of ENDS use may reduce initiation of cigarette use because some adolescents and young adults who otherwise would have initiated cigarette users will become ENDS users instead. It may also delay initiation of cigarette use for others, including some proportion who would not have otherwise used traditional cigarettes. Presumably FDA and state policy makers will take these possibilities into account in setting the MLA and will carefully monitor the promotion and use of ENDS, especially by adolescents and young adults.

Although the full benefits of preventing initiation of tobacco use will take decades to accrue, some direct health benefits, including those from reduced secondhand smoke exposure, will be immediate. Perhaps the greatest uncertainty in the committee's assessment is the currently unpredictable effects of the marketing and use of ENDS and other novel tobacco products. However, in the absence of transformative changes in the tobacco market, social norms and attitudes, or the epidemiology of tobacco use, the committee is reasonably confident that raising the MLA will reduce tobacco initiation, particularly among adolescents 15 to 17 years of age, will improve health across the life span, and will save lives.

REFERENCES

Adriani, W., V. Deroche-Gamonet, M. Le Moal, G. Laviola, and P. V. Piazza. 2006. Preexposure during or following adolescence differently affects nicotine-rewarding properties in adult rats. *Psychopharmacology* 184(3–4):382–390.

Arrazola, R. A., N. M. Kuiper, and S. R. Dube. 2014. Patterns of current use of tobacco products among U.S. high school students for 2000–2012—Findings from the National Youth Tobacco Survey. *Journal of Adolescent Health* 54(1):54–60.

Bonnie, R. J., and E. S. Scott. 2013. The teenage brain: Adolescent brain research and the law. *Current Directions in Psychological Science* 22(2):158–161.

Dierker, L., and R. Mermelstein. 2010. Early emerging nicotine-dependence symptoms: A signal of propensity for chronic smoking behavior in adolescents. *Journal of Pediatrics* 156(5):818–822.

Hamilton, V. E. 2010. Immature citizens and the state. *Brigham Young University Law Review* 1055(4):1055–1148.

HHS (Department of Health and Human Services). 2014. *The health consequences of smoking—50 years of progress: A report of the Surgeon General*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

Holford, T. R., R. Meza, K. E. Warner, C. Meernik, J. Jeon, S. H. Moolgavkar, and D. T. Levy. 2014. Tobacco control and the reduction in smoking-related premature deaths in the United States, 1964–2012. *JAMA* 311(2):164–171.

IOM (Institute of Medicine). 2007. *Ending the tobacco problem: A blueprint for the nation*. Edited by R. J. Bonnie. Washington, DC: The National Academies Press.

IOM and NRC (Institute of Medicine and National Research Council). 2004. *Reducing underage drinking: A collective responsibility*. Edited by R. J. Bonnie. Washington, DC: The National Academies Press.

Jamner, L. D., C. K. Whalen, S. E. Loughlin, R. Mermelstein, J. Audrain-McGovern, S. Krishnan-Sarin, J. K. Worden, and F. M. Leslie. 2003. Tobacco use across the formative years: A road map to developmental vulnerabilities. *Nicotine & Tobacco Research* 5(Suppl 1):S71–S87.

Johnston, L. D., P. M. O'Malley, J. G. Bachman, J. E. Schulenberg, and R. A. Miech. 2014a. *Monitoring the Future: National survey results on drug use, 1975–2013: Volume 1, Secondary school students*. Ann Arbor: Institute for Social Research, University of Michigan.

Johnston, L. D., P. M. O'Malley, R. A. Miech, J. G. Bachman, and J. E. Schulenberg. 2014b. *Monitoring the Future: National survey results on drug use, 1975–2013: Overview, key findings on adolescent drug use*. Ann Arbor: Institute for Social Research, University of Michigan.

Ling, P. M., and S. A. Glantz. 2002. Why and how the tobacco industry sells cigarettes to young adults: Evidence from industry documents. *American Journal of Public Health* 92(6):908–916.

SAMHSA (Substance Abuse and Mental Health Services Administration). 2013. *Results from the 2012 National Survey on Drug Use and Health: Summary of national findings*. Rockville, MD: Substance Abuse and Mental Health Services Administration; Center for Behavioral Statistics and Quality; Department of Population Surveys.

Schiller, J. S., B. W. Ward, and G. Freeman. 2014. Early release of selected estimates based on data from the 2013 National Health Interview Survey. U.S. Department of Health and Human Services, Centers for Disease Control and Prevention and National Center for Health Statistics. http://www.cdc.gov/nchs/data/nhis/earlyrelease/earlyrelease201406.pdf (accessed February 22, 2015).

Steinberg, L. 2012. Should the science of adolescent brain development inform public policy? *Issues in Science and Technology* 28(3):67–78.

Surgeon General's Advisory Committee on Smoking and Health. 1964. *Smoking and health: Report of the Advisory Committee to the Surgeon General of the Public Health Service*. Washington, DC: U.S. Government Printing Office.

Wills, T. A., R. Knight, R. J. Williams, I. Pagano, and J. D. Sargent. 2014. Risk factors for exclusive e-cigarette use and dual e-cigarette use and tobacco use in adolescents. *Pediatrics* 135(1):e43–e51.

1

Introduction

The study of the relationship between tobacco use and health problems has a long history. The classic papers by Doll and colleagues began to appear in 1950, with the first prospective study linking cigarette smoking and lung cancer published in 1954 (Doll and Hill, 1954), following up on many cross-sectional studies. A number of other important studies added to the growing evidence base about the health risks of smoking (e.g., Cornfield et al., 1959; Dorn, 1959; Hammond and Horn, 1958; Wynder and Graham, 1950). A seminal report, *Smoking and Health: Report of the Advisory Committee to the Surgeon General of the Public Health Service*,[1] was published in 1964, and since that time Surgeons General have released 32 other reports on a variety of topics related to tobacco use (HHS, 2014).

Smoking rates in the United States have declined substantially since 1965 when the prevalence of current cigarette smoking was approximately 42 percent (HHS, 2014). Furthermore, it has recently been estimated that tobacco control policies in the United States since 1965 have led to 8 million fewer premature deaths and have extended the mean life span by 19 to 20 years per death postponed, corresponding to an increment of about 2 years in life expectancy at age 40 (Holford et al., 2014). However, tobacco use continues to have major public health implications: While the prevalence of current cigarette smoking among U.S. adults declined from 24.7 percent in 1997 to 17.8 percent in 2013 (NCHS, 2014), more than 42

[1] This report is often referred to as the first Surgeon General's report on smoking; however, the authors were actually a nongovernmental advisory committee to the Surgeon General.

million American adults still smoke, leading to about 480,000 premature deaths each year (HHS, 2014).

TOBACCO USE IN ADOLESCENTS AND YOUNG ADULTS

According to the most recent results from an annual survey of adolescents in grades 8, 10, and 12, American teens are smoking less than ever before (Johnston et al., 2014). Smoking in this age group peaked in 1996–1997 before beginning a fairly steady and substantial decline that continued through the mid-2000s (HHS, 2014). In 2013 the number of adolescents who reported having smoked in the previous 30 days had decreased from peak levels seen in the mid-1990s by 79 percent in grade 8, 70 percent in grade 10, and 56 percent in grade 12 (Johnston et al., 2014). Other surveys show similar trends (Kann et al., 2014; SAMHSA, 2013). While tremendous strides have been made, each day more than 3,000 adolescents try their first cigarette, and, if current trends continue, 5.6 million adolescents alive today in the United States are likely to die prematurely of smoking-related illness (HHS, 2014).

Tobacco use by young adults (those between 18 and 24 years of age) also poses serious concerns. While nearly 90 percent of people who have ever smoked daily first tried a cigarette before 19 years of age, the fact that another 9.4 percent tried their first cigarette before the age of 26 should not be overlooked (see Table 2-8 in Chapter 2). Additionally, only 54 percent of daily smokers are smoking daily before age 18, but 85 percent are doing so by age 21, and 94 percent before age 25 (see Table 2-8 in Chapter 2). These data strongly suggest that if someone is not a regular tobacco user by 25 years of age, it is highly unlikely they will become one.

Data from 2012 show that current cigarette use among adults was highest among persons ages 21 to 25 years (34.1 percent) (SAMHSA, 2013). Certain emerging patterns of tobacco use among young adults are also of concern, including an increase in the number of young adults who smoke lightly (fewer than five cigarettes per day) or intermittently (nondaily) (Fagan and Rigotti, 2009; Pierce et al., 2009) but do not consider themselves "smokers" (Leas et al., 2014). There has also been a very recent increase in the use of other tobacco products, such as electronic cigarettes and hookahs, among college students (HHS, 2012; Johnston et al., 2014).

Research suggests that brain and psychosocial development continues past the age of 18 years (IOM and NRC, 2014), the age of legal tobacco purchase in the United States. The self-regulatory system matures gradually, beginning in pre-adolescence and continuing through young adulthood (Steinberg, 2012). High-risk behaviors, including tobacco use, are generally more common in adolescents and young adults than in older adults. Additionally, the tobacco industry, prohibited from marketing to those younger than 18 years of age, has for decades targeted marketing and promotional activities to young adults (Sepe et al., 2002). The convergence of the neurobiological factors and the tobacco use epidemiology reinforces the importance of preventing young adults, in addition to children and adolescents, from becoming tobacco users.

HIGH-RISK POPULATIONS

Neither the prevalence of cigarette smoking nor the use of other tobacco products is evenly distributed in the population; rather, both are more heavily concentrated in certain population subgroups than in others. Over time in the United States, cigarette smoking has become more and more concentrated in lower socioeconomic groups defined by few years of schooling and lower income (Fagan et al., 2007). Smoking prevalence also varies across racial and ethnic groups, with the highest prevalence among American Indians and Alaskan natives and the lowest among Asian Americans (Fagan et al., 2007).

Sexual orientation is also strongly associated with the prevalence of current smoking. Smoking prevalence is much higher among sexual minorities than in the population as a whole (Lee et al., 2009; Ryan et al., 2001). The prevalence of smoking among persons with a history of mental illness is approximately double the prevalence in the general population (Lasser et al., 2000). This increased likelihood of smoking in those with a history of mental illness is not limited to one or a few psychiatric diagnoses but rather is a cross-cutting association that applies to psychiatric diagnoses across the board (Lasser et al., 2000). Historically, the prevalence of smoking has been higher among active duty military personnel (Bray et al., 2006) and veterans of the military (Brown, 2010) than in the general population. There is evidence that this disparity is diminishing in the veteran population (Hamlett-Berry et al., 2013).

BRIEF HISTORY OF TOBACCO CONTROL

The release of the 1964 report on smoking and health spurred our current tobacco control activities, and efforts increased dramatically beginning in the 1990s. In the early 1990s tobacco control advocates and policy makers focused on preventing children from initiating tobacco use. Congress included an important policy lever, known as the Synar Amendment to the Alcohol, Drug Abuse, and Mental Health Administration Reorganization Act,[2] aimed at decreasing youth access to tobacco. The Synar program re-

[2] ADAMHA Reorganization Act of 1992, Public Law 102-321, 102nd Cong. (July 10, 1992).

quires states to have laws in place prohibiting the sale and distribution of tobacco products to persons under the age of 18 and to enforce those laws effectively (SAMHSA, 2014). Failure to meet these requirements may result in a state losing 40 percent of its substance abuse prevention and treatment block grant. The Synar program is described in detail in Chapter 5.

In 1994 a committee convened by the Institute of Medicine (IOM) released the report *Growing Up Tobacco Free* (IOM, 1994). The report called for a comprehensive youth-oriented tobacco control strategy. The strategy included Congress establishing a regulatory program for tobacco products within an appropriate agency of the Public Health Service. In 1995 the commissioner of the Food and Drug Administration (FDA), Dr. David Kessler, famously declared smoking a "pediatric disease" because "nicotine addiction begins when most tobacco users are teen-agers" (Hilts, 1995). In 1996 FDA issued a final rule prohibiting the sale of cigarettes and smokeless tobacco to any person under age 18 and imposing restrictions on the marketing, labeling, and advertising of tobacco products (HHS, 1996). While this 1996 rule was invalidated in 2000 by a Supreme Court decision ruling that FDA did not have the authority to regulate tobacco products,[3] it was specifically incorporated in the Family Smoking Prevention and Tobacco Control Act of 2009[4] (hereafter referred to as the Tobacco Control Act).

The Master Settlement Agreement of 1998 (MSA) resulted from settlements between the attorneys general of 46 states and the 4 largest tobacco manufacturers (NAAG, 1998). The MSA required the companies to make annual payments to the states as compensation for some of the medical costs of caring for people with smoking-related diseases; to curtail or end certain tobacco marketing practices; and to dissolve tobacco industry organizations. The MSA also called for the establishment of a national foundation, which led to the creation of the American Legacy Foundation, a nonprofit tobacco control research and education organization known for its early and aggressive media campaigns about the dangers of tobacco use.

The child-focused strategy, although not universally embraced (Craig and Boris, 2007; Glantz, 1996), galvanized attention and resources, and significant successes followed. For example, the proportion of students in grades 9 through 12 who had used tobacco products in the past 30 days (including cigarettes, smokeless tobacco products, and cigars) decreased 46.1 percent between 1997 and 2011, from 43.4 percent to 23.4 percent (CDC, 2012b). This remarkable progress sprung from a number of well-established policy levers: increased state and federal excise taxes, compre-

[3] *FDA v. Brown & Williamson Tobacco Corp.*, 529 U.S. 120, 120 S. Ct. 1291, 146 L. Ed. 2d 121 (2000).

[4] Family Smoking Prevention and Tobacco Control Act of 2009, Public Law 111-31, 111th Cong. (June 22, 2009).

hensive state tobacco control programs, smoke-free policies that help to denormalize smoking behavior and to decrease secondhand smoke exposure, national and local media campaigns to alert children and adolescents to the dangers of tobacco use and to de-glamorize the behavior, promotion of cessation strategies, school-based programs, and surveillance and evaluation.

Today, most tobacco control programs are administered at the state and local levels. States fund their tobacco control programs through a variety of revenue streams, including state general funds, federal government funding, tobacco industry settlement payments, cigarette excise taxes, and funding from nonprofit organizations. The Office on Smoking and Health at the Centers for Disease Control and Prevention (CDC) compiles and publishes an evidence-based guide to help states plan and establish effective tobacco control programs (CDC, 2014). CDC recommends that state programs be funded at $10.53 per person in the state population. While most states spend significantly less than that (CDC, 2012a), funding for state tobacco control programs has nonetheless been shown to be associated with decreases in adolescent and young adult smoking (Farrelly et al., 2013, 2014).

STATEMENT OF TASK

The Tobacco Control Act amended the Federal Food, Drug, and Cosmetic Act to grant FDA broad authority over tobacco products administered by a newly created Center for Tobacco Products (CTP) funded with user fees paid by the tobacco industry. The Tobacco Control Act directed FDA to, among other things, issue regulations to restrict cigarette and smokeless tobacco retail sales to youth and restrict tobacco product advertising and marketing to youth. (See Box 1-1 for a summary of the major components of the Tobacco Control Act.) On the other hand, the act specifically prohibits FDA from taking certain actions, including reducing nicotine levels in tobacco products to zero, requiring a prescription to purchase tobacco products, banning the face-to-face sale of tobacco products in any one specific category retail environment, banning specific classes of tobacco products, and establishing a minimum age of sale of tobacco products higher than 18 years of age.[5] The Tobacco Control Act did, however, direct FDA to convene a panel of experts to conduct a study on "the public health implications of raising the minimum age to purchase tobacco products" and to submit a report to Congress on the issue.

[5] Family Smoking Prevention and Tobacco Control Act of 2009, Public Law 111-31 § 906, 111th Cong. (June 22, 2009).

BOX 1-1
Key Components of the Family Smoking Prevention and Tobacco Control Act of 2009

What the Tobacco Control Act does

Restricts cigarettes and smokeless tobacco retail sales to youth by directing FDA to issue regulations which, among other things:

- Require proof of age to purchase these tobacco products—the federal minimum age to purchase is 18—Sec. 102
- Require face-to-face sales, with certain exemptions for vending machines and self-service displays in adult-only facilities—Sec. 102
- Ban the sale of packages of fewer than 20 cigarettes—Sec. 102

Restricts tobacco product advertising and marketing to youth by directing FDA to issue regulations which, among other things:

- Limit color and design of packaging and advertisements, including audio-visual advertisements—Sec. 102 (However, implementation of this provision is uncertain due to pending litigation. See *Discount Tobacco City & Lottery v. USA*, formerly *Commonwealth Brands v. FDA*.)
- Ban tobacco product sponsorship of sporting or entertainment events under the brand name of cigarettes or smokeless tobacco—Sec.102
- Ban free samples of cigarettes and brand-name non-tobacco promotional items—Sec. 102

Note: Among its many provisions, the Tobacco Control Act required FDA to reissue its 1996 final regulations aimed at restricting the sale and distribution of cigarette and smokeless tobacco products—Sec. 102

The Tobacco Control Act specifically

Requires bigger, more prominent warning labels for cigarettes and smokeless tobacco products:

However, the implementation date of more prominent warning labels for cigarettes is uncertain, due to ongoing proceedings in the case of *R. J. Reynolds Tobacco Co. v. U.S. Food and Drug Administration*, No. 11-1482 (D.D.C.), on appeal, No. 11-5332 (D.C.Cir.).

Gives FDA authority over, among other things:

- Registration and inspection of tobacco companies—Sec. 905 of the FDCA
- Standards for tobacco products—Sec. 907 of the FDCA
- "Premarket Review" of new tobacco products—Sec. 910 and 905 of the FDCA
- "Modified risk" products—Sec. 911 of the FDCA
- Enforcement action plan for advertising and promotion restrictions—Sec. 105

The Tobacco Control Act also requires

- Tobacco industry must disclose research on the health, toxicological, behavioral, or physiologic effects of tobacco use—Sec. 904 of the FDCA
- Tobacco industry must disclose information on ingredients and constituents in tobacco products, and must notify FDA of any changes—Sec. 904 of the FDCA

How FDA oversees the implementation of the Tobacco Control Act

Among other things, FDA:

- Established the Center for Tobacco Products to implement the Tobacco Control Act—Sec. 901 of the FDCA
- Established the Tobacco Products Scientific Advisory Committee to provide advice, information, and recommendations to FDA—Sec. 917 of the FDCA
- Assesses user fees on tobacco product manufacturers and importers based on their market share. The fees are used to fund FDA activities related to the regulation of tobacco products—Sec. 919 of the FDCA
- Reports to Congress on how best to encourage companies to develop innovative products that help people stop smoking—Sec. 918 of the FDCA
- Issues regulations and conducts inspections to investigate illicit trade in tobacco products—Sec. 920 of the FDCA
- Convenes a panel of experts to study the public health implications of raising the minimum age to purchase tobacco products—Sec. 104

Limits on FDA's authority:

FDA cannot:

- Ban certain specified classes of tobacco products—Sec. 907 of the FDCA
- Require the reduction of nicotine yields to zero—Sec. 907 of the FDCA
- Require prescriptions to purchase tobacco products—Sec. 906 of the FDCA
- Ban face-to-face tobacco sales in any particular category of retail outlet—Sec. 906 of the FDCA

The Tobacco Control Act preserves the authority of state, local, and tribal governments to regulate tobacco products in certain specific respects. It also prohibits, with certain exceptions, state and local requirements that are different from, or in addition to, requirements under the provisions of the FDCA relating to specified areas.

SOURCE: FDA, 2014.

In August 2013 FDA contracted with the IOM to convene a committee to:

1. Examine existing literature on tobacco use initiation, and
2. Use modeling and other methods, as appropriate, to predict the likely public health outcomes of raising the minimum age for purchase of tobacco products to 21 years and 25 years.

The resulting Committee on the Public Health Implications of Raising the Minimum Age for Purchasing Tobacco Products comprises experts in public health law, epidemiology of tobacco use and tobacco risks, adolescent and young adult development, risk behaviors and perceptions, public health policy and practice, and public policy modeling. (See Appendix F for the biographical sketches of committee members.) The committee met five times, including holding a public workshop. (See Appendix E for the agendas of public meetings.)

Interpreting the Statement of Task

At its first meeting, a representative of CTP discussed the charge with the committee. During that discussion, CTP urged the committee to include in its analysis the impact of raising the minimum age to 19, 21, and 25 years of age and the committee has done so. CTP also encouraged the committee to conceive broadly the definition of "public health impact." As described in future chapters, the committee assessed the effects of possible policy changes on tobacco initiation, prevalence, morbidity, and mortality. However, because the charge is limited to public health implications, the committee did not analyze the overall economic impact of raising the minimum age.

Because the Tobacco Control Act refers to both minimum age for purchase[6] and minimum age for sale,[7] there is some ambiguity regarding the scope of the legal restriction the committee has been instructed to assess. The committee interpreted its charge to focus on the minimum age of legal access to tobacco products (MLA) in the context of the body of youth access laws and enforcement policies currently in place across the country. As will be discussed at length in this report, these laws and policies vary considerably, not only in the scope of the conduct that is prohibited but also in the prescribed penalties for violations. What all of the laws and policies have in common, however, is a focus on curtailing retail access to tobacco products by underage persons, with little, if any, emphasis on punishing

[6] Id. § 104.
[7] Id. § 906.

the underage users of tobacco products themselves. As requested by CTP, the committee has made no recommendations on whether the MLA should be raised. The report is limited to findings and conclusions bearing on the public health implications of raising the MLA as well as a review of relevant policy considerations.

As the reader will see, there exists an abundance of relevant data on adolescent tobacco use, risks of tobacco use, effects of youth access restrictions and their enforcement, and adolescent and young adult brain and psychosocial development. However, there are many important unknowns, including a rapidly changing landscape of tobacco products. The recent increase in the use of electronic nicotine delivery systems and hookahs by adolescents and young adults could have a substantial effect on the use of cigarettes and other combustible tobacco products, but it is too early to make informed predictions about these effects.

Additionally, there is no direct empirical evidence on the effects on adolescent and young adult tobacco use of raising the MLA above 18 years of age. Four states have an MLA of 19 years, but the effect of setting the age at 19 has not been studied. Several small jurisdictions in Massachusetts have raised the MLA above 18 years, but, again, the effect of doing so has not been evaluated. New York City raised the MLA to 21 years as of May 2014, but insufficient time has passed to study its effect. In the absence of pertinent studies of the effect of raising the MLA for tobacco, the committee drew on the relevant bodies of literature on adolescent and young adult development, the epidemiology of tobacco use, enforcement of youth access restrictions, studies of the effect of raising the minimum legal drinking age for alcohol, and the effects of other tobacco control policies to estimate the likely effects of raising the MLA for tobacco on initiation of tobacco use and the health consequences of that level of tobacco use.

Use of Models in This Report

The charge to the committee specifically includes the use of modeling. Simulation modeling is the primary tool used to assess the potential outcomes, benefits, and costs of public health and policy interventions (Feuer et al., 2004; Habbema et al., 2006; NRC, 1994; Thompson and Graham, 1996). Models complement traditional statistical and epidemiological approaches, and they translate and synthesize available evidence into an integrated framework to assist with decision making. Notable examples of the application of simulation models in non-tobacco public health policy include pandemic preparedness (Halloran et al., 2008), the design of optimal vaccination strategies (Elbasha et al., 2009; Kim and Goldie, 2008; Kim et al., 2009; Thompson, 2013; Thompson et al., 2015; Van de Velde et al., 2012), cocaine use simulations (Caulkins et al., 2007; Rydell and

Everingham, 1994), and the assessment of effective cancer screening strategies (de Koning et al., 2014; Knudsen et al., 2007; Mandelblatt et al., 2009; Zauber et al., 2008). Some guidelines exist to support the development of policy models in some domains, and generally they suggest that comparing and contrasting the predictions from different models can enhance the validity of the conclusions and allow for the exploration of a wider range of assumptions and of potential policy and health outcomes (Caro et al., 2012; Eddy et al., 2012; Habbema et al., 2006; Mandelblatt et al., 2009; Weinstein et al., 2003; WHO, 2008; Zauber et al., 2008).

To date, tobacco control simulation models have focused primarily on cigarette smoking and have provided estimates of the impact of current policies (program evaluation), forecasts of their future effects (status quo projections), and assessments of the possible effects of new policies (Ahmad, 2005a,b; HHS, 2014; Holford et al., 2014; Levy et al., 2005, 2010, 2012; Mendez and Warner, 2000; Mendez et al., 2013; NCI, 2007; Warner and Mendez, 2012). Reports from the U.S. government have highlighted the important insights of these models (HHS, 2014; NCI, 2007).

For this report, the committee commissioned the use of two established cigarette smoking macro-simulation models to complement its conclusions about the effects of a change in the MLA on tobacco initiation by providing quantitative estimates of how the likely effects on initiation would affect future smoking prevalence and select measures of smoking-related morbidity and mortality. The models are the Cancer Intervention and Surveillance Modeling Network (CISNET)[8] smoking population model and the SimSmoke model. Both models simulate annual age-specific smoking prevalence and smoking-attributable mortality. In addition, CISNET models the variation in smoking patterns by birth cohort and can account for the effects of smoking intensity. SimSmoke models the effects of important tobacco control policies and supports the simulation of maternal and child health outcomes. While increasing the MLA is currently the purview of states and localities, the models project the effects of a policy change on the United States as a whole and cannot take into consideration important differences across the country that could influence the magnitude of the effect of raising the MLA in states or localities.

[8] CISNET is a consortium of National Cancer Institute–sponsored investigators who use statistical modeling to improve the understanding of cancer control interventions in prevention, screening, and treatment and also their effects on population trends in incidence and mortality. As noted, for simplicity, the committee uses CISNET to refer both to the consortium as well as to the CISNET smoking population model used in this report.

OUTLINE OF THE REPORT

The next five chapters provide foundational material on tobacco use patterns (Chapter 2), brain and psychosocial development in adolescents and young adults (Chapter 3), health effects of tobacco use (Chapter 4), the current legal landscape regarding minimum age laws and the enforcement of youth access restrictions (Chapter 5), and the effectiveness of youth access restrictions (Chapter 6). The committee's conclusions regarding the likely impact of raising the MLA on initiation and prevalence of tobacco use are set forth in Chapter 7 and the conclusions on the likely impact of raising the MLA on morbidity and mortality are found in Chapter 8. The report concludes with a discussion of the considerations for policy makers. The details of the models used can be found in Appendix D, along with comprehensive results.

REFERENCES

Ahmad, S. 2005a. Closing the youth access gap: The projected health benefits and cost savings of a national policy to raise the legal smoking age to 21 in the United States. *Health Policy* 75(1):74–84.

———. 2005b. The cost-effectiveness of raising the legal smoking age in California. *Medical Decision Making* 25(3):330–340.

Bray, R. M., K. L. Rae Olmsted, J. Williams, R. P. Sanchez, and M. Hartzell. 2006. Progress toward Healthy People 2000 objectives among U.S. military personnel. *Preventive Medicine* 42(5):390–396.

Brown, D. W. 2010. Smoking prevalence among U.S. veterans. *Journal of General Internal Medicine* 25(2):147–149.

Caro, J. J., A. H. Briggs, U. Siebert, K. M. Kuntz, and ISPOR–SMDM Modeling Good Research Practices Task Force. 2012. Modeling good research practices—Overview: A report of the ISPOR–SMDM Modeling Good Research Practices Task Force-1. *Medical Decision Making* 32(5):667–677.

Caulkins, J. P., P. Dietze, and A. Ritter. 2007. Dynamic compartmental model of trends in Australian drug use. *Health Care Management Science* 10(2):151–162.

CDC (Centers for Disease Control and Prevention). 2012a. State tobacco revenues compared with tobacco control appropriations—United States 1998–2010. *Morbidity and Mortality Weekly Report* 61(20):370–374.

———. 2012b. Trends in the prevalence of tobacco use—National YRBS: 1991–2011. http://www.cdc.gov/healthyyouth/yrbs/pdf/us_tobacco_trend_yrbs.pdf (accessed January 20, 2015).

———. 2014. *Best practices for comprehensive tobacco control programs—2014*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

Cornfield, J., W. Haenszel, E. C. Hammond, A. M. Lilienfeld, M. B. Shimkin, and E. L. Wynder. 1959. Smoking and lung cancer: Recent evidence and a discussion of some questions. *Journal of the National Cancer Institute* 22(1):173–203.

Craig, M. J., and N. W. Boris. 2007. Youth tobacco access restrictions: Time to shift resources to other interventions? *Health Promotion Practice* 8(1):22–27.

de Koning, H. J., R. Meza, S. K. Plevritis, K. ten Haaf, V. N. Munshi, J. Jeon, S. A. Erdogan, C. Y. Kong, S. S. Han, J. van Rosmalen, S. E. Choi, P. F. Pinsky, A. Berrington de Gonzalez, C. D. Berg, W. C. Black, M. C. Tammemagi, W. D. Hazelton, E. J. Feuer, and P. M. McMahon. 2014. Benefits and harms of computed tomography lung cancer screening strategies: A comparative modeling study for the U.S. Preventive Services Task Force. *Annals of Internal Medicine* 160(5):311–320.

Doll, R., and A. B. Hill. 1954. The mortality of doctors in relation to their smoking habits. *BMJ* 1(4877):1451–1455.

Dorn, H. F. 1959. Tobacco consumption and mortality from cancer and other diseases. *Public Health Reports* 74(7):581–593.

Eddy, D. M., W. Hollingworth, J. J. Caro, J. Tsevat, K. M. McDonald, J. B. Wong, and ISPOR-SMDM Modeling Good Research Practices Task Force. 2012. Model transparency and validation: A report of the ISPOR–SMDM Modeling Good Research Practices Task Force-7. *Value in Health* 15(6):843–850.

Elbasha, E. H., E. J. Dasbach, R. P. Insinga, R. M. Haupt, and E. Barr. 2009. Age-based programs for vaccination against HPV. *Value in Health* 12(5):697–707.

Fagan, P., and N. A. Rigotti. 2009. Light and intermittent smoking: The road less traveled. *Nicotine & Tobacco Research* 11(2):107–110.

Fagan, P., E. T. Moolchan, D. Lawrence, A. Fernander, and P. K. Ponder. 2007. Identifying health disparities across the tobacco continuum. *Addiction* 102(Suppl 2):5–29.

Farrelly, M. C., B. R. Loomis, B. Han, J. Gfroerer, N. Kuiper, G. L. Couzens, S. Dube, and R. S. Caraballo. 2013. A comprehensive examination of the influence of state tobacco control programs and policies on youth smoking. *American Journal of Public Health* 103(3):549–555.

Farrelly, M. C., B. R. Loomis, N. Kuiper, B. Han, J. Gfroerer, R. S. Caraballo, T. F. Pechacek, and G. L. Couzens. 2014. Are tobacco control policies effective in reducing young adult smoking? *Journal of Adolescent Health* 54(4):481–486.

FDA (Food and Drug Administration). 2014. Overview of the Family Smoking Prevention and Tobacco Control Act. http://www.fda.gov/downloads/TobaccoProducts/GuidanceComplianceRegulatoryInformation/UCM336940.pdf (accessed November 20, 2014).

Feuer, E. J., R. Etzioni, K. A. Cronin, and A. Mariotto. 2004. The use of modeling to understand the impact of screening on U.S. mortality: Examples from mammography and PSA testing. *Statistical Methods in Medical Research* 13(6):421–442.

Glantz, S. A. 1996. Preventing tobacco use—The youth access trap. *American Journal of Public Health* 86(2):156–158.

Habbema, J. D., C. B. Schechter, K. A. Cronin, L. D. Clarke, and E. J. Feuer. 2006. Modeling cancer natural history, epidemiology, and control: Reflections on the CISNET breast group experience. *Journal of the National Cancer Institute Monographs* 36:122–126.

Halloran, M. E., N. M. Ferguson, S. Eubank, I. M. Longini, Jr., D. A. Cummings, B. Lewis, S. Xu, C. Fraser, A. Vullikanti, T. C. Germann, D. Wagener, R. Beckman, K. Kadau, C. Barrett, C. A. Macken, D. S. Burke, and P. Cooley. 2008. Modeling targeted layered containment of an influenza pandemic in the United States. *Proceedings of the National Academy of Sciences of the United States of America* 105(12):4639–4644.

Hamlett-Berry, K., D. E. Christofferson, and R. A. Martinello. 2013. Smoking and tobacco use within the Department of Veterans Affairs. *American Journal of Public Health* 103(7):e3.

Hammond, E. C., and D. Horn. 1958. Smoking and death rates: Report on forty-four months of follow-up of 187,783 men, 2: Death rates by cause. *JAMA* 166(11):1294–1308.

HHS (Department of Health and Human Services). 1996. 21 CFR parts 801, 803, 804, 807, 820, and 897, Regulations restricting the sale and distribution of cigarettes and smokeless tobacco to protect children and adolescents; final rule. *Federal Register* 61(168):44396–44618.

———. 2012. *Preventing tobacco use among youth and young adults: A report of the Surgeon General*. Atlanta GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

———. 2014. *The health consequences of smoking—50 years of progress: A report of the Surgeon General.* Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

Hilts, P. J. 1995. F.D.A. Head calls smoking a pediatric disease. *The New York Times* (March 9, 1995). http://www.nytimes.com/1995/03/09/us/fda-head-calls-smoking-a-pediatric-disease.html (accessed February 4, 2015).

Holford, T. R., R. Meza, K. E. Warner, C. Meernik, J. Jeon, S. H. Moolgavkar, and D. T. Levy. 2014. Tobacco control and the reduction in smoking-related premature deaths in the United States, 1964–2012. *JAMA* 311(2):164–171.

IOM (Institute of Medicine). 1994. *Growing up tobacco free: Preventing nicotine addiction in children and youths*. Edited by B. S. Lynch and R. J. Bonnie. Washington, DC: National Academy Press.

IOM and NRC (Institute of Medicine and National Research Council). 2014. *Investing in the health and well-being of young adults*. Edited by R. J. Bonnie, C. Stroud, and H. Breiner. Washington, DC: The National Academies Press.

Johnston, L. D., P. M. O'Malley, R. A. Miech, J. G. Bachman, and J. E. Schulenberg. 2014. *Monitoring the future: National survey results on drug use, 1975–2013: Overview, key findings on adolescent drug use*. Ann Arbor: Institute for Social Research, University of Michigan.

Kann, L., S. Kinchen, S. L. Shanklin, K. H. Flint, J. Hawkins, W. A. Harris, R. Lowry, E. O'Malley Olsen, T. McManus, D. Chyen, L. Whittle, E. Taylor, Z. Demissie, N. Brener, J. Thornton, J. Moore, and S. Zaza, Centers for Disease Control and Prevention. 2014. Youth risk behavior surveillance—United States, 2013. *Morbidity and Mortality Weekly Report Surveillance Summaries* 63(4):1–168.

Kim, J. J., and S. J. Goldie. 2008. Health and economic implications of HPV vaccination in the United States. *New England Journal of Medicine* 359(8):821–832.

Kim, J. J., J. Ortendahl, and S. J. Goldie. 2009. Cost-effectiveness of human papillomavirus vaccination and cervical cancer screening in women older than 30 years in the United States. *Annals of Internal Medicine* 151(8):538–545.

Knudsen, A. B., P. M. McMahon, and G. S. Gazelle. 2007. Use of modeling to evaluate the cost-effectiveness of cancer screening programs. *Journal of Clinical Oncology* 25(2):203–208.

Lasser, K., J. W. Boyd, S. Woolhandler, D. U. Himmelstein, D. McCormick, and D. H. Bor. 2000. Smoking and mental illness: A population-based prevalence study. *JAMA* 284(20):2606–2610.

Leas, E. C., R. W. Zablocki, S. D. Edland, and W. K. Al-Delaimy. 2014. Smokers who report smoking but do not consider themselves smokers: A phenomenon in need of further attention. *Tobacco Control.* Epub February 5.

Lee, J. G., G. K. Griffin, and C. L. Melvin. 2009. Tobacco use among sexual minorities in the USA, 1987 to May 2007: A systematic review. *Tobacco Control* 18(4):275–282.

Levy, D. T., N. Nikolayev, and E. A. Mumford. 2005. Recent trends in smoking and the role of public policies: Results from the SimSmoke tobacco control policy simulation model. *Addiction* 100(10):1526–1537.

Levy, D. T., A. L. Graham, P. L. Mabry, D. B. Abrams, and C. T. Orleans. 2010. Modeling the impact of smoking cessation treatment policies on quit rates. *American Journal of Preventive Medicine* 38(3S):S364–S372.

Levy, D., L. M. de Almeida, and A. Szklo. 2012. The Brazil SimSmoke policy simulation model: The effect of strong tobacco control policies on smoking prevalence and smoking-attributable deaths in a middle income nation. *PLoS Medicine* 9(11):1–12.

Mandelblatt, J. S., K. A. Cronin, S. Bailey, D. A. Berry, H. J. de Koning, G. Draisma, H. Huang, S. J. Lee, M. Munsell, S. K. Plevritis, P. Ravdin, C. B. Schechter, B. Sigal, M. A. Stoto, N. K. Stout, N. T. van Ravesteyn, J. Venier, M. Zelen, E. J. Feuer, and Breast Cancer Working Group of the Cancer Intervention Surveillance Modeling Network. 2009. Effects of mammography screening under different screening schedules: Model estimates of potential benefits and harms. *Annals of Internal Medicine* 151(10):738–747.

Mendez, D., and K. E. Warner. 2000. Smoking prevalence in 2010: Why the Healthy People goal is unattainable. *American Journal of Public Health* 90(3):401–403.

Mendez, D., O. Alshanqeety, and K. E. Warner. 2013. The potential impact of smoking control policies on future global smoking trends. *Tobacco Control* 22(1):46–51.

NAAG (National Association of Attorneys General). 1998. Master settlement agreement. http://publichealthlawcenter.org/sites/default/files/resources/master-settlement-agreement.pdf (accessed September 5, 2014).

NCHS (National Center for Health Statistics). 2014. Early release of selected estimates based on data from the 2013 National Health Interview Survey. http://www.cdc.gov/nchs/data/nhis/earlyrelease/earlyrelease201403.pdf (accessed February 6, 2015).

NCI (National Cancer Institute). 2007. *Greater than the sum: Systems thinking in tobacco control*. Tobacco Control Monograph No. 18. Edited by A. Best, P. I. Clark, S. J. Leischow, and W. M. K. Torchim. Bethesda, MD: U.S. Department of Health and Human Services, National Institutes of Health, National Cancer Institute.

NRC (National Research Council). 1994. *Science and judgment in risk assessment*. Washington, DC: National Academy Press.

Pierce, J. P., M. M. White, and K. Messer. 2009. Changing age-specific patterns of cigarette consumption in the United States, 1992–2002: Association with smoke-free homes and state-level tobacco control activity. *Nicotine & Tobacco Research* 11(2):171–177.

Ryan, H., P. M. Wortley, A. Easton, L. Pederson, and G. Greenwood. 2001. Smoking among lesbians, gays, and bisexuals: A review of the literature. *American Journal of Preventive Medicine* 21(2):142–149.

Rydell, C. P., and S. S. Everingham. 1994. *Controlling cocaine: Supply versus demand programs*. Santa Monica, CA: RAND Corporation.

SAMHSA (Substance Abuse and Mental Health Services Administration). 2013. *Results from the 2012 National Survey on Drug Use and Health: Summary of national findings*. Rockville, MD: Substance Abuse and Mental Health Services Administration.

———. 2014. About the Synar amendment and program. http://beta.samhsa.gov/synar/about (accessed September 8, 2014).

Sepe, E., P. M. Ling, and S. A. Glantz. 2002. Smooth moves: Bar and nightclub tobacco promotions that target young adults. *American Journal of Public Health* 92(3):414–419.

Steinberg, L. 2012. Should the science of adolescent brain development inform public policy? *Issues in Science and Technology* 28(3):67–78.

Thompson, K. M. 2013. Modeling poliovirus risks and the legacy of polio eradication. *Risk Analysis* 33(4):505–515.

Thompson, K. M., and J. D. Graham. 1996. Going beyond the single number: Using probabilistic risk assessment to improve risk management. *Human and Ecological Risk Assessment* 2(4):1008–1034.

Thompson, K. M., R. J. Duintjer Tebbens, M. A. Pallansch, S. G. F. Wassilak, and S. L. Cochi. 2015. Polio eradicators use integrated analytical models to make better decisions. *Interfaces* 45(1):5–25.

Van de Velde, N., M. C. Boily, M. Drolet, E. L. Franco, M. H. Mayrand, E. V. Kliewer, F. Coutlee, J. F. Laprise, T. Malagon, and M. Brisson. 2012. Population-level impact of the bivalent, quadrivalent, and nonavalent human papillomavirus vaccines: A model-based analysis. *Journal of the National Cancer Institute* 104(22):1712–1723.

Warner, K. E., and D. Mendez. 2012. Accuracy and importance of projections from a dynamic simulation model of smoking prevalence in the United States. *American Journal of Public Health* 102(11):2045–2048.

Weinstein, M. C., B. O'Brien, J. Hornberger, J. Jackson, M. Johannesson, C. McCabe, B. R. Luce, and ISPOR Task Force on Good Research Practices—Modeling Studies. 2003. Principles of good practice for decision analytic modeling in health-care evaluation: Report of the ISPOR Task Force on Good Research Practices—Modeling studies. *Value in Health* 6(1):9–17.

WHO (World Health Organization). 2008. *WHO guide for standardization of economic evaluations of immunization programmes*. Geneva, Switzerland: Initiative for Vaccine Research of the Department of Immunization, Vaccines, and Biologicals.

Wynder, E. L., and E. A. Graham. 1950. Tobacco smoking as a possible etiologic factor in bronchiogenic carcinoma: A study of 684 proved cases. *JAMA* 143(4):329–336.

Zauber, A. G., I. Lansdorp-Vogelaar, A. B. Knudsen, J. Wilschut, M. van Ballegooijen, and K. M. Kuntz. 2008. Evaluating test strategies for colorectal cancer screening: A decision analysis for the U.S. Preventive Services Task Force. *Annals of Internal Medicine* 149(9):659–669.

2

Patterns of Tobacco Use by Adolescents and Young Adults

Several national surveys provide data for estimation of smoking behavior among adolescents and young adults in the United States. These data sources include Monitoring the Future Study (MTF), National Health Interview Survey (NHIS), National Longitudinal Study of Adolescent Health (Add Health), National Survey on Drug Use and Health (NSDUH), National Youth Tobacco Survey (NYTS), and Youth Risk Behavior Surveillance System (YRBSS). This chapter summarizes the rates of adolescent and young adult tobacco use as reported in these sources as well as in the 2012 Surgeon General's report *Preventing Tobacco Use Among Youth and Young Adults* (HHS, 2012). When discussing the rates of tobacco use, "tobacco use" is defined to include use of cigarettes, smokeless tobacco, cigars, and electronic nicotine delivery systems (ENDS), or "e-cigarettes." Data on rates of tobacco use among different groups, including at-risk populations, are also presented. A comprehensive synthesis of these data is described in the 2012 Surgeon General's report. This chapter then continues with evidence about the effect of age of initiation on patterns of nicotine dependence and cessation.

PREVALENCE OF CIGARETTE SMOKING

Cigarette smoking is the most common way that adolescents and young adults use tobacco, and data on prevalence of cigarette smoking are the most comprehensive and systematic and have the longest history of collection among all data on tobacco use. Additionally, combusted tobacco such as traditional cigarettes is responsible for the vast majority of tobacco-related death and disease in the United States (HHS, 2014). Thus, much of this review will focus on adolescent and young adult cigarette use; however, data on other tobacco products will be provided where available.

Table 2-1 provides current cigarette smoking rates from the 2013 YRBSS by gender, race/ethnicity, and grade. Data from the 2013 YRBSS show that slightly fewer than one in five high school seniors (19 percent) were current cigarette smokers, defined as having smoked within the 30 days immediately before the survey (Kann et al., 2014). Monitoring the Future reports similar data, with 16 percent being current smokers (Johnston et al., 2014b). These prevalence data indicate that there has been a continued decline in smoking among high school students in recent years, although the decline has been occurring at a slower rate than in the early 2000s (HHS, 2012). Both YRBSS and MTF show a substantial increase in cigarette use with increasing grade level (although YRBSS shows a decline from the 11th to the 12th, which is likely due to the fact that a number of students drop out between the 11th and 12th grades). For comparable grades (10th and 12th), the estimates for YRBSS are slightly and consistently higher than for MTF, probably due to differences in how questions are asked. The different estimates from the surveys could result from a variety of factors, and each of the surveys has relative strengths and weaknesses (SAMHSA, 2012b). YRBSS and MTF are school-based samples, so these surveys exclude school dropouts and young adults who have graduated from high school. NSDUH, on the other hand,

TABLE 2-1 Percentage of High School Students Who Currently Smoke Cigarettes by Gender, Race/Ethnicity, and Grade—YRBSS, 2013

	Female	Male	Total
Race/Ethnicity:			
White Non-Hispanic	18.1	19.1	18.6
Black Non-Hispanic	6.2	10.5	8.2
Hispanic	13.1	15.0	14.0
Grade:			
9	10.0	10.3	10.2
10	12.6	13.6	13.2
11	18.9	23.4	21.1
12	18.7	19.6	19.2
Total	15.0	16.4	15.7

NOTE: Current smoking defined as having smoked on at least 1 day during the 30 days before the survey.
SOURCE: Kann et al., 2014.

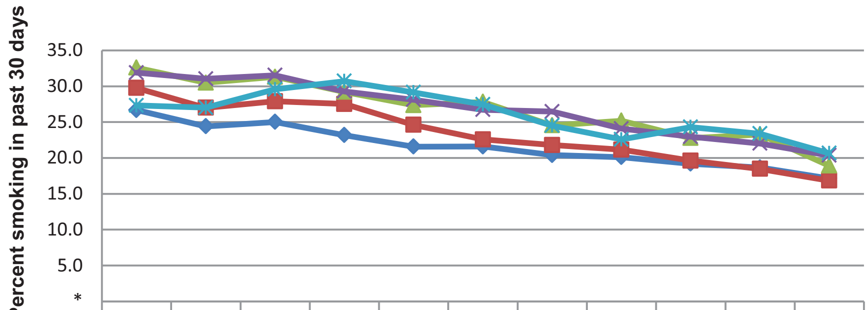
includes dropouts and has all ages 12 and older. Current smoking prevalence is highest among white adolescents, followed by Hispanic and black adolescents. Trends are similar among young adults (HHS, 2012). While black and Hispanic males smoke more than females, prevalence rates of current smoking are the same for males and females among whites.

Table 2-2 shows NSDUH estimates of monthly cigarette use by age. Note that prevalence of use continues to increase post-high school, with a

TABLE 2-2 Percentages Used Cigarettes in Past Month by Age, NSDUH, 2012

Age	Percentage
12	0.5
13	1.8
14	3.3
15	6.0
16	11.1
17	16.1
18	25.1
19	27.7
20	32.1
21	33.4
22	35.1
23	33.0
24	35.4
25	33.6
26–29	33.4
30–34	31.9
35–39	26.7
40–44	24.3
45–49	26.0
50–54	24.5
55–59	21.5
60–64	16.9
65+	10.0
Total	22.1

SOURCE: Table 2.12B from SAMHSA, 2013a.



	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
18	26.7	24.4	25.0	23.2	21.6	21.6	20.4	20.1	19.2	18.7	17.1
19-20	29.8	27.0	27.9	27.5	24.6	22.6	21.8	21.2	19.6	18.5	16.8
21-22	32.6	30.5	31.3	29.2	27.3	27.8	24.5	25.2	22.8	23.3	18.9
23-24	31.9	31.0	31.5	29.3	28.1	26.7	26.5	24.1	23.0	22.0	20.4
25-26	27.3	27.0	29.6	30.7	29.1	27.5	24.5	22.6	24.3	23.4	20.7

FIGURE 2-1 Trends in 30-day cigarette smoking prevalence by age group, 18–26, MTF, 2002 through 2012.
SOURCE: Johnston et al., 2013.

sharp increase at age 18, then leveling off around ages 21 to 22. The sharp increase from 16.1 percent at age 17 to 25.1 percent at age 18 is presumably due at least in part to the fact that the minimum legal age for purchase of tobacco products is 18.

Although MTF is a school-based sample, the study includes a longitudinal component, allowing for estimates for smoking rates for young adults who are high school graduates. Figure 2-1 shows trends from 2002 to 2012 in prevalence of 30-day cigarette smoking by age groups, from 18 to 26.

The trends show continuing declines in cigarette use among young adult high school graduates, with some convergence among age groups. NSDUH, which includes dropouts, also shows declines through 2012 among those ages 18 to 25 (SAMHSA, 2013a).

Finding 2-1: Almost one in five high school seniors is a current (in the past 30 days) cigarette smoker, compared with one in three young adults.

Socioeconomic Status

For some years cigarette smoking has been more concentrated among those with lower socioeconomic status but in recent years that concentration has become more pronounced. In adolescents and young adults, socioeconomic status is typically assessed using measures of parental (often maternal) educational attainment or of the adolescent or young adult's educational goals. Table 2-3 provides data from 10th graders in two MTF studies to illustrate the point. In 1997, when smoking rates among adolescents reached their recent peak, smoking rates were slightly higher among 10th graders whose parents had less education, but by 2013 the discrepancies had substantially widened due to a greater decline among students whose parents had more education compared with those whose parents had less education, with 13–14 percent of those whose parents had less education being smokers compared to 5–6 percent of those whose parents had more education.

The relationship between socioeconomic status and smoking also differs by racial/ethnic category (HHS, 2012). Bachman and colleagues (2011), for example, used data from MTF and found that for white students in 8th through 12th grades there was a clear negative linear relationship between parental education and smoking rates. For black students, a similar negative relationship existed between smoking and parental education, but the relationship was much smaller. For Hispanic students, the relationship was nonlinear, with smoking rates relatively high among Hispanic students with parents of higher education levels compared to white and black students, and relatively low among Hispanic students with the least educated parents compared to whites and blacks. It is possible, however, that these findings

TABLE 2-3 Percentage of 10th Graders Who Smoked Cigarettes in the Past 30 Days, by Parental Education, MTF, 1997 and 2013

Parental Education	1997	2013
1.0–2.0 (low)	28.2	12.8
2.5–3.0	33.2	13.6
3.5–4.0	30.9	10.2
4.5–5.0	28.5	6.0
5.5–6.0 (high)	24.6	4.9
Total	29.8	9.1

NOTE: Parental education is an average of mother's education and father's education. Response categories are (1) completed grade school or less, (2) some high school, (3) completed high school, (4) some college, (5) completed college, and (6) graduate or professional school after college.
SOURCE: Johnston et al., 2014a.

TABLE 2-4 Percentage of 10th Graders Who Smoked Cigarettes in the Past 30 Days, by 4-Year College Plans, MTF, 1997 and 2013

4-Year College Plans?	1997	2013
No	47.2	23.3
Yes	26.8	7.4
Total	29.8	9.1

NOTE: Respondents indicated how likely they were to graduate from a 4-year college program; those who said "definitely" or "probably will" were coded "yes."
SOURCE: Johnston et al., 2014a.

are due to the high number of Hispanic parents with low socioeconomic status (as defined by parental education).

As a further illustration, Table 2-4 provides smoking rates for two groups: those who expect to complete a 4-year college program versus those who do not. In 1997 those in the latter group were almost twice as likely to be current smokers as those in the former group (47.2 percent versus 26.8 percent), but by 2013 the ratio was more than 3 to 1 (23.3 percent versus 7.4 percent).

Among young adults, smoking rates similarly differ by education. Those who do not enroll in college are more likely to have started smoking at a younger age and to be current smokers, and they are less likely to attempt to quit smoking than their peers who enroll in college (Green et al., 2007). Also, among young adults not attending college, full-time employment is associated with higher rates of tobacco use (Welte et al., 2011).

GEOGRAPHIC VARIATION

Tables 2-5 and 2-6 provide the percentage of 12- to 17-year-olds who smoked cigarettes in the past month by region of the country and by state of residence, in combined years 2002–2003 and 2010–2011. (Combining two years of data is necessary because of the small numbers of cases available in many states.) Figure 2-2 provides a visual display of the considerable variation by state for 2010–2011. Utah had the lowest rate (5.1 percent), and West Virginia had the highest (11.8 percent) (SAMHSA, 2012c). The 10 highest states (red color in Figure 2-2, greater than 9.7 percent) were, in descending order: West Virginia, Montana, Kentucky, Missouri, Wyoming, Iowa, New Hampshire, Vermont, Oklahoma, and South Dakota. The nine lowest states, plus the District of Columbia (white color in Figure 2-2, 7.11 percent or less), were, in descending order: Texas, Virginia, Nevada,

TABLE 2-5 Percentage Using Cigarettes in the Past Month, Ages 12–17, by Region, NSDUH, 2002–2003 and 2010–2011

Region	2002–2003	2010–2011	Percentage Point Change
Total U.S.	12.57	8.07	–4.50
Northeast	12.72	8.14	–4.58
Midwest	14.63	8.84	–5.79
South	13.21	8.19	–5.02
West	9.47	7.13	–2.34

SOURCE: SAMHSA, 2012c.

Florida, New York, Hawaii, California, District of Columbia, Maryland, and Utah. Of the four regions of the country, the Midwest had the highest rates of smoking among 12- to 17-year-olds (8.8 percent), and the West had the lowest (7.1 percent). Between 2002–2003 and 2010–2011, all regions and all states showed declines.

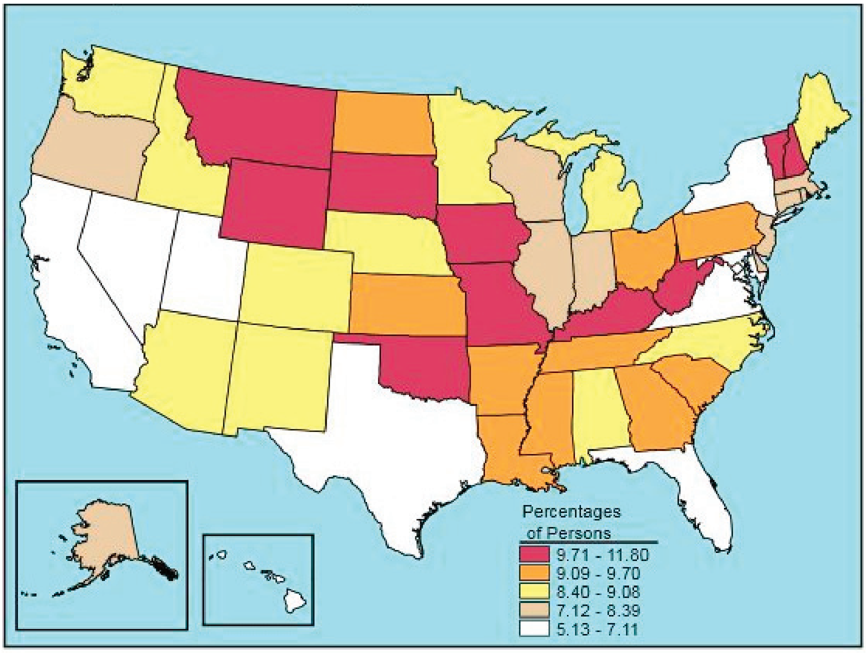


FIGURE 2-2 Cigarette use in the past month among adolescents ages 12 to 17, by state. Average annual percentages, NSDUH, 2010 and 2011.
SOURCE: SAMHSA, 2012a.

TABLE 2-6 Percentage Using Cigarettes in the Past Month, Ages 12–17, by State, NSDUH, 2002–2003 and 2010–2011

State	2002–2003	2010–2011	Change	State	2002–2003	2010–2011	Change
Alabama	13.69	8.84	–4.85	Montana	16.1	11.73	–4.37
Alaska	13.25	7.84	–5.41	Nebraska	16.36	8.87	–7.49
Arizona	12.84	8.76	–4.08	Nevada	12.73	6.95	–5.78
Arkansas	16.05	9.35	–6.7	New Hampshire	14.03	10.7	–3.33
California	7.48	6.25	–1.23	New Jersey	11.83	8.35	–3.48
Colorado	13.74	8.64	–5.1	New Mexico	12.34	9.08	–3.26
Connecticut	13.45	8.02	–5.43	New York	11.81	6.83	–4.98
Delaware	14.07	8.16	–5.91	North Carolina	14.78	8.86	–5.92
District of Columbia	7.1	5.99	–1.11	North Dakota	17.53	9.64	–7.89
Florida	12.26	6.91	–5.35	Ohio	14.52	9.62	–4.9
Georgia	12.83	9.41	–3.42	Oklahoma	14.96	10.21	–4.75
Hawaii	8.78	6.68	–2.1	Oregon	11.29	7.45	–3.84
Idaho	12.48	8.57	–3.91	Pennsylvania	14.73	9.58	–5.15

Illinois	13	7.28	–5.72	Rhode Island	13.72	8.39	–5.33
Indiana	14.39	8.06	–6.33	South Carolina	12.21	9.7	–2.51
Iowa	14.27	10.8	–3.47	South Dakota	19.79	10.18	–9.61
Kansas	13.95	9.62	–4.33	Tennessee	14.33	9.18	–5.15
Kentucky	17.62	11.66	–5.96	Texas	11.65	7.11	–4.54
Louisiana	15.01	9.14	–5.87	Utah	6.57	5.13	–1.44
Maine	12.16	8.87	–3.29	Vermont	14.84	10.48	–4.36
Maryland	11.08	5.9	–5.18	Virginia	14.17	6.99	–7.18
Massachusetts	11.69	8.16	–3.53	Washington	10.84	8.56	–2.28
Michigan	13.59	8.4	–5.19	West Virginia	17.34	11.8	–5.54
Minnesota	15.67	8.7	–6.97	Wisconsin	15.32	8.1	–7.22
Mississippi	12.83	9.37	–3.46	Wyoming	12.78	11.26	–1.52
Missouri	17.88	11.6	–6.28				

SOURCE: SAMHSA, 2012c.

Metropolitan Status

Table 2-7 provides prevalence of 30-day smoking by age group and by metropolitan status for adolescents and young adults. In each age group, the nonmetropolitan segment has the highest rate of smoking and the large metropolitan has the lowest, with the small metropolitan segment being intermediate.

Use of other tobacco products similarly varies by metropolitan status, with greater use in more rural communities and less use in more urban areas. Adolescents and young adults residing in rural communities are more likely to use tobacco and, particularly, smokeless tobacco or chew because of the cultural norms set within their communities (Melnick et al., 2001; Peek et al., in preparation). Rural life is often associated with the rodeo or being a cowboy (Peek et al., in preparation), with males playing sports such as baseball (whose athletes use smokeless tobacco at high rates), and with men being more macho and tough (Melnick et al., 2001; Peek et al., in preparation). These attitudes often translate into a situation in which it is socially normative to use tobacco in order to mirror these images. Furthermore, in these often insular, small communities where everyone is connected and knowledgeable of each other's action, younger adolescents are able to obtain chew and other tobacco products from members of their community more easily (Peek et al., in preparation).

TABLE 2-7 Percentage Smoking in the Past 30 Days by Age and Metropolitan Status, NSDUH, 2012

	12–13	14–15	16–17	18–20	21–25
Large Metropolitan	0.9	3.7	11.6	26.3	32.0
Small Metropolitan	1.1	5.4	15.2	28.9	34.5
Non-Metropolitan	1.7	8.1	18.1	34.3	42.0
Total	1.1	4.9	13.7	28.3	34.2

SOURCE: Committee analysis from SAMHSA, 2013a.

OTHER INDIVIDUAL RISK FACTORS FOR TOBACCO USE

Mental Illness

Tobacco use is also more common among those with mental illness, in part because these individuals use nicotine as a means of "self-medication," mood regulation, and stress mitigation (Ziedonis et al., 2008). On the other hand, Goodman and Capitman (2000) assessed 8,704 adolescents and found that depressive symptoms did not predict smoking. Instead, smoking predicted subsequent depressive symptoms. Similarly, greater levels of smoking during adolescence and early adulthood have been associated with a higher risk for agoraphobia, general anxiety disorder, and panic disorder (Johnson et al., 2000), suggesting that while there is a strong relationship between mental illness and smoking, the nature of this relationship is still unclear.

Sexual Orientation

Lesbian, gay, bisexual, transgender, questioning, or queer (LGBTQ) adolescents and young adults appear to use smoking as a means of coping with the stigma associated with their sexual identity (Rosario et al., 1997). Higher smoking rates among LGBTQ youth persist even after accounting for psychosocial factors such as depression, self-esteem, and familial smoking habits (Austin et al., 2004). However, it is also the case that supportive social environments (operationalized by assessing the proportion of same sex couples living in the counties studied, the proportion of schools with gay–straight alliances, the proportion of schools with policies protecting gay students, and the proportion of schools with antidiscrimination policies) have been associated with lower rate of tobacco use (Hatzenbuehler et al., 2011).

Finding 2-2: Significant disparities in tobacco use remain among adolescents and young adults nationwide. The lowest rates are found in the western United States, in large metropolitan areas, among African Americans, adolescents who plan to go to college, and adolescents whose parents' education includes graduate school or a professional degree.

INITIATION

The Surgeon General's 2012 report stated that one of the most important and widely cited findings from the 1964 Surgeon General's report on smoking and health was that cigarette smoking almost always begins before adulthood (HHS, 2012). The 2012 report corroborated that the finding still held. Table 2-8 in this report updates that information and shows that the finding is still true. Among adults ages 30 to 34 who ever smoked daily, 89.8 percent had first tried a cigarette before age 19, and 99.2 percent before age 26. The 2012 Surgeon General's report emphasized that a relatively high proportion of adult smokers initiate at a relatively early age. For example, more than one-third (36.7 percent) of adults who had ever tried a cigarette reported trying their first cigarette by age 14. The figure in Table 2-8 (36.2 percent) is virtually identical to this number (36.2 percent).

A Note on the Definition of Initiation

The preceding data on initiation has used the typical definition of initiation as being the point in time at which one first tries a cigarette, which is the way that initiation is measured by most surveys of adolescents and young adults. However, the NHIS survey used a different definition of age of initiation, which is often used in surveys of adults, and does not treat a person as having initiated smoking until that person has smoked at least 100 cigarettes. In the models reported in Chapter 8, NHIS data are used as the basis for estimating the effects that changing the minimum legal age has on initiation. This raises the question of how different these definitions are in practice. NSDUH asks about both the age of first use and whether the respondent has ever used 100-plus cigarettes in his or her life, so these data can be used to compare the distributions of ages of initiation for all NSDUH respondents versus just those who progressed to smoking 100-plus cigarettes. To summarize the results of this comparison, while the distributions are not identical, they are quite close, suggesting that this adjustment is not a major concern.

The age of first use was cross-tabulated with having smoked at least 100 cigarettes across the lifetime for 26- to 34-year-old respondents and separately for all respondents 26 and older in the NSDUH surveys of 2002 through 2012, combined. The results for all respondents 26 and older have the advantage of being based on a larger number of respondents, but the restriction to 26- to 34-year-olds limits the analysis to younger respondents, whose cigarette initiation patterns may differ from those of older respondents from earlier generations.

Figure 2-3 shows the distributions of ages of initiation for 26- to 34-year-olds. The comparison of interest is between the thick black line (for all respondents) and the thick red line (just for those who progressed to 100-plus cigarettes). The black line in some sense corresponds to MTF and other data that ask about age of first use for all who have ever smoked any cigarettes; the red line corresponds to the NHIS data, the input for the models.

TABLE 2-8 Cumulative Percentage of Recalled Ages at Which Respondents First Used a Cigarette and Began Smoking Daily, by Smoking Status Among 30- to 34-Year-Olds, NSDUH, 2012

	All Persons		Persons Who Had Ever Tried a Cigarette	Persons Who Ever Smoked Daily	
Age	First Tried a Cigarette	Began Smoking Daily	First Tried a Cigarette	First Tried a Cigarette	Began Smoking Daily
≤10	3.8	0.4	5.4	7.0	1.1
11	5.9	1.1	8.5	11.4	2.7
12	11.9	2.3	17.0	21.4	5.8
13	17.4	3.9	25.0	30.6	9.8
14	25.2	6.1	36.2	45.6	15.4
15	34.6	9.8	49.7	62.3	24.8
16	43.5	15.9	62.4	75.0	40.1
17	48.9	21.3	70.2	81.9	53.9
18	56.7	27.3	81.5	89.8	69.0
19	60.0	30.5	86.1	94.1	77.0
20	63.0	33.6	90.5	95.9	84.9
21	64.9	35.1	93.3	97.1	88.5
22	66.1	36.0	94.9	98.0	90.7
23	66.8	36.4	95.9	98.5	92.0
24	67.1	37.1	96.4	98.5	93.6

continued

TABLE 2-8 Continued

	All Persons		Persons Who Had Ever Tried a Cigarette	Persons Who Ever Smoked Daily	
Age	First Tried a Cigarette	Began Smoking Daily	First Tried a Cigarette	First Tried a Cigarette	Began Smoking Daily
25	68.0	38.4	97.7	99.2	96.8
26	68.4	38.6	98.2	99.4	97.5
27	68.8	38.8	98.9	99.5	98.0
28	69.0	38.9	99.1	99.7	98.1
29	69.2	39.2	99.3	99.9	98.9
30	69.5	39.5	99.8	100.0	99.8
31	69.5	39.5	99.8	100.0	99.8
32	69.6	39.5	100.0	100.0	99.8
33	69.6	39.6	100.0	100.0	99.9
34	69.6	39.6	100.0	100.0	100.0
Never smoked	100	100	NA	NA	NA

SOURCE: Committee analysis of data from HHS et al., 2014.

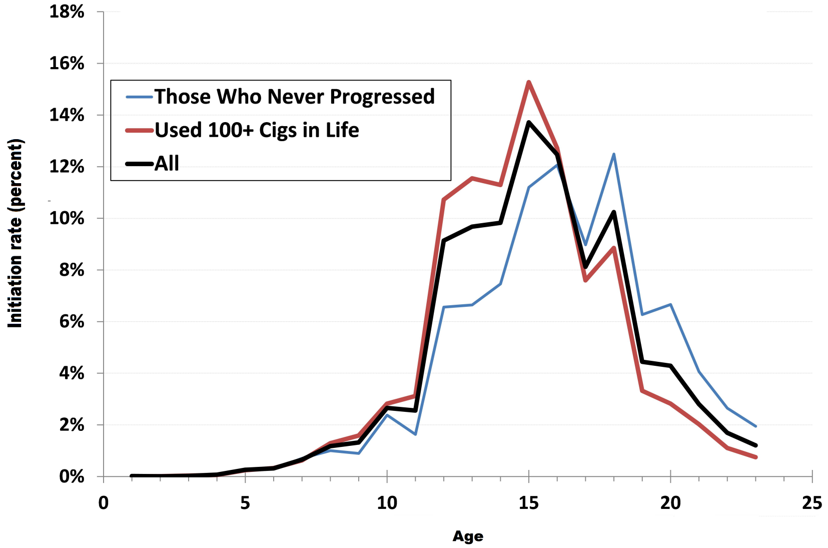


FIGURE 2-3 Age distribution of cigarette initiation reported by 26- to 34-year-olds, broken down by those who did versus those who did not progress to using 100-plus cigarettes in their lifetimes (62 percent progressed; 38 percent did not), NSDUH, 2002 through 2012.
SOURCE: Committee analysis of data from HHS et al., 2014.

Those who ended up smoking more heavily have a distribution of ages of initiation that skews slightly younger, with more initiating at ages 12–16 and fewer initiating after 17. The largest difference is at age 13; 9.7 percent of all smokers initiated at age 13, but 11.6 percent of those who progressed did so.

Figure 2-4, which shows data for all respondents age 26 and above, shows even smaller differences between those who did and those who did not progress to smoking 100-plus cigarettes.

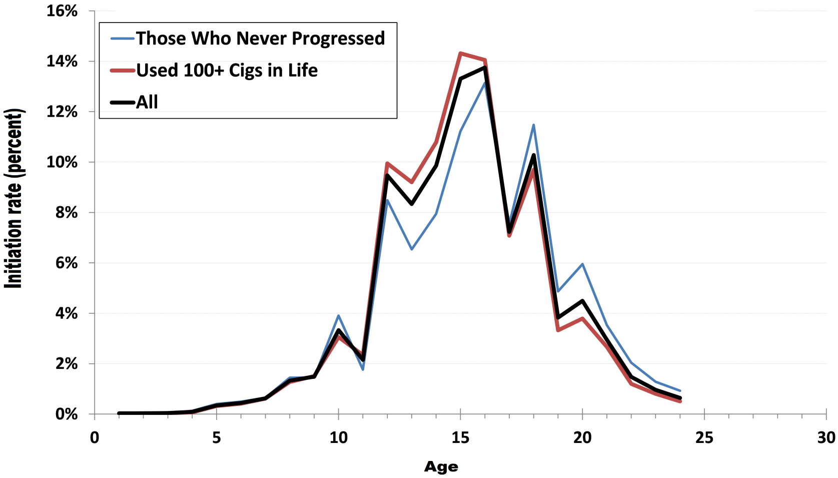


FIGURE 2-4 Age distribution of cigarette initiation reported by those 26 years old and older, broken down by those who did versus those who did not progress to using 100-plus cigarettes in their lifetimes, NSDUH, 2002 through 2012.
SOURCE: Committee analysis from HHS et al., 2014.

Finding 2-3: Among adults who become daily smokers, nearly all report first use of cigarettes before 19 years of age (90 percent), with 99 percent reporting first use before 26 years of age.

SMOKING INTENSITY

The most commonly used metric of smoking intensity is the number of cigarettes smoked per smoking day. Table 2-9 provides the average number of cigarettes smoked per smoking day for those who smoked cigarettes in the past 30 days, by age, based on 2012 NSDUH data. The right-most two columns compare the data for those who smoked less than about half a pack per day with those who smoked half a pack or more per smoking day. There are substantial increases between ages 12 through 15 and age 16, and between ages 17 and 18, but then relatively little increase in the average number of cigarettes smoked per smoking day in the age range from 18 to 20. Intensity increases substantially after that. An alternative metric for gauging the overall exposure to cigarettes is the number of days that an individual has smoked in the past month. This metric captures the frequency or regularity of use.

TABLE 2-9 Average Number of Cigarettes per Smoking Day in Past 30 Days, NSDUH, 2012

Number of cigarettes	<1	1	2–5	(½ Pack) 6–15	(1 Pack) 16–25	(1½ Packs) 26–35	(2+ Packs) 35+	Row Total	Less than ½ Pack	½ Pack or More
Age:										
12–15	33.3	26.9	33.6	4.5	1.2	0.1	0.5	100	93.7	6.3
16	24.8	20.3	36.4	16.9	1.1	0.0	0.5	100	81.5	18.5
17	21.8	23.1	35.8	14.7	4.7	0.0	0.0	100	80.7	19.4
18	15.5	20.5	34.9	20.6	5.6	1.2	1.6	100	70.9	29.0
19	17.7	18.1	34.9	19.8	8.3	0.8	0.4	100	70.7	29.3
20	12.9	19.2	35.7	22.9	8.3	0.7	0.4	100	67.8	32.3
21	13.2	16.1	32.7	25.8	9.0	2.4	0.8	100	62.0	38.0
22–23	14.1	14.1	33.8	25.0	10.9	1.8	0.3	100	62.0	38.0
24–25	10.9	11.6	32.1	27.3	15.2	2.2	0.6	100	54.6	45.3
26–29	11.9	12.3	30.4	27.6	14.5	2.5	0.7	100	54.6	45.3
30–34	7.6	6.7	26.7	31.6	21.5	3.8	2.1	100	41.0	59.0
35–49	6.5	6.2	20.4	29.7	28.4	6.9	2.0	100	33.1	67.0
50–64	3.6	6.4	19.2	29.5	27.2	9.3	4.8	100	29.2	70.8
65+	2.8	5.7	23.9	31.2	22.8	8.0	5.4	100	32.4	67.5

NOTE: Entries are percentages. The survey question was, "On the days you smoked cigarettes during the past 30 days, how many cigarettes did you smoke per day, on average?"
SOURCE: Committee analysis of data from HHS et al., 2014.

Emerging Patterns

In general, the rates of cigarette smoking have been declining, although there have been recent signs of a deceleration in that decline (SAMHSA, 2013b). In addition to this general decline, there has also been clear evidence of an increasing trend toward lighter use. One indication of this is that among those who smoked cigarettes in the past 30 days, the proportion of those who smoke every day has been decreasing, and, conversely, the proportion of nondaily smokers has been increasing. Table 2-10 provides the percentages, from 1991 to 2013, of past-30-day smokers who smoked less often than daily for four age groups, based on the Monitoring the Future study. Among young adults ages 19 to 28, the percentage of current smokers who were nondaily smokers rose steadily from 23 percent in 1991 to 40 percent in 2013. The rise in this population of lighter smokers has important implications for the understanding of nicotine addiction and dependence (Shiffman, 2009).

OTHER TOBACCO PRODUCTS

While there are several sources of reliable information on cigarettes, there is less extensive information on other tobacco products, particularly for trends in their use. The situation regarding tobacco products other than traditional cigarettes is currently highly volatile, with new products being introduced and existing products being modified. NYTS asks questions about a range of non-cigarette tobacco products, including cigars, smokeless tobacco, tobacco smoked with a hookah, pipes, electronic cigarettes, snus, kreteks, bidis, and dissolvable tobacco. Table 2-11 provides results from the 2011 and 2012 surveys.

The various products are ordered in Table 2-11 according to their total prevalence in 2012, from highest to lowest. Overall, just about one in four high school students reported using at least one tobacco product during the previous 30 days (23.3 percent in 2012). Cigarettes were the most commonly used, at 14.0 percent, but cigars were not far behind at 12.6 percent. “Cigars” includes cigars, cigarillos, and little cigars. This class of products has seen major changes in the types and number of products available and in the marketing of the products. Little cigars may be very similar to cigarettes in size and shape, and may be flavored with fruit or candy. They are typically taxed at lower rates than cigarettes and may therefore be more affordable. While the rates of current cigarette use have seen a significant decrease, the rates of smokeless tobacco use, including the use of chew, dip, or moist snuff, have remained stable or even increased. For example, among Americans age 12 or older, 3.1 percent were current (past-month) users of smokeless tobacco in 1998, and that figure was at 3.5 percent in 2012 (SAMHSA, 2013a).

TABLE 2-10 Percentage of Past 30-Day Smokers Who Smoked Less Than Daily, MTF, 2013

	Grade			
Year	8th	10th	12th	Young adult (19–28)
1991	49.7	39.4	34.6	23.0
1992	54.8	42.8	38.1	26.1
1993	50.3	42.5	36.5	25.7
1994	52.7	42.5	37.8	26.1
1995	51.3	41.6	35.5	27.4
1996	50.5	39.8	34.7	27.6
1997	53.6	39.6	32.6	31.1
1998	53.9	42.8	36.2	29.1
1999	53.7	38.1	33.2	29.0
2000	49.3	41.4	34.4	27.6
2001	54.9	42.7	35.6	29.8
2002	52.3	42.9	36.7	27.4
2003	55.9	46.7	35.2	28.5
2004	52.2	48.1	37.6	28.8
2005	57.0	49.7	41.4	31.5
2006	54.0	47.6	43.5	31.1
2007	57.7	48.6	43.1	34.0
2008	54.4	52.0	44.1	32.1
2009	58.5	51.9	44.3	35.6
2010	59.2	51.5	44.3	33.9
2011	60.7	53.4	44.9	35.5
2012	61.2	53.7	46.7	35.0
2013	60	51.6	47.9	39.5

SOURCE: Johnston et al., 2014c.

According to the 2011 YRBSS, 12.8 percent of adolescent males and 2.2 percent of adolescent females in the United States reported current use of smokeless tobacco (Eaton et al., 2012). Overall, current use of smokeless tobacco was higher among whites (9.3 percent) than among Hispanics (5.9 percent) or blacks (3.1 percent). In the NYTS survey, smokeless tobacco, which includes chewing tobacco, snuff, and dip, was used by 6.4 percent

TABLE 2-11 Percentage of High School Students Using Tobacco Products in Past 30 Days, by Gender, NYTS, 2011–2012

	Total		Female		Male		Male/Female
	2011	2012	2011	2012	2011	2012	Ratio in 2012
Any tobacco	24.3	23.3	19.0	18.1	29.4	28.3	1.56
Cigarettes	15.8	14.0	13.8	11.7	17.7	16.3	1.39
Cigars	11.6	12.6	7.4	8.4	15.7	16.7	1.99
Smokeless tobacco	7.3	6.4	1.6	1.5	12.9	11.2	7.47
Hookahs	4.1	5.4	3.5	4.5	4.8	6.2	1.38
Pipes	4.0	4.5	2.8	3.2	5.1	5.8	1.81
Electronic cigarettes	1.5	2.8	0.7	1.9	2.3	3.7	1.95
Snus	2.9	2.5	0.8	0.9	5.1	3.9	4.33
Kreteks	1.7	1.0	0.8	0.5	2.4	1.5	3.00
Bidis	2.0	0.9	1.0	0.5	2.9	1.3	2.60
Dissolvable tobacco	0.4	0.8	0.1	0.6	0.6	1.0	1.67

SOURCE: Arrazola et al., 2013.

of those surveyed. Another form of smokeless tobacco is snus, which is a relatively new product in the United States and was used by 2.5 percent.

Approximately 5 percent of the respondents reported using the hookah (waterpipe), and an equal number reported smoking pipes. Electronic cigarettes are an increasingly visible part of the tobacco product scene, but as of 2012 less than 3 percent of high school students reported using them. Nevertheless, ENDS use is increasing rapidly among adolescents. In 2014, for the first time in a U.S. national study, Monitoring the Future reported that more high school students used e-cigarettes than traditional cigarettes or any other tobacco product. The difference in the use of e-cigarettes versus traditional cigarettes was greater among younger students: 9 percent of 8th grade students reported using an e-cigarette in the past 30 days, as compared with 4 percent for traditional cigarettes; 16 percent of 10th grade students reported using an e-cigarette, as compared with 7 percent for traditional cigarettes; and 17 percent of 12th grade students reported using an e-cigarette, as compared with 15 percent for traditional cigarettes (Wadley and Bronson, 2014). Kreteks, bidis, and dissolvable tobacco (another recent addition to the group of smokeless tobacco products) all were used by 1 percent or less of respondents.

Males were more likely than females to use at least one tobacco product (28.3 percent versus 18.1 percent in 2012), and, for any given product, males were more likely than females to report using that product. The male/female ratios were particularly high for smokeless tobacco and the newer smokeless snus. The Surgeon General's 2012 report noted that as of 2010, about 1 in 10 high school senior males was a current smokeless tobacco user and about 1 in 5 high school senior males was a current cigar smoker (HHS, 2012). The 2013 YRBSS found that about one in six high school senior males was a current smokeless tobacco user, and about one in four high school senior males was a current cigar smoker (Kann et al., 2014). The use of these two classes of tobacco products clearly has not declined in recent years (HHS, 2012; Kann et al., 2014).

Table 2-12 provides some limited information on the use of tobacco products among adolescents and adults, as reported by NSDUH. As with NYTS, cigars are found to make up a relatively high proportion of tobacco product use, particularly among young adults.

Some limited trend data on smoking tobacco with a hookah are available from the Monitoring the Future study. Table 2-13 shows that smoking tobacco with a hookah is particularly popular among college students, with 26 percent reporting in 2013 having done so at least once in the previous 12 months. Even among 12th graders, the behavior is relatively common, with 21 percent reporting having done so in 2013. However, much of this behavior is light or experimental, with only 9 percent of 12th graders reporting having smoked with a hookah more than five times in the previous 12 months (Wadley and Barnes, 2013).

TABLE 2-12 Percentage Who Used Tobacco Products in Past 30 Days by Age, NSDUH, 2012

Age	Smokeless Tobacco	Cigars	Pipe	Cigarettes	Any Tobacco Products
12–13	0.4	0.4	0.3	1.2	1.6
14–15	1.7	1.7	0.5	4.6	6.3
16–17	4.0	5.6	1.2	13.6	17.6
18–20	5.4	11.9	2.1	28.2	34.9
21–25	5.6	10.0	1.6	34.1	40.0
26–34	4.7	7.3	1.1	32.6	37.5
35+	3.0	3.9	0.8	20.1	24.7

SOURCE: SAMHSA, 2013a.

TABLE 2-13 Prevalence of Hookah Use in Past 12 Months, MTF, 2010 Through 2013

	2010	2011	2012	2013
12th grade	17.1	18.5	18.3	21.4
College students		27.9	25.7	26.1
Young adults (19–28)		20.1	19.1	20.4

SOURCES: Johnston et al., 2014b; Wadley and Barnes, 2013.

The Surgeon General's report of 2012 data concluded that concurrent use of multiple tobacco products (poly-tobacco use; usually using cigarettes and another tobacco product) was prevalent among adolescents. Among those who use tobacco, nearly one-third of high school females and more than one-half of high school males report having used more than one tobacco product in the past 30 days. By 2012, more than one-third of high school female users were poly-tobacco users. In the 2012 NYTS, of the 15.4 percent of high school females who reported tobacco use, 38 percent of them—or 5.9 percent of all high school females—reported using more than one tobacco product; the corresponding figures for high school males were 55 percent of 25.3 percent, or 13.8 percent of all high school males (Arrazola et al., 2014).

Finding 2-4: Concurrent use of multiple tobacco products is prevalent among adolescents.

Finding 2-5: It is difficult to assess trends in non-cigarette products because the products themselves are changing. While cigarette use has been declining, the use of some other products has not.

PATTERNS OF USE AND PROGRESSION OF NICOTINE DEPENDENCE

Tobacco use in adolescents and in young adults is not a unitary phenomenon; instead it is best characterized by a series of events that involve multiple behaviors and feelings (Mayhew et al., 2000) and transitions in a sequence from initial trials with tobacco to more occasional use, to the development of dependence and regular use, through to cessation. Tobacco use in adolescence is highly variable in terms of both frequency of use and intensity of use (Mermelstein et al., 2002).

Age-based prevalence data for tobacco use provide cross-sectional views of tobacco use from which one can assume patterns of progression. However, while such cross-sectional prevalence data can provide information about the total number of smokers at a given age and even offer insights into how many individuals have started or stopped smoking in a given year, they are less directly informative about individual differences in progression of tobacco use behavior. With the use of newer data analytic techniques (e.g., latent variable growth mixture modeling), researchers have identified various trajectories of smoking behavior among adolescents and young adults (e.g., Bernat et al., 2008; Brook et al., 2008; Chassin et al., 2008; Colder et al., 2001, 2008; Costello et al., 2008; Jackson et al., 2008; Lessov-Schlaggar et al., 2008; Riggs et al., 2007; Stanton et al., 2004; Tucker et al., 2006). These approaches may help to better describe the heterogeneity of longitudinal patterns of use and to identify factors that discriminate among the different trajectories. Among the trajectories that have been identified are groups of adolescents who experiment but have non-escalating trajectories and other groups that escalate rapidly. Unfortunately, these studies have not to date provided the fine-grained age detail during the young adult period necessary to reliably identify the differences between those individuals who initiate and escalate starting in young adulthood and those who initiate during the earlier adolescent years. In addition, most of these studies have provided data on the broad population of adolescents, most of whom fall into the nonsmoking trajectories. As such, they provide less in-depth information on the patterns of progression of those adolescents who try tobacco use. Furthermore, all of these studies have focused exclusively on cigarette use, and none have considered how the use of other tobacco products (e.g., cigars, smokeless tobacco, hookah, etc.) may affect these trajectories. In addition, to date there has been no systematic data collected concerning how patterns of tobacco product use may vary by product or by combinations of products, including product switching. The changing landscape of available tobacco products may well affect overall patterns of use.

The often irregular pattern of tobacco use behavior presents a challenge for clearly identifying exactly when nicotine dependence develops in the progression of tobacco use. The level of dependence symptoms that individuals experience is believed to be the most important factor contributing to smoking persistence and failed cessation efforts. Nicotine dependence is characterized by physiological adaptations (e.g., tolerance, withdrawal) and other accommodating behaviors (e.g., time spent in activities necessary to obtain and use nicotine and to recover from its effects and the forfeiting or reduction of important social, occupational, or recreational activities) resulting from chronic smoking. Nicotine dependence predicts smoking regularity and quantity across adolescence into young adulthood (Dierker and Mermelstein, 2010; O'Loughlin et al., 2003; Selya et al., 2013). Ongoing longitudinal studies of adolescent smoking that have examined the development of nicotine dependence symptoms suggest that nicotine dependence follows different developmental trajectories in different individuals (Hu et al., 2008) and that for some adolescents, nicotine dependence symptoms emerge very soon after the onset of smoking and at low levels of nicotine exposure, well before the establishment of daily smoking patterns (Dierker and Mermelstein, 2010; DiFranza et al., 2002). The McGill Study on the Natural History of Nicotine Dependence in Teens confirmed individual differences in the emergence of dependence and identified adolescents meeting the criteria for ICD-10 nicotine dependence even among sporadic and monthly smokers (O'Loughlin et al., 2003). Demographic (gender, ethnicity) differences may also affect the development of nicotine dependence at low levels of smoking exposure. For example, women have been shown to have higher rates of dependence than men who engage in the same amount of smoking (Kandel and Chen, 2000). In addition, compared to other racial groups, whites have been found to have lower rates of lifetime nicotine dependence (Hu et al., 2006; Kandel and Chen, 2000) and higher quit rates (Fagan et al., 2007). It may well be that some of the differences in the patterns of development of nicotine dependence, especially with regard to age sensitivity, may be explained by individual differences in patterns of brain development, genetics, or initial sensitivity to nicotine (Swan and Lessov-Schlaggar, 2007).

There is considerable evidence that age of initiation is associated with levels of nicotine dependence. As presented in the 2012 Surgeon General's report (HHS, 2012), data from the NSDUH 2007–2010 surveys show that a younger age of initiation is strongly associated with greater nicotine dependence in both young adulthood (18 to 25 years old) and older adulthood (26 years and older). Consistent dose–response gradients were present, indicating that the younger the age of initiation, the greater the degree of nicotine dependence. Furthermore, these associations held true regardless whether age of initiation was measured as the age of the first puff or the age an individual first smoked daily and were also independent of the length of the transition from the first cigarette to daily smoking (HHS, 2012). Longitudinal studies following participants from adolescence to young adulthood also showed a statistically significant gradient, with younger ages of initiation associated with greater nicotine dependence (Buchmann et al., 2013; Hu et al., 2006). The association between earlier age of initiation and greater nicotine dependence in early life also persists into adulthood. Cross-sectional data in 21- to 30-year-olds (Breslau and Peterson, 1996) and in later adulthood (Lando et al., 1999; Park et al., 2004) also show clear gradients indicating that the earlier the age of starting cigarette smoking, the greater the nicotine dependence; in both studies the strong association between a younger age of initiation and greater nicotine dependence was clearly evident across ages of initiation ranging from adolescence to 25 years of age and older. These findings suggest that there is no apparent threshold beyond which this association does not apply.

Finding 2-6: Symptoms of nicotine dependence can develop even at low levels of exposure to smoking, well before the establishment of daily smoking.

Age of Initiation and Smoking Intensity

Smoking intensity, defined as the number of cigarettes smoked per day, is strongly related to nicotine dependence and to all health outcomes. Strong associations between younger ages of smoking initiation and heavier smoking are evident even in studies that have examined this question among adolescents who started smoking before high school and assessed smoking intensity in high school (Escobedo et al., 1993; Everett et al., 1999; Reidpath et al., 2014). Strong and statistically significant associations were also observed in longitudinal studies that followed individuals from adolescence to young adulthood (Buchmann et al., 2013; Hu et al., 2006).

U.S. national cross-sectional data indicate that an earlier age of first puffing a cigarette or of smoking cigarettes daily were both strongly associated with a greater likelihood of being a heavier smoker both in 18- to 25-year-olds and in those 26 years and older and that this association remained consistent regardless of the transition time from first trying a cigarette to becoming a daily smoker (HHS, 2014). Additional cross-sectional studies document a strong dose-dependent association between a younger age of initiation and a greater number of cigarettes smoked per day in young adulthood (Breslau, 1993) and in older adulthood (Chen and Millar, 1998; D'Avanzo et al., 1994; Fernandez et al., 1999; Hu et al., 2006; Lando et al., 1999; Taioli and Wynder, 1991).

Age of Initiation and Continued Smoking

The evidence reviewed above that a younger age of initiation is associated with greater nicotine dependence and greater smoking intensity supports the suggestion that an earlier age of initiation would be associated with an increased likelihood of remaining a smoker throughout the life span, and the empirical data on this association supports that assumption. An earlier age of starting to smoke cigarettes has been associated with an increased likelihood of remaining a smoker (or reduced likelihood of quitting) in several studies that span periods of life starting at various points from pre-high school to high school (Everett et al., 1999) and progressing to young adults (Breslau and Peterson, 1996) and older adulthood (Chen and Millar, 1998; D'Avanzo et al., 1994; Eisner et al., 2000; Khuder et al., 1999). The influence of the age of initiation on smoking cessation does not appear to simply be an artifact of an early initiation of smoking being associated with a longer duration of smoking, all else being held equal (Breslau and Peterson, 1996).

Finding 2-7: An earlier age of initiation is associated with greater levels of nicotine dependence.

Finding 2-8: An earlier age of initiation is associated with greater intensity and persistence of smoking beyond adolescence and through adulthood.

TOBACCO CESSATION AMONG ADOLESCENTS AND YOUNG ADULTS

As noted above, a sizable portion of adolescent smokers, even those who are infrequent and light smokers, show signs of nicotine addiction and are likely to continue smoking into adulthood. The fact that adolescents do not seem to spontaneously "mature out" of smoking (Mermelstein, 2003) does not necessarily reflect a lack of motivation to quit. Rather, a majority of adolescent smokers want to quit, and many of them make serious attempts to do so (Bancej et al., 2007; Marshall et al., 2006). However, tobacco cessation among adolescents is challenging. Despite a lower frequency and intensity of use in adolescents compared with adults, the rates of cessation among adolescents are low, and most adolescents experience difficulty in quitting (Mermelstein, 2003; O'Loughlin et al., 2009). Most adolescents who want to quit attempt to do so without any formal assistance, and of the few who have formal assistance, even fewer use evidence-based approaches (Curry et al., 2009). Although there are a number of good behaviorally based interventions for adolescents, and these interventions increase the chances of adolescent smokers achieving cessation, their reach is limited and their overall success rates are lower than one finds with adult evidence-based programs (Curry et al., 2009). A recent Cochrane meta-analysis of tobacco cessation interventions for regular smokers younger than 20 reported mixed findings for interventions, with the more complex counseling approaches showing some promise, but few trials showing pharmacotherapy to be effective in helping adolescent smokers quit (Stanton and Grimshaw, 2013). The review concluded that there is not yet sufficient evidence to recommend one specific approach for widespread implementation for adolescent smokers.

The developmental challenges of adolescence may also interfere with an adolescent smoker's ability to quit. These challenges include the adolescent's stage of cognitive development and ability to problem-solve and maintain coping skills under periods of emotional arousal, particularly arousal brought on during nicotine withdrawal, as well as other age-based challenges that come with an adolescent's lack of control over his or her environment and lack of ability to modify cues that may promote smoking (Curry et al., 2009). Thus, not all adolescents who smoke may have the cognitive, environmental, and emotional resources to make cessation attempts successful. Cessation attempts are also less successful among adolescents who smoke more or who smoke daily (Bancej et al., 2007). In one of the few studies to examine the discontinuation of smoking among adolescents who are light and mostly intermittent smokers, O'Loughlin et al. (2014) found that males and older adolescents were more likely to discontinue smoking, and suggested that older adolescents may be more successful for a variety of reasons, including moving into adult roles, developing increased skills to manage a quit attempt, and having more exposure to cessation aids.

Young adults also find cessation challenging, and the evidence is mixed as to whether young adults are more successful than older adults, with relatively few studies having compared cessation rates across age groups. Messer et al. (2008) found that young adults ages 18 to 24 were more likely to quit successfully than older adults. However, Villanti et al. (2010) found that there is limited evidence for the efficacy of cessation interventions specifically geared to young adults. In a meta-analysis addressing the question of whether cessation interventions that are successful for older adults work equally well for young adults, Suls et al. (2012) found that interventions that are efficacious for the general adult population are equally effective for young adults. The larger problem, however, is attracting young adults to evidence-based cessation programs (Suls et al., 2012).

In sum, adolescents, even those who are light and intermittent adolescent smokers, have difficulty stopping their tobacco use, especially once dependence symptoms have emerged, even if the symptoms have not yet reached the level of fully developed nicotine dependence. In addition, evidence-based cessation interventions for adolescents are not as easily or widely available as they are for adults, and pharmacological approaches are limited in both reach and effectiveness (Curry et al., 2009). More cessation options are available for young adults, and success in quitting may be easier to achieve during the young adult years.

Finding 2-9: Tobacco cessation among adolescents is difficult to achieve, with few, if any, well-supported interventions that are available for widespread dissemination. More effective treatment options are available for young and older adults.

REFERENCES

Arrazola, R. A., S. Dube, and B. A. King. 2013. Tobacco product use among middle and high school students—United States, 2011 and 2012. *Morbidity and Mortality Weekly Report* 62(45):893–897.

Arrazola, R. A., N. M. Kuiper, and S. R. Dube. 2014. Patterns of current use of tobacco products among U.S. high school students for 2000–2012—Findings from the National Youth Tobacco Survey. *Journal of Adolescent Health* 54(1):54–60.

Austin, S. B., N. Ziyadeh, L. B. Fisher, J. A. Kahn, G. A. Colditz, and A. L. Frazier. 2004. Sexual orientation and tobacco use in a cohort study of U.S. adolescent girls and boys. *Archives of Pediatrics and Adolescent Medicine* 158(4):317–322.

Bachman, J. G., P. M. O'Malley, L. D. Johnston, J. E. Schulenberg, and J. M. Wallace, Jr. 2011. Racial/ethnic differences in the relationship between parental education and substance use among U.S. 8th-, 10th-, and 12th-grade students: Findings from the Monitoring the Future project. *Journal of Studies on Alcohol and Drugs* 72(2):279–285.

Bancej, C., J. O'Loughlin, R. W. Platt, G. Paradis, and A. Gervais. 2007. Smoking cessation attempts among adolescent smokers: A systematic review of prevalence studies. *Tobacco Control* 16(6):e8.

Bernat, D. H., D. J. Erickson, R. Widorne, C. L. Perry, and J. L. Forster. 2008. Adolescent smoking trajectories: Results from a population-based cohort study. *Journal of Adolescent Health* 43(4):334–340.

Breslau, N. 1993. Daily cigarette consumption in early adulthood: Age of smoking initiation and duration of smoking. *Drug and Alcohol Dependence* 33(3):287–291.

Breslau, N., and E. L. Peterson. 1996. Smoking cessation in young adults: Age at initiation of cigarette smoking and other suspected influences. *American Journal of Public Health* 86(2):214–220.

Brook, D. W., J. S. Brook, C. Zhang, M. Whiteman, P. Cohen, and S. J. Finch. 2008. Developmental trajectories of cigarette smoking from adolescence to the early thirties: Personality and behavioral risk factors. *Nicotine & Tobacco Research* 10(8):1283–1291.

Buchmann, A. F., D. Blomeyer, C. Jennen–Steinmetz, M. H. Schmidt, G. Esser, T. Banaschewski, and M. Laucht. 2013. Early smoking onset may promise initial pleasurable sensations and later addiction. *Addiction Biology* 18(6):947–954.

Chassin, L., C. Presson, D. C. Seo, S. J. Sherman, J. Macy, R. J. Wirth, and P. Curran. 2008. Multiple trajectories of cigarette smoking and the intergenerational transmission of smoking: A multigenerational, longitudinal study of a Midwestern community sample. *Health Psychology* 27(6):819–828.

Chen, J., and W. J. Millar. 1998. Age of smoking initiation: Implications for quitting. *Health Reports* 9(4):39–46.

Colder, C. R., P. Mehta, K. Balanda, R. T. Campbell, K. P. Mayhew, W. R. Stanton, M. A. Pentz, and B. R. Flay. 2001. Identifying trajectories of adolescent smoking: An application of latent growth mixture modeling. *Health Psychology* 20(2):127–135.

Colder, C. R., B. R. Flay, E. Segawa, D. Hedeker, and TERN members. 2008. Trajectories of smoking among freshmen college students with prior smoking history and risk for future smoking: Data from the University Project Tobacco Etiology Research Network (UpTERN) study. *Addiction* 103(9):1534–1543.

Costello, D. M., L. C. Dierker, B. L. Jones, and J. S. Rose. 2008. Trajectories of smoking from adolescence to early adulthood and their psychosocial risk factors. *Health Psychology* 27(6):811–818.

Curry, S. J., R. J. Mermelstein, and A. K. Sporer. 2009. Therapy for specific problems: Youth tobacco cessation. *Annual Review of Psychology* 60:229–255.

D'Avanzo, B., C. La Vecchia, and E. Negri. 1994. Age at starting smoking and number of cigarettes smoked. *Annals of Epidemiology* 4(6):455–459.

Dierker, L., and R. Mermelstein. 2010. Early emerging nicotine-dependence symptoms: A signal of propensity for chronic smoking behavior in adolescents. *Journal of Pediatrics* 156(5):818–822.

DiFranza, J. R., J. A. Savageau, N. A. Rigotti, K. Fletcher, J. K. Ockene, A. D. McNeill, M. Coleman, and C. Wood. 2002. Development of symptoms of tobacco dependence in youth: 30 month follow up data from the DANDY study. *Tobacco Control* 11(3): 228–235.

Eaton, D. K., L. Kann, S. Kinchen, S. L. Shanklin, K. H. Flint, J. Hawkins, W. A. Harris, R. Lowry, T. McManus, D. Chyen, L. Whittle, C. Lim, and H. Wechsler. 2012. Youth risk behavior surveillance—United States, 2011. *Morbidity and Mortality Weekly Report* 61(4):1–162.

Eisner, M. D., E. H. Yelin, P. P. Katz, S. C. Shiboski, J. Henke, and P. D. Blanc. 2000. Predictors of cigarette smoking and smoking cessation among adults with asthma. *American Journal of Public Health* 90(8):1307–1311.

Escobedo, L. G., S. E. Marcus, D. Holtzman, and G. A. Giovino. 1993. Sports participation, age at smoking initiation, and the risk of smoking among U.S. high school students. *JAMA* 269(11):1391–1395.

Everett, S. A., C. W. Warren, D. Sharp, L. Kann, C. G. Husten, and L. S. Crossett. 1999. Initiation of cigarette smoking and subsequent smoking behavior among U.S. high school students. *Preventive Medicine* 29(5):327–333.

Fagan, P., E. T. Moolchan, D. Lawrence, A. Fernander, and P. K. Ponder. 2007. Identifying health disparities across the tobacco continuum. *Addiction* 102(Suppl 2):5–29.

Fernandez, E., A. Schiaffino, C. La Vecchia, J. M. Borras, M. Nebot, E. Salto, R. Tresserras, L. Rajmil, J. R. Villalbi, and A. Segura. 1999. Age at starting smoking and number of cigarettes smoked in Catalonia, Spain. *Preventive Medicine* 28(4):361–366.

Goodman, E., and J. Capitman. 2000. Depressive symptoms and cigarette smoking among teens. *Pediatrics* 106(4):748–755.

Green, M. P., K. L. McCausland, H. Xiao, J. C. Duke, D. M. Vallone, and C. G. Healton. 2007. A closer look at smoking among young adults: Where tobacco control should focus its attention. *American Journal of Public Health* 97(8):1427–1433.

Hatzenbuehler, M. L., N. F. Wieringa, and K. M. Keyes. 2011. Community-level determinants of tobacco use disparities in lesbian, gay, and bisexual youth: Results from a population-based study. *Archives of Pediatrics and Adolescent Medicine* 165(6):527–532.

HHS (Department of Health and Human Services). 2012. *Preventing tobacco use among youth and young adults: A report of the Surgeon General*. Atlanta GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

———. 2014. *The health consequences of smoking— 50 years of progress: A report of the Surgeon General*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

HHS, SAMHSA, and CBHSQ (Department of Health and Human Services, Substance Abuse and Mental Health Services Administration, and Center for Behavioral Health Statistics and Quality). 2014. National survey on drug use and health, 2012. *ICPSR34933-v2*: Ann Arbor, MI: Inter-University Consortium for Political and Social Research [distributor], 2014-10-06. http://doi.org/10.3886/ICPSR34933.v2 (accessed February 6, 2015).

Hu, M. C., M. Davies, and D. B. Kandel. 2006. Epidemiology and correlates of daily smoking and nicotine dependence among young adults in the United States. *American Journal of Public Health* 96(2):299–308.

Hu, M. C., B. Muthen, C. Schaffran, P. C. Griesler, and D. B. Kandel. 2008. Developmental trajectories of criteria of nicotine dependence in adolescence. *Drug and Alcohol Dependence* 98(1–2):94–104.

Jackson, K. M., K. J. Sher, and J. E. Schulenberg. 2008. Conjoint developmental trajectories of young adult substance use. *Alcoholism: Clinical and Experimental Research* 32(5):723–737.

Johnson, J. G., P. Cohen, D. S. Pine, D. F. Klein, S. Kasen, and J. S. Brook. 2000. Association between cigarette smoking and anxiety disorders during adolescence and early adulthood. *JAMA* 284(18):2348–2351.

Johnston, L. D., P. M. O'Malley, J. G. Bachman, and J. E. Schulenberg. 2013. *Monitoring the future: National survey results on drug use 1975–2012: Volume 2, College students & adults ages 19–50*. Ann Arbor, MI: Institute for Social Research, University of Michigan.

Johnston, L. D., P. M. O'Malley, J. G. Bachman, J. E. Schulenberg, and R. A. Miech. 2014a. *Demographic subgroup trends among adolescents in the use of various licit and illicit drugs 1975–2013*. Ann Arbor, MI: Institute for Social Research, University of Michigan.

———. 2014b. *Monitoring the future: National survey results on drug use 1975–2013. Volume 1: Secondary school students*. Ann Arbor: Institute for Social Research, University of Michigan.

———. 2014c. *Monitoring the future: National survey results on drug use 1975–2013: Volume 2, college students & adults ages 19–55*. Ann Arbor: Institute for Social Research, the University of Michigan.

Kandel, D. B., and K. Chen. 2000. Extent of smoking and nicotine dependence in the United States: 1991–1993. *Nicotine & Tobacco Research* 2(3):263–274.

Kann, L., S. Kinchen, S. L. Shanklin, K. H. Flint, J. Hawkins, W. A. Harris, R. Lowry, E. O'Malley Olsen, T. McManus, D. Chyen, L. Whittle, E. Taylor, Z. Demissie, N. Brener, J. Thornton, J. Moore, and S. Zaza, Centers for Disease Control and Prevention. 2014. Youth risk behavior surveillance—United States, 2013. *Morbidity and Mortality Weekly Report Surveillance Summaries* 63(4):1–168.

Khuder, S. A., H. H. Dayal, and A. B. Mutgi. 1999. Age at smoking onset and its effect on smoking cessation. *Addictive Behaviors* 24(5):673–677.

Lando, H. A., D. T. Thai, D. M. Murray, L. A. Robinson, R. W. Jeffery, N. E. Sherwood, and D. J. Hennrikus. 1999. Age of initiation, smoking patterns, and risk in a population of working adults. *Preventive Medicine* 29(6 Part 1):590–598.

Lessov-Schlaggar, C. N., H. Hops, J. Brigham, K. S. Hudmon, J. A. Andrews, E. Tildesley, D. McBride, L. M. Jack, H. S. Javitz, and G. E. Swan. 2008. Adolescent smoking trajectories and nicotine dependence. *Nicotine & Tobacco Research* 10(2):341–351.

Marshall, L., M. Schooley, H. Ryan, P. Cox, A. Easton, C. Healton, K. Jackson, K. C. Davis, and G. Homsi. 2006. Youth tobacco surveillance —United States, 2001–2002. *Morbidity and Mortality Weekly Report* 55(3):1–56.

Mayhew, K. P., B. R. Flay, and J. A. Mott. 2000. Stages in the development of adolescent smoking. *Drug and Alcohol Dependence* 59(Suppl 1):S61–S81.

Melnick, M. J., K. E. Miller, D. F. Sabo, M. P. Farrell, and G. M. Barnes. 2001. Tobacco use among high school athletes and nonathletes: Results of the 1997 Youth Risk Behavior Survey. *Adolescence* 36(144):727–747.

Mermelstein, R. 2003. Teen smoking cessation. *Tobacco Control* 12(Suppl 1):i25–i34.

Mermelstein, R., S. M. Colby, C. Patten, A. Prokhorov, R. Brown, M. Myers, W. Adelman, K. Hudmon, and P. McDonald. 2002. Methodological issues in measuring treatment outcome in adolescent smoking cessation studies. *Nicotine & Tobacco Research* 4(4): 395–403.

Messer, K., D. R. Trinidad, W. K. Al-Delaimy, and J. P. Pierce. 2008. Smoking cessation rates in the United States: A comparison of young adult and older smokers. *American Journal of Public Health* 98(2):317–322.

O'Loughlin, J., J. DiFranza, R. F. Tyndale, G. Meshefedjian, E. McMillan-Davey, P. B. S. Clarke, J. Hanley, and G. Paradis. 2003. Nicotine-dependence symptoms are associated with smoking frequency in adolescents. *American Journal of Preventive Medicine* 25(3):219–225.

O'Loughlin, J., A. Gervais, E. Dugas, and G. Meshefedjian. 2009. Milestones in the process of cessation among novice adolescent smokers. *American Journal of Public Health* 99(3):499–504.

O'Loughlin, J. L., M. P. Sylvestre, E. N. Dugas, and I. Karp. 2014. Predictors of the occurrence of smoking discontinuation in novice adolescent smokers. *Cancer Epidemiology, Biomarkers & Prevention* 23(6):1090–1101.

Park, S. M., K. Y. Son, Y. J. Lee, H. C. Lee, J. H. Kang, Y. J. Lee, Y. J. Chang, and Y. H. Yun. 2004. A preliminary investigation of early smoking initiation and nicotine dependence in Korean adults. *Drug and Alcohol Dependence* 74(2):197–203.

Peek, K. J., J. Kusel, S. L. Eyre, C. L. Auerswald, and B. L. Halpern-Felsher. In preparation (unpublished). *Understanding smokeless tobacco initiation and use among rural youth: An unexplored population*.

Reidpath, D. D., T. M. Davey, A. Kadirvelu, I. N. Soyiri, and P. Allotey. 2014. Does one cigarette make an adolescent smoker, and is it influenced by age and age of smoking initiation? Evidence of association from the U.S. Youth Risk Behavior Surveillance System (2011). *Preventive Medicine* 59:37–41.

Riggs, N. R., C. P. Chou, C. Li, and M. A. Pentz. 2007. Adolescent to emerging adulthood smoking trajectories: When do smoking trajectories diverge, and do they predict early adulthood nicotine dependence? *Nicotine & Tobacco Research* 9(11):1147–1154.

Rosario, M., J. Hunter, and M. Gwadz. 1997. Exploration of substance use among lesbian, gay, and bisexual youth: Prevalence and correlates. *Journal of Adolescent Research* 12(4):454–476.

SAMHSA (Substance Abuse and Mental Health Services Administration). 2012a. 2010–2011 National Survey on Drug Use and Health national maps of prevalence estimates by state. http://www.samhsa.gov/data/NSDUH/2k11State/NSDUHsae2011/Maps/NSDUHsaeMaps2011.htm (accessed January 28, 2015).

———. 2012b. *Comparing and evaluating youth substance use estimates from the National Survey on Drug Use and Health and other surveys*. Rockville, MD: Substance Abuse and Mental Health Services Administration; Center for Behavioral Statistics and Quality; Department of Population Surveys.

———. 2012c. *National Survey on Drug Use and Health: Comparison of 2002–2003 and 2010–2011 model-based prevalence estimates (50 states and the District of Columbia)*. Rockville, MD: Substance Abuse and Mental Health Services Administration; Center for Behavioral Statistics and Quality; Department of Population Surveys.

———. 2013a. *Results from the 2012 National Survey on Drug Use and Health: Detailed tables*. Rockville, MD: Substance Abuse and Mental Health Services Administration; Center for Behavioral Statistics and Quality; Department of Population Surveys.

———. 2013b. *Results from the 2012 National Survey on Drug Use and Health: Summary of national findings*. Rockville, MD: Substance Abuse and Mental Health Services Administration; Center for Behavioral Statistics and Quality; Department of Population Surveys.

Selya, A. S., L. C. Dierker, J. S. Rose, D. Hedeker, X. Tan, R. Li, and R. J. Mermelstein. 2013. Time-varying effects of smoking quantity and nicotine dependence on adolescent smoking regularity. *Drug and Alcohol Dependence* 128(3):230–237.

Shiffman, S. 2009. Light and intermittent smokers: Background and perspective. *Nicotine & Tobacco Research* 11(2):122–125.

Stanton, A., and G. Grimshaw. 2013. Tobacco cessation interventions for young people. *Cochrane Database of Systematic Reviews* 23(8).

Stanton, W. R., B. R. Flay, C. R. Colder, and P. Mehta. 2004. Identifying and predicting adolescent smokers' developmental trajectories. *Nicotine & Tobacco Research* 6(5):843–852.

Suls, J. M., T. M. Luger, S. J. Curry, R. J. Mermelstein, A. K. Sporer, and L. C. An. 2012. Efficacy of smoking-cessation interventions for young adults: A meta-analysis. *American Journal of Preventive Medicine* 42(6):655–662.

Swan, G. E., and C. N. Lessov-Schlaggar. 2007. The effects of tobacco smoke and nicotine on cognition and the brain. *Neuropsychology Review* 17(3):259–273.

Taioli, E., and E. L. Wynder. 1991. Effect of the age at which smoking begins on frequency of smoking in adulthood. *New England Journal of Medicine* 325(13):968–969.

Tucker, J. S., P. L. Ellickson, M. Orlando, and D. J. Klein. 2006. Cigarette smoking from adolescence to young adulthood: Women's developmental trajectories and associates outcomes. *Women's Health Issues* 16(1):30–37.

Villanti, A. C., H. S. McKay, D. B. Abrams, D. R. Holtgrave, and J. V. Bowie. 2010. Smoking-cessation interventions for U.S. young adults: A systematic review. *American Journal of Preventive Medicine* 39(6):564–574.

Wadley, J., and S. Barnes. 2013. Teen smoking continues to decline in 2013. Ann Arbor, MI: University of Michigan News Service. http://home.isr.umich.edu/releases/teen-smoking-continues-to-decline-in-2013 (accessed February 6, 2015).

Wadley, J., and A. Bronson. 2014. E-cigarettes surpass tobacco cigarettes among teens. Ann Arbor, MI: University of Michigan News Service. http://ns.umich.edu/new/multimedia/videos/22575-e-cigarettes-surpass-tobacco-cigarettes-among-teens (accessed February 6, 2015).

Welte, J. W., G. M. Barnes, M. C. O. Tidwell, and J. H. Hoffman. 2011. Tobacco use, heavy use, and dependence among adolescents and young adults in the United States. *Substance Use and Misuse* 46(9):1090–1098.

Ziedonis, D., B. Hitsman, J. C. Beckham, M. Zvolensky, L. E. Adler, J. Audrain-McGovern, N. Breslau, R. A. Brown, T. P. George, J. Williams, P. S. Calhoun, and W. T. Riley. 2008. Tobacco use and cessation in psychiatric disorders: National Institute of Mental Health report. *Nicotine & Tobacco Research* 10(12):1691–1715.

3

The Developmental and Environmental Context of Adolescent and Young Adult Tobacco Use

Tobacco use is the result of a complex and dynamic interplay of multiple converging developmental, social, and environmental factors. Many of these factors are developmentally related, with adolescence and young adulthood as a key period of vulnerability to tobacco use and the progression to nicotine dependence (Jamner et al., 2003).

The development of adult decision-making skills and abilities is a continuous process that begins in early adolescence and continues into and through young adulthood, with no firm age periods for when specific developmental milestones occur. Furthermore, there are individual variations, with spurts of change and disjuncture resulting from social and environmental factors that influence the normative developmental process. These social influences are particularly salient in later adolescence and young adulthood.

Although previously considered a relatively short transition period, the late teens through the early 20s (ages approximately 18 to 26) is now considered a distinct period of life known as young adulthood (IOM and NRC, 2014). The newfound focus on this developmental period is due in part to prolonged education, delayed marriage, and delayed parenthood—events that historically marked adulthood, adult roles, and adult responsibility (Settersten and Ray, 2010)—and in part to studies showing that the brain continues to develop until the mid-20s (Giedd, 2008; Luna et al., 2004). Individuals in young adulthood face developmental and life changes that may make them particularly susceptible to drug use for several reasons: a desire to explore their identity, a response to the instability and disruption associated with life changes, or because of a tendency to focus on the possible positive consequences of drug use rather than negative consequences. Additionally, this is a time period when experimentation with risky behavior is most tolerated (IOM and NRC, 2014).

The unique psychosocial maturation of the adolescent and young adult developmental period, coupled with various environmental and social influences, results in a milieu that increases the desire for engaging in health-risk behaviors, including tobacco use. Furthermore, brain function and heightened sensitivity to nicotine characteristic of this period of development provides the biological context underlying the psychosocial and environmental influences related to adolescents' and young adults' decisions to start and continue to use tobacco.

The chapter begins with a review of the complex and layered cognitive, psychosocial, and biological aspects of adolescent and young adult development, with a focus on factors most likely to explain the heightened likelihood of tobacco initiation, continued use, and dependence. The chapter then ties these factors into the decision-making capabilities of adolescents and young adults. The chapter concludes with a discussion of the environmental context of tobacco use, including salient residential, school, and work changes and the role of tobacco marketing on adolescent and young adult tobacco use.

COGNITIVE, PSYCHOSOCIAL, AND BIOLOGICAL DEVELOPMENT IN ADOLESCENTS AND YOUNG ADULTS

Adolescence and young adulthood is a period of change with respect to cognitive, psychosocial, neurobiological, and physical development. These changes often result in increased vulnerabilities to using tobacco. These factors are reviewed next.

Cognitive Development

During adolescence, thinking becomes less concrete and more abstract, giving adolescents the ability to consider many components necessary for competent decision making at one time, consider potential positive and negative outcomes associated with each decision, and plan for the future. Studies have shown that by the time adolescents reach age 16, their general cognitive abilities, such as the ability to understand consequences—including the risks and benefits of their decisions—to process information, and to reason, are essentially identical to those of adults (Albert and Steinberg, 2011; Halpern-Felsher and Cauffman, 2001; Steinberg et al., 2009a). For example, in a study of 935 individuals ranging from age 10 to 30, Steinberg and colleagues (2009a) found no significant differences in cognitive skills between older adolescents (as young as ages 15–16) and adults.

Although there are individual differences and within-age-group variation, most adolescents reach a level of cognitive maturity comparable to adults by age 16. Despite the fact that cognitive maturity is reached by mid-adolescence, other aspects of psychosocial maturity, such as peer influence, sensation seeking, reward seeking, and impulse control, are still developing (as discussed later in this chapter). These different developmental systems explain in part why adolescents and young adults may have the cognitive ability to make safe and healthy decisions, yet are more prone than adults to make risky decisions. As shown below, even though adolescents have the ability to think abstractly and judge risks, they do not always adequately employ these abilities. Instead, adolescents are often seeking rewards and pleasures and therefore may decide to use tobacco despite knowing and understanding both the short-term and long-term risks.

Perceptions of Risks and Benefits

A hallmark of cognitive development is the ability to identify and understand consequences associated with a particular behavior. Perceptions of social, physical, and health risks associated with any given behavior as well as the perceived benefits, including both social and physical benefits, are key components of any competent decision. Research has shown that such perceptions actually predict the onset of behavior (Song et al., 2009b).

Adolescents, young adults, and adults are generally similar in their ability to identify and consider positive and negative consequences of their decisions. In some cases, adolescents actually perceive greater risks than do adults (e.g., Millstein and Halpern-Felsher, 2002). Several studies have shown that adolescents and young adults consider risks, benefits, and the value of behavior-related outcomes just prior to deciding on a particular behavior and that adolescents and young adults are keenly aware of risks (e.g., Halpern-Felsher and Cauffman, 2001; Lewis, 1981; Michels et al., 2005). In a review article, Albert and Steinberg (2011) concluded that there are few differences between the evaluations that adolescents (with ages varying depending on the study sample) and adults make of the risks inherent in various risky behaviors and few differences in their perceptions of the seriousness of these consequences (see also Kuther, 2003). Despite adolescents' general understanding—and often overestimation—of risks, the perceptions of risks are only one part of the equation that adolescents and young adults use to make decisions. Adolescents naturally consider the importance of the social and physical benefits that they perceive they will gain from any given behavior (Song et al., 2009b). Furthermore, adolescents' emotional immaturity and psychosocial factors influencing their behavior, such as impulsivity and peer pressure, often override the cognitive understanding of a risk.

Perceptions of Tobacco-Related Risks and Benefits Associated with Tobacco Use

Many studies have examined risk and benefit perceptions related to tobacco use. In general, studies show that people who smoke perceive less harm and greater benefits from cigarettes than do nonsmokers (Chassin et al., 2000; Fischhoff et al., 2010; Halpern-Felsher et al., 2004; Morrell et al., 2010; Soldz and Cui, 2002; Song et al., 2009b). Compared to nonsmokers, those who have smoked believe that they are less likely to experience long-term risks, such as lung cancer, heart attack, addiction, and death, and less likely to experience short-term consequences, such as smelling bad or having trouble breathing (Halpern-Felsher et al., 2004; Morrell et al., 2010; Song et al., 2009a). Smokers also believe that they are more likely to experience pleasure, feel relaxed, and "look cool" from smoking when compared to nonsmokers (Halpern-Felsher et al., 2004; Morrell et al., 2010; Song et al., 2009b). A prospective study of adolescents 14 to 16 years old demonstrated that perceptions of low long- and short-term risk and greater benefits predict the onset of tobacco use (Song et al., 2009b).

A much smaller body of work has examined whether perceptions of risks and benefits vary by type, brand, or packaging of the tobacco product. Historically, this research has focused on light and ultra-light cigarettes, with studies showing that most adults and adolescents incorrectly perceive that light cigarettes deliver less tar and nicotine, produce milder sensations, result in less health risk, and can make cessation easier (Etter et al., 2003; Gilpin et al., 2002; Kozlowski et al., 1998; Kropp and Halpern-Felsher, 2004; Shiffman et al., 2001; Tindle et al., 2006). More recent research has shown that consumers perceive that menthol-flavored cigarettes are less harmful than non-menthol-flavored cigarettes (Anderson, 2011; Klausner, 2011). Similarly, perceptions of the harms associated with snus (Choi et al., 2012; Øverland et al., 2008), smokeless tobacco (Callery et al., 2011), and cigars (Nyman et al., 2002) are lower compared to the perceived harms of cigarettes, and people perceive differences in risk based on type and color of product packaging (Bansal-Travers et al., 2011).

Psychosocial Development

In addition to developing the ability to consider the possible consequences of actions, including the likelihood and value of each consequence, adolescents and young adults are also maturing with respect to their psychosocial abilities. Psychosocial components relevant to tobacco decision making include social and peer comparison, sensation seeking and impulsivity, peer affiliation, susceptibility to peer pressure, the ability to understand and plan for the future, and perceived social norms.

While individuals vary even within the same age range, generally speaking most adolescents are on par with adults by age 16 with respect to thinking about the future (e.g., Albert and Steinberg, 2011; Halpern-Felsher and Cauffman, 2001; Steinberg et al., 2009b). However, other critical aspects of psychosocial development, such as those associated with peer pressure, sensation seeking, reward seeking, and impulse control, are much less developed during adolescence than during adulthood (Halpern-Felsher and Cauffman, 2001; Steinberg, 2008; Steinberg et al., 2008, 2009a; Zuckerman, 1979). "Dynamic accounts of factors that predict adolescent decisions" take into consideration the social, emotional, and self-regulatory factors that help explain why adolescents can make decisions just as rationally as adults, but often do not (Albert and Steinberg, 2011, p. 211). These areas of immaturity help explain why adolescents and young adults are more susceptible than older adults to initiating tobacco use.

Future Perspective Taking

Future perspective taking includes the ability to project into the future, to consider possible positive and negative outcomes associated with choices, and to plan for the future (Steinberg et al., 2009b), and is a hallmark of decision-making competence. Without an adequate understanding of future consequences and without the ability to have the future be part of present planning, it is more difficult to make decisions about behavior, including whether or not to use tobacco. It is not enough to have a working understanding of the possible risks and benefits that might come from using tobacco; it is equally important to be able to apply that information to making decisions about behaviors that could have an effect in the future. Steinberg and colleagues (2009b) found that the ability to plan for the future and to anticipate future consequences continues to develop through the mid-20s (see also Halpern-Felsher and Cauffman, 2001).

Sensation Seeking and Impulsivity

Sensation seeking refers to the drive to seek out experiences that are new, different, exciting, and highly stimulating as well as the willingness to take risks in order to have these experiences (Steinberg, 2008; Zuckerman, 1979). Higher sensation seeking is associated with drug use in early and middle adolescence (e.g., ages 12–16) (Kosten et al., 1994; Teichman et al., 1989) and with pubertal development; early maturers tend to rate higher on sensation-seeking scales and also on drug-seeking behavior (Martin et al., 2001; Steinberg, 2008). While sensation seeking follows a developmental trajectory, it is also viewed as a stable trait that is associated with risky behavior (Zuckerman, 2007).

Impulsivity refers to a tendency to make decisions in a quick fashion, without much thought or information. Impulsivity steadily declines from age 10 on (Steinberg et al., 2008). Becoming competent to make decisions requires that adolescents be able to control their desires and resist impulsive actions. Recent studies have highlighted the complex relationship among impulsivity, peer pressure, and delinquent behavior. Vitulano and colleagues (2010) have found that individuals with low impulsivity are actually more vulnerable to delinquent peer influences than those with high impulsivity. Thus, adolescents find themselves in a bit of a quagmire in that those with high impulsivity are likely to engage in risky behavior and those with low impulsivity are particularly sensitive to peer pressure that may also lead them to engage in risky behavior.

While impulsivity and sensation seeking are related, they are distinct features of decision making. Impulsive behavior may lead to experiences that are neither stimulating nor rewarding, and individuals may make the decision to engage in sensation-seeking behavior in a deliberate and non-impulsive manner (Steinberg et al., 2008). Additionally, while impulsive behavior decreases in a linear fashion from age 10 on, sensation-seeking patterns of development follow a curvilinear pattern in which sensation seeking increases between childhood and early adolescence and then either declines or remains stable in late adolescence and adulthood (Steinberg et al., 2008). For example, Steinberg and colleagues found that while 16- to 17-year-olds and 18- to 21-year-olds exhibit more impulse control than 10- to 15-year-olds, they exhibit significantly less impulse control than 22- to 25-year-olds and 26- to 30-year-olds.

Thus, adolescence and young adulthood is a time of low impulse control coupled with high rates of sensation seeking, which results in a greater likelihood that individuals in these development periods will engage in risky behavior. The coupling of low impulse control and high sensation seeking is especially harmful in more emotionally charged situations, in which adolescents are seeking rewards and pleasure yet do not have the ability to control these desires. Hence, adolescents are more likely to seek rewards such as those associated with tobacco use than they will be later in life, once the connections between their rewards pathways and impulse control are more in sync, which occurs in their mid-20s (Steinberg, 2013).

Social Norms

Social norms refer to common codes of behavior for a social group. The construct is used in a number of disciplines and theories of health behavior, including the Theory of Planned Behavior (Ajzen, 1985), Social Cognitive Theory (Bandura, 2001), and the Theory of Normative Social Behavior (Rimal and Real, 2005). Social norms are often classified as either descriptive norms, which are perceptions of how people actually behave (which are often operationalized as perceived prevalence rates), and injunctive norms, which are perceptions of how people should behave (and are often operationalized by asking who would approve or disapprove of you engaging in a behavior) (Cialdini et al., 1990; Kallgren et al., 2000).

Both injunctive and descriptive norms are associated with smoking behaviors among adolescents and young adults. Alexander and colleagues (2001) analyzed data from the National Longitudinal Study of Adolescent Health and found that among 7th through 12th graders, adolescents in peer groups where 50 percent or more members smoked, or whose best friends smoked, were two times more likely to also smoke than those in peer groups in which fewer than half of the members smoked. Additionally, popular students who went to schools with higher smoking rates were more likely to smoke than non-popular students, while popular students in schools with low smoking rates were less likely to smoke. Etcheverry and Agnew (2008) found that among college students, friends, and romantic partners, smoking and injunctive norms were predictive of smoking behavior.

Peer Affiliation and Susceptibility to Peer Pressure

The ability to make rational decisions is mediated by a number of factors and, for adolescents, social factors in particular play a very large role in behavioral decision making. The transition to adolescence is marked by a decrease in time spent with parents and an increase in time spent either alone or with peers (Steinberg and Morris, 2001). This is a time period in which the opinions and actions of peers become increasingly important in influencing behavior (Crone and Dahl, 2012). Observational studies show that adolescents who engage in delinquent behavior are more likely to do so in groups (as opposed to adults, who are more likely to engage in delinquent behavior alone) (Albert et al., 2013; IOM and NRC, 2011; Zimring, 2000). Experimental studies have also shown that adolescents are more likely to make riskier decisions when they are told that they are being observed by peers than when they believe they are working alone (Albert et al., 2013). Compared with adults, adolescents exhibit exaggerated responses to positive social cues, and this reaction is coupled with more impulsive responses to stimuli (Albert et al., 2013; Gardner and Steinberg, 2005).

Generally, susceptibility to peer pressure that is undesirable or that goes against an individual's goals decreases steadily from age 14 to 18 (Steinberg and Monahan, 2007). In order to make competent decisions, individuals must have the ability to resist undue pressure from others. That being said, studies also show that peers remain powerful influences and reinforcers of behavior even in late adolescence and young adulthood. For example, Duncan and colleagues found that males entering college with a history of binge drinking were more likely to binge drink if they were paired with roommates who also binge drank in high school than they were if they were paired with a roommate who did not binge drink (Duncan et al., 2005). Furthermore, an experimental study assessing the differences in how peers influence risky behavior in adolescents (ages 13–16), young adults (ages 18–22) and adults (ages 24 and older) found that all three age groups made safe decisions when alone. However, in the presence of peers, both adolescents and young adults made risky decisions, with adolescents making riskier decisions than young adults, while adults, on average, made the safest decisions (Gardner and Steinberg, 2005).

Importance of Experience

Behavioral decisions and the perceptions of related outcomes are influenced by the extent to which a person has knowledge of and experience with the behavior or behavior-linked outcomes (Albert and Steinberg, 2011; IOM and NRC, 2004). Knowledge varies not only across ages but also within age groups. Adolescents and, to a lesser extent, young adults experience greater motivation to seek external rewards compared to adults, which results in this age group being more likely to exhibit approach behaviors (i.e., those driven by positive or desirable events or outcomes) than avoidance behaviors (i.e., those driven by negative or undesirable events or outcomes) (Elliot, 1999). Risk taking and sensation seeking can be viewed as part of this drive to experience potential rewards; thus, adolescence is a period in which individuals are particularly likely to initiate behaviors such as smoking (Lydon et al., 2014). This is particularly troubling because individuals who initiate smoking during adolescence are more likely to have a pleasurable first experience than individuals who initiate smoking in adulthood. Furthermore, studies show that pleasurable initial experiences are associated with rapid progression to regular smoking as well as continued smoking (DiFranza et al., 2007; Sartor et al., 2010).

In addition to the impact of having (or not having) direct personal experiences with particular consequences of behaviors, research has also investigated the effect of vicarious experiences, or knowledge about behaviors and related positive and negative outcomes experienced by others (Morrell et al., 2010). Applied to tobacco, adolescents and young adults rarely have knowledge of peers who have experienced tobacco-related disease, which lowers their perceptions of the likelihood of negative outcomes occurring after using tobacco (Morrell et al., 2010). When adolescents and young adults have had experience with tobacco-related illness, it is often in those much senior to them. Given their immature sense of the future and their ease at discounting the idea that what happens to others may also apply to themselves, adolescents often do not apply the experiences of others to themselves (Morrell et al., 2010).

Additional Psychosocial Aspects of Young Adulthood

Later adolescence through young adulthood is a time of great demographic change and instability, including changes involving place of residence, employment, school attendance, and family formation, all of which play a substantial role in influencing tobacco use. Around age 18, most young people have moved away from home, and young adults continue to change residences more than any other age group (Arnett, 2000). In 2012, among adults ages 18 to 31, 23 percent were married and living in their own residence, 27 percent lived independently with others (i.e., cohabitating, living with a roommate or as a boarder, or in single parenthood), and fewer than 10 percent were living on their own (Fry, 2014). Young adults are also experiencing changes in their employment status, as they obtain various part-time or full-time jobs to earn money for school and living expenses, move, change colleges, and so on. Although employment rates among young adults have declined considerably over the past few decades, this decline has been largely offset by increases in educational attainment (IOM and NRC, 2014). Indeed, young adults are significantly more educated now compared with previous generations, with twice as many adults ages 18 to 31 having attained some education beyond high school in 2012 than in 1968 (Fry, 2014). However, while 85 percent of young adults enroll in college within 1 year of their 18th birthday, a majority of these young adults have not completed their degrees before age 25 (IOM and NRC, 2014). Young adults who do complete college often continue their education in graduate or professional school (Arnett, 2000). Finally, in terms of family formation, by age 25 nearly half of all young adults report having cohabitated with a romantic partner, roughly one-third have become a parent, and more than a quarter have married, with nearly two-thirds of young adults having engaged in at least one of these family formation transitions (IOM and NRC, 2014). These demographic changes and instabilities are likely to play a role in young adults' initiation with tobacco.

Young adulthood is also an intense time of personal change and growth, which occur as the young adult is less subject to parental and societal restrictions, while simultaneously not being bound by the restrictions and responsibilities that typically characterize adulthood. Given that delay in assuming adult roles and responsibilities, the young adult period is ripe for exploration and experimentation. Young adult exploration is not so much to prepare for adult roles, but for the sake of exploration itself; it is a time of exploration prior to settling into adult roles and responsibilities. This is a time with very little expectation for marriage, parenthood, or permanent employment, coupled with few, if any, parental restrictions, which creates a near-perfect atmosphere for identity development (Arnett, 2000, 2004). Furthermore, as young adults explore new living situations, including being away from parental restrictions and opportunities for cohabitation, and also affiliate more with peers who use tobacco, it stands to reason that opportunities for greater substance use will emerge.

Self-reflection is an important characteristic of young adult identity exploration, and three areas of self-reflection that often occur during young adulthood may affect decisions regarding tobacco use. The first is the extent to which young adults feel as if they have reached adulthood. In addition to demographic shifts, studies show that a large number of young adults do not consider themselves to have achieved adult status, as defined by financial independence and family formation; they can be characterized as still being in the "age of feeling in-between" (Arnett, 2004; Nelson and Barry, 2005). Second, given the vast amount of exploration desired by young adults and the limited restrictions and accountability that results from work or family obligations, young adults are likely to feel less accountable and therefore less vulnerable to risks during this "age of possibilities" (Arnett, 2004). Finally, young adults' perceptions of the extent to which their peers are using tobacco, as well as whether tobacco use is viewed as acceptable, are likely to influence patterns of tobacco use (Simons-Morton et al., 2001).

A number of important findings can be drawn from the above review:

Finding 3-1: The period from adolescence through young adulthood is one of continuous development that involves increasing cognitive skills and psychosocial maturity. There are no specific age markers.

Finding 3-2: The development of some cognitive abilities, such as understanding risks and benefits, is achieved by age 16. However, many areas of psychosocial maturity, including sensation seeking, impulsivity, and future perspective taking continue to develop and change through late adolescence and into young adulthood.

Finding 3-3: Adolescence is a period of greatest peer affiliation and susceptibility to peer influence.

Biological Development of Adolescents and Young Adults

Physical Development

Physical development, including the development of secondary sexual characteristics, is one of the most important and noticeable hallmarks of adolescence. The emergence of these newly developed physical features occurs on average between the ages of 10 and 15 for both girls and boys (Susman et al., 2010), leading adolescents to begin to have more of an adult-like appearance, which then often results in their own and others' beliefs that they can and should adopt more adult roles. However, as noted below, looking like an adult does not equate to having the cognitive, social, or emotional readiness to make adult-like decisions.

Physically maturing either earlier (the lowest 10 to 15 percent of the adolescent population) or later (the highest 10 to 15 percent of the adolescent population) is associated with an individual's likelihood of engaging in risky behavior, including tobacco use (Cance et al., 2013; Mendle and Ferrero, 2012; Mendle et al., 2007). For males, being either an early or late maturer can have negative outcomes on psychosocial adjustment (Mendle and Ferrero, 2012) and can lead to increased substance use (Cance et al., 2013). For females, being an earlier physical maturer can result in adjustment problems and, most relevant to tobacco use, to problems with body image that can lead to eating disorders (Mendle et al., 2007). Studies have shown that girls, primarily white girls, sometimes initiate tobacco use in order to lose weight (HHS, 2012). By contrast, for females, having a later physical maturation can be protective against risky behaviors and adjustment issues, including tobacco use, as compared with males, who have more adjustment difficulty if they mature late (Crockett and Petersen, 1987; Mendle and Ferrero, 2012; Mendle et al., 2007; Siegel et al., 1999).

Neurobiological Development

Physical maturation, including brain development, occurs throughout the adolescent and young adult years. Neuroscience research provides insights that show how brain maturation affects the social and emotional development of adolescents and young adults and helps explain why they are more susceptible to using tobacco than are adults.

The majority of the recent research on adolescent and young adult brain development has found that both structural and functional changes occur during adolescence, continuing into young adulthood (e.g., Giedd, 2008; Luna et al., 2004). There are four lobes in the brain: the parietal lobe, occipital lobe, temporal lobe, and frontal lobe. The frontal lobe, the largest part of the brain, contains the prefrontal cortex, which is located in the front of the brain, behind the forehead. The prefrontal cortex is responsible for executive functioning, including cognition, thought, imagination, abstract thinking, planning, and impulse control. Brain development begins at the back and progresses to the front of the brain, with the prefrontal cortex being one of the last areas to mature (Gogtay et al., 2004; Sowell et al., 1999).

The prefrontal regions of the brain, which regulate executive functioning and oversee critical abilities for decision making, show gradual changes in structure and function during adolescence (Casey et al., 2000) and are not fully developed until later in young adulthood (Steinberg, 2007). As a result, self-regulatory and self-control skills are not yet fully developed. In contrast, the neural network responsible for social and emotional development matures earlier, closer to the onset of puberty, and may well drive much of adolescent decision making (Steinberg, 2007). This imbalance between impulsive and reflective neural systems is normal in adolescents (Steinberg, 2007).

Throughout childhood and early adolescence, the brain undergoes synaptic overproduction, in which connections between neurons proliferate in the brain. Since this leads to more neural connections than can survive, the brain then undergoes a selective synaptic "pruning" process in adolescence into young adulthood, in which unused synapses are selectively eliminated. The synapses that survive this pruning process become more efficient and adept at transmitting information between neurons. For the prefrontal regions of the brain, which is responsible for individuals' ability to think, this pruning process results in greater cognitive abilities (Casey et al., 2008; Giedd, 2008; IOM and NRC, 2011; Johnson et al., 2009; Weinberger et al., 2005).

At around the same time, a process of myelination occurs, whereby the amount of white matter—the part of the brain that modulates the signals between nerves—increases in the prefrontal cortex. In this myelination process, nerve fibers become coated or sheathed in myelin, a white fatty substance. Myelin accelerates the velocity at which signals travel along nerves, making nerve-to-nerve communication faster and more efficient. This process continues until young adulthood and results in more efficient neural connections, which in turn results in improvements in higher-order cognitive functioning, planning, understanding of positive and negative consequences, and decision making.

During adolescence and through young adulthood, there is also an increase in the number of dopamine transmitters in the brain. These receptors connect to the limbic system, which is the part of the brain most responsible for emotions, rewards, and punishment. This increase in dopamine receptors during this period results in an increased desire for rewards and increased sensation seeking in order to feed these desires for reward (Counotte et al., 2011).

Finally, during adolescence and into young adulthood, more and more efficient connections develop between the prefrontal cortex and the limbic system. With greater connectivity, there is more likelihood of self-regulation and impulse control. During adolescence, there is less communication among the various centers of the brain and, hence, less likelihood to control impulses associated with rewards (Steinberg, 2013).

These processes of neurodevelopment have been shown to continue through the mid-20s, with large individual differences in the rate and amount of brain maturation over time. As such, the portions of the brain believed to be most responsible for decision making, impulse control, peer susceptibility, and other aspects of psychosocial maturity are not fully developed until young adulthood, with males developing more slowly than females (Casey et al., 2008; Giedd, 2008; Luna et al., 2004).

Research on the brain helps explain why adolescents and young adults are more likely to act impulsively and to make emotionally based decisions. This pattern is due in part to the fact that the amygdala—a part of the limbic system—rather than the prefrontal cortex is used in many decision tasks during adolescence and young adulthood (Smith et al., 2013; Steinberg, 2007). Brain imaging research shows that the prefrontal cortex, which controls self-regulation, impulse control, and sensation seeking, is less mature and less effectively used in adolescents than in adults (Casey et al., 2008; Luna et al., 2010; Smith et al., 2013). Of particular importance is that the limbic and paralimbic areas of the brain (amygdala, orbitofrontal cortex, medial prefrontal cortex, superior temporal sulcus, and ventral striatum) are developing during adolescence. Given that the areas of the brain particularly responsible for processing social and emotional information and reward pathways develop earlier, it stands to reason that adolescents are particularly focused on engaging in activities for which they receive rewards and acceptance from their peers and others (Smith et al., 2013). This reward seeking and focus on peer acceptance is responsible in part for greater risk taking during adolescence. Using functional magnetic resonance imaging (fMRI), Chein and colleagues (2011) examined activity within the brains of adolescents (14 to 18 years old), young adults (19 to 22 years old) and adults (24 to 29 years old) to determine which parts of the brain are more active when an individual is making simple driving decisions that are observed by peers. The researchers found that, compared to adults, adolescents used those areas of the brain most responsible for cognitive control less. Furthermore, there was more activation in the reward areas of the brain among adolescents than among adults.

As adolescents age into young adulthood, the part of the brain used to make decisions and understand information changes, with gradual improvements and shifts to the brain areas more responsible for higher-level cognitive control. Furthermore, the ability to process information and to do so without or with limited influence from others and with little emotional influences is not fully developed until the mid-20s (Giedd, 2008; Luna et al., 2004).

Implications of Tobacco Use for the Neurobiology of the Adolescent and Young Adult Brain

The developing adolescent brain is vulnerable to tobacco use not only because of its biological immaturity but also because some of the brain areas that are critical to the emergence of nicotine dependence may not be fully developed until late adolescence or young adulthood. The ongoing changes in both brain structure and function are likely to heighten an adolescent's vulnerability to tobacco use. The neurobiological stages and changes characteristic of adolescence, as described above, may translate directly into challenges adolescents will have in competently planning and executing the complex array of coping skills that are needed to resist prompts to use tobacco. Although most logical reasoning abilities are developed by age 16 (Steinberg et al., 2009a), the fact that some psychosocial capacities of adolescents are still immature, including delay of gratification, impulse control, emotional regulation, and the ability to resist social influences, may undermine the plans and efforts needed to resist tobacco use in the presence of cues to use. Steinberg (2007) suggests that when adolescents are emotionally aroused, their cognitive control mechanisms are further compromised.

Casey and Jones (2010) outlined how the imbalance in adolescents' developing neurobiological systems makes them particularly susceptible to the motivational properties of substances. Smoking-specific models of adolescent smoking initiation and brain development (Lydon et al., 2014) show that the adolescent developmental period is particularly critical with regards to smoking initiation. Nicotine exposure also affects the adolescent brain differently than the adult brain. Individuals exposed to nicotine during adolescence are more likely to experience the symptoms of a protracted abstinence syndrome than are individuals exposed to nicotine only in adulthood; thus, adolescents who use tobacco products are more at risk for continuation and relapse than individuals who started to use tobacco products in adulthood (Lydon et al., 2014).

In addition to the imbalance in the maturational stages of different brain regions, the adolescent brain may be especially primed to be receptive to the rewarding effects of nicotine. Adolescent brain development is characterized by a dynamic combination of changes, including increased innervations of fibers with modulatory neurotransmitters, synaptic pruning, increased myelination of higher-order associative areas (notably the prefrontal cortex), and adaptations of various receptor levels (Counotte et al., 2011). The levels of different receptor types follow a pattern of peaking in adolescence and then declining to adult levels; thus, adolescent brains may be especially sensitive to the effects of nicotine. Some of the receptor level changes that occur during adolescence include those that play important roles in modulating the circuitry of the prefrontal cortex and in mediating nicotine reward signals (e.g., glutamate receptors, dopamine, and nicotinic acetylcholine receptors). Adolescents also have greater brain reactivity to rewards in general than do young adults, which may also be related to novelty seeking such as tobacco use (Chein et al., 2011).

Most of the evidence about the vulnerability of the adolescent brain to nicotine comes from animal studies because of the ethical challenges of conducting this type of research in humans. Substantial evidence from these animal studies suggests that the adolescent brain has heightened sensitivity to the reinforcing effects of nicotine compared to the adult brain (Jamner et al., 2003; Slotkin, 2002), as demonstrated by both conditioned place preference paradigms and self-administration of nicotine (Belluzzi et al., 2004; Chen et al., 2008; Shram et al., 2006; Torres et al., 2008). While both animal and human studies indicate that adolescents experience fewer nicotine withdrawal symptoms than adults (Counotte et al., 2011), studies show that the reinforcing effects of nicotine are greater in adolescent rats than in adult rats, and additives to cigarettes, such as acetaldehyde, may also enhance the rate of the self-administration of nicotine in adolescent but not adult rats (Belluzzi et al., 2004). Animal models also suggest that exposure to nicotine during adolescence may increase the potential for dependence in adulthood, as adolescent rats exposed to nicotine increase their intravenous self-administration of nicotine when they reach adulthood (Adriani et al., 2003). In contrast, when rats are exposed to nicotine only after adolescence, the rewarding properties are reduced in conditioned place preference paradigms (Adriani et al., 2006).

The c-Fos gene is a marker of neuronal activation during brain development whose expression in response to nicotine is known to vary with age, with discrete periods of sensitivity in adolescence. The cingulate cortex, which is important for attention, and the retrosplenial cortex, which is activated by emotionally salient stimuli, show increased nicotine c-Fos mRNA in adolescence than in adulthood (Goldstein and Volkow, 2002; Jamner et al., 2003). These brain areas are connected with the primary visual cortex, where visual stimuli are processed initially. The visual cortex c-Fos mRNA is activated by nicotine in adolescence but is not similarly activated in adult brains, suggesting that even occasional tobacco use during adolescence may prime receptivity to the visual cues in tobacco advertising (Jamner et al., 2003).

Both the cingulate cortex and the retrosplenial cortex also influence areas of the amygdala, which are important in regulating attention, memory, and emotional response to sensory stimuli (Jamner et al., 2003; Swanson and Petrovich, 1998). Even low doses of nicotine in adolescence cause increases in c-Fos mRNA in the medial extended amygdala. This pathway also is critical to regulation of two other areas, the shell of the nucleus acumbens and the paraventricular nucleus of the hypothalamus, which regulate pathways for endocrine and behavioral outputs (Jamner et al., 2003; Swanson, 2000). c-Fos mRNA expression in the paraventricular nucleus is extremely sensitive to nicotine in the adolescent brain, and only during late adolescence (not adulthood) does nicotine-induced c-Fos expression appear in the shell of the nucleus acumbens.

In short, there are multiple brain regions that are highly activated during adolescence, and these regions form interconnected circuits that are critical to attention and motivational behavior. It is worth noting that brain development varies by sex, and these developmental differences may provide clues to differential rates of tobacco use seen in adolescent boys and girls. For example, in both animal and human studies, males are often more responsive to the rewarding effects of nicotine than are females (Donny et al., 2000; Perkins et al., 1999). There may also be sex differences in the effects of nicotine withdrawal. In animal models, nicotine administration in adolescents produces changes in brain circuitry, cell damage, and loss related to learning and memory, but these effects may be greater in the female hippocampus than in the male (Slotkin, 2002). To date, however, it has proved difficult to determine whether sex differences in patterns of brain development influence differences in the developmental trajectories of tobacco use.

In sum, brain development continues beyond adolescence into young adulthood. Individuals continue to undergo normal neurobiological changes, including developmental transformation of the prefrontal cortex and limbic brain regions, and myelination of the intracortical and meso-limbic dopamine systems continues (Benes, 1989; Thompson and Nelson, 2001). These patterns reflect growing executive function control, improved decision making, and decreases in behavioral impulsivity (Casey and Jones, 2010; Smith et al., 2013; Steinberg, 2004, 2013). The reward centers of the brain are most activated during adolescence (Chein et al., 2011; Steinberg, 2013).

The literature implies critical findings concerning adolescent and young adult brain development and its application to tobacco use. Most germane to this report are the following findings:

Finding 3-4: Brain development continues until about age 25.

Finding 3-5: While the development of some cognitive abilities is achieved by age 16, the parts of the brain most responsible for decision making, impulse control, sensation seeking, future perspective taking, and peer susceptibility and conformity continue to develop and change through young adulthood.

Finding 3-6: Animal studies suggest that adolescent brains, because of their level of development, are uniquely vulnerable to the effects of nicotine and nicotine addiction.

TOBACCO-RELATED DECISION MAKING BY ADOLESCENTS AND YOUNG ADULTS

Traditional models of decision making—for example, the Theory of Reasoned Action (see Fishbein, 1979), the Theory of Planned Behavior (Ajzen, 1985), and the Health Belief Model (Rosenstock, 1974)—describe decision making as taking place through a deliberate, analytic process; a process that involves many of the cognitive abilities discussed previously. According to these theories, decisions are based on cognitive processes that involve: (1) an assessment of the potential positive and negative outcomes associated with the behavior in question; (2) an assessment of the likelihood of experiencing personal harm from engaging in the behavior, including the likelihood that each positive (benefit) and negative (risk) outcome can and would occur; (3) consideration of one's desire to engage in the behavior, given the potential positive and negative consequences; (4) perceptions of the extent to which similar others are engaging in the behavior; (5) perceptions of the extent to which others would accept or not accept engagement in the behavior; and (6) intention to engage in the behavior.

The understanding that adolescent cognitive abilities are largely forged by about age 16 while psychosocial maturation is still continuing has led to the development of new decision-making models that include both cognitive and noncognitive components. These dual-process models are especially relevant to tobacco use, which involves a deliberate decision process in a developmental context strongly affected by psychosocial influences that adolescents are not always equipped to process.

The dual-process models include, first, the cognitive path involving the more traditional, deliberate, reasoned, and informed aspects of the decision process. In this path, decisions rely on cognitive skills such as weighing risks and benefits and social norms, and these attitudes are expected to predict intentions and ultimately behavior. This is the path sometimes used by adolescents when making decisions that are less emotional, and it is the path most often used by adults.

The second path, which is used more often by adolescents during emotional decisions such as whether to use tobacco, involves the noncognitive aspects of decision making, such as impulsiveness, sensation seeking, and reward seeking. The influence of this path is rooted in the asynchrony observed in the adolescent and young adult brain structure and function. This path involves the more hypersensitive affective system, which leads to decisions that are more affectively based and influenced by psychosocial factors, such as peers, lower impulse control, increased sensation seeking, and self-regulation (Smith et al., 2013), particularly in an emotionally charged situation such as develops when an adolescent is faced with the dilemma of whether or not to use tobacco.

Given these two paths to decision making, it is evident that adolescents and, in some cases, young adults are strongly susceptible to developmentally grounded social and emotional influences in making decisions concerning tobacco use. Delaying the socially sanctioned opportunity for this decision, and strengthening the social disincentives to use tobacco, can reasonably be expected to reduce the likelihood that adolescents and young adults will affiliate with peers who are using tobacco and reduce the chances that they will be induced or pressured to use tobacco while their brains continue to mature.

Finding 3-7: The developmental trajectories in adolescents and young adults may be altered by social and environmental contextual influences. Such changes are commonly observed because of normative developmental transitions into and out of school or work or because of changes in living arrangements or relationships.

TOBACCO INDUSTRY TARGETING ADOLESCENTS AND YOUNG ADULTS

Tobacco industry influence is an important environmental factor that increases adolescents' and young adults' susceptibility to using tobacco use. Tobacco companies have historically targeted children and young adults, recognizing that they needed the "youth market" to perpetuate the sales of their products (Teague, 1973). Since the 1998 Master Settlement Agreement, tobacco companies are legally prohibited from marketing to individuals younger than 18 years of age (NAAG, 1998). But while traditional cigarette advertisements are no longer allowed in broadcast television or radio, tobacco companies have responded to these restrictions by increasing their advertising and promotion at points of purchase (Feighery et al., 2001; Henriksen, 2012) and vigorously marketing to young adults via promotions at venues such as bars or events such as concerts (Ling and Glantz, 2002). The aggressive marketing of tobacco products at points of purchase and popular venues as well as the heavy exposure to images of tobacco use that individuals receive via television and movies is troubling, as studies show that adolescents and young adults may be particularly vulnerable to such marketing practices (e.g., Scull et al., 2010; Ward et al., 2006). According to recent theories of media exposure, such as the "super peer" theory (Brown et al., 2005), the media exerts a distinct influence on adolescents' perceptions of what is normal, acceptable, and expected of them, and it may actually exert more influence than either parents or peers (Ward et al., 2006). For example, Scull and colleagues (2010) found that adolescents' beliefs regarding the attractiveness of advertisements for alcohol and tobacco, how realistic they felt the ads were, and how similar they felt they were to individuals in the ads predicted current use and intentions to use alcohol and tobacco over and above variables of peer and parental influence.

As described in previously secret tobacco industry documents, tobacco companies use marketing strategies to shape consumers' and potential consumers' perceptions of risk and to increase beliefs in the acceptability of tobacco products (Anderson, 2011). For example, the tobacco industry used terms such as "light" and "mild" to encourage tobacco use as the awareness of the health dangers of smoking grew (Etter et al., 2003; Gilpin et al., 2002; Kropp and Halpern-Felsher, 2004; Shiffman et al., 2001; Tindle et al., 2006). Similarly, a review of more than 900 tobacco industry documents revealed that menthol cigarettes were marketed as healthier than non-menthol cigarettes; such marketing was related to adolescents' and young adults' perceptions that menthol-flavored cigarettes were a healthier alternative (Anderson, 2011; Klausner, 2011). In addition, the tobacco industry has used aspirational visual imagery (e.g., sexy women smoking, baseball players using smokeless tobacco) to motivate tobacco use (Cortese et al., 2009; Mejia and Ling, 2010; Toll and Ling, 2005). The prominent use of the Internet and social media to market new products such as electronic nicotine delivery systems (ENDS) and smokeless tobacco further facilitates these marketing strategies and increases the tobacco companies' reach, relevance, and opportunities to interact with young consumers, which results in perceptions of reduced risk, greater benefits, and greater social acceptability of marketed tobacco products. These messages are especially effective when the marketing messages appear to come from peers and other tobacco consumers rather than the manufacturer (Sepe et al., 2002).

Numerous longitudinal studies have found a significant relationship between exposure to cigarette marketing and subsequent smoking behavior. Hanewinkel and colleagues (2011), for example, found that adolescents with high levels of exposure to cigarette advertising were significantly more likely to smoke than adolescents who had been exposed to low levels of cigarette advertising, while exposure to other types of advertising did not affect smoking initiation rates (Hanewinkel et al., 2011). Anti-tobacco counter-marketing campaigns such as the truth® campaign have also been shown to be successful at reducing tobacco initiation and use among adolescents and young adults (Davis et al., 2009; Emery et al., 2012; Farrelly et al., 2005, 2009; Richardson et al., 2010; Sly et al., 2001).

Point-of-sale marketing is also associated with adolescent initiation of smoking (Slater et al., 2007). In a longitudinal study showing that adolescents who frequently visit liquor stores, convenience stores, and markets with high concentrations of point-of-sale advertising for cigarettes are significantly more likely to initiate smoking (Henriksen et al., 2010). Among young adults, it has been shown that both smokers and nonsmokers ages 18 to 30 are twice as likely to attend bars and clubs than their older counterparts, and they are also more attracted and susceptible to tobacco advertising (Biener and Albers, 2004). Ling and Glantz have also shown that marketing targeted at young adults has the consequence of promoting smoking in older teens as well (Ling and Glantz, 2002).

Influence of Seeing Smoking in the Movies

Overall, between 1950 and 1990 there was a decrease in depictions of smoking in the movies, but this was followed by a rapid increase so that by 2002 depictions of smoking were comparable in scale to what had existed in 1950 (Charlesworth and Glantz, 2005). This trend has continued, and between 2011 and 2012 there was a 45 percent increase in the number of tobacco incidents displayed per movie (Glantz et al., 2013). Exposure to smoking images in movies as well as in other sources such as newspapers and television has been found to be associated with positive assessments related to the social acceptability of smoking, smoking as a means of stress and emotional control (Watson et al., 2003), and assessments of smoking being “sexy” and “stylish” (McCool et al., 2004). Experimental studies and cross-sectional surveys have found a relationship between exposure to smoking images in the movies and smoking initiation, and longitudinal studies have found that adolescents with higher exposure to smoking in the movies were more likely to initiate smoking than peers who reported low levels of exposure (Dal Cin et al., 2012).

The tobacco industry’s efforts to manipulate tobacco-related perceptions and acceptability are more concerning as new tobacco products come to market (Ganz et al., 2015; Grana and Ling, 2014; Kornfield et al., 2015; Pokhrel et al., 2015). The tobacco industry has continued to market tobacco products aggressively. The impact of this marketing will depend on Food and Drug Administration regulation of marketing and promotional materials.

IMPLICATIONS

It is clear that the juxtaposition of numerous risk factors during the adolescent and young adult years is likely to increase the probability that first trials of tobacco use will turn into persistent use. These factors include the sequence of neurodevelopment in the adolescent years, the unique sensitivity of the adolescent brain to the rewarding properties of nicotine, the early development of symptoms of dependence in an adolescent’s smoking experience (well before reaching the 100-cigarette lifetime threshold), and the difficulties that adolescents have in stopping smoking. Delaying the onset of any tobacco use beyond adolescence will likely decrease the probability that early trials of tobacco will be experienced as rewarding and to increase an individual's ability to discontinue tobacco use after initial trials.

REFERENCES

Adriani, W., S. Spijker, V. Deroche-Gamonet, G. Laviola, M. Le Moal, A. B. Smit, and P. V. Piazza. 2003. Evidence for enhanced neurobehavioral vulnerability to nicotine during periadolescence in rats. *Journal of Neuroscience* 23(11):4712–4716.

Adriani, W., V. Deroche-Gamonet, M. Le Moal, G. Laviola, and P. V. Piazza. 2006. Preexposure during or following adolescence differently affects nicotine-rewarding properties in adult rats. *Psychopharmacology* 184(3–4):382–390.

Ajzen, I. 1985. *From intentions to actions: A theory of planned behavior*. Berlin: Springer.

Albert, D., and L. Steinberg. 2011. Judgment and decision making in adolescence. *Journal of Research on Adolescence* 21(1):211–224.

Albert, D., J. Chein, and L. Steinberg. 2013. The teenage brain: Peer influences on adolescent decision making. *Current Directions in Psychological Science* 22(2):114–120.

Alexander, C., M. Piazza, D. Mekos, and T. Valente. 2001. Peers, schools, and adolescent cigarette smoking. *Journal of Adolescent Health* 29(1):22–30.

Anderson, S. J. 2011. Marketing of menthol cigarettes and consumer perceptions: A review of tobacco industry documents. *Tobacco Control* 20(Suppl 2):ii20–ii28.

Arnett, J. J. 2000. Emerging adulthood—A theory of development from the late teens through the twenties. *American Psychologist* 55(5):469–480.

———. 2004. *Emerging adulthood: The winding road from the late teens through the twenties*. New York: Oxford University Press.

Bandura, A. 2001. Social cognitive theory: An agentic perspective. *Annual Review of Psychology* 52:1–26.

Bansal-Travers, M., D. Hammond, P. Smith, and K. M. Cummings. 2011. The impact of cigarette pack design, descriptors, and warning labels on risk perception in the U.S. *American Journal of Preventive Medicine* 40(6):674–682.

Belluzzi, J. D., R. Wang, and F. M. Leslie. 2004. Acetaldehyde enhances acquisition of nicotine self-administration in adolescent rats. *Neuropsychopharmacology* 30(4):705–712.

Benes, F. M. 1989. Myelination of cortical-hippocampal relays during late adolescence. *Schizophrenia Bulletin* 15(4):585–593.

Biener, L., and A. B. Albers. 2004. Young adults: Vulnerable new targets of tobacco marketing. *American Journal of Public Health* 94(2):326–330.

Brown, J. D., C. T. Halpern, and K. L. L'Engle. 2005. Mass media as a sexual super peer for early maturing girls. *Journal of Adolescent Health* 36(5):420–427.

Callery, W. E., D. Hammond, R. J. O'Connor, and G. T. Fong. 2011. The appeal of smokeless tobacco products among young Canadian smokers: The impact of pictorial health warnings and relative risk messages. *Nicotine & Tobacco Research* 13(5):373–383.

Cance, J. D., S. T. Ennett, A. A. Morgan-Lopez, V. A. Foshee, and A. E. Talley. 2013. Perceived pubertal timing and recent substance use among adolescents: A longitudinal perspective. *Addiction* 108(10):1845–1854.

Casey, B., and R. M. Jones. 2010. Neurobiology of the adolescent brain and behavior: Implications for substance use disorders. *Journal of the American Academy of Child and Adolescent Psychiatry* 49(12):1189–1201.

Casey, B., J. N. Giedd, and K. M. Thomas. 2000. Structural and functional brain development and its relation to cognitive development. *Biological Psychology* 54(1-3):241–257.

Casey, B., R. M. Jones, and T. A. Hare. 2008. The adolescent brain. *Annals of the New York Academy of Sciences* 1124:111–126.

Charlesworth, A., and S. A. Glantz. 2005. Smoking in the movies increases adolescent smoking: A review. *Pediatrics* 116(6):1516–1528.

Chassin, L., C. C. Presson, S. C. Pitts, and S. J. Sherman. 2000. The natural history of cigarette smoking from adolescence to adulthood in a Midwestern community sample: Multiple trajectories and their psychosocial correlates. *Health Psychology* 19(3):223–231.

Chein, J., D. Albert, L. O'Brien, K. Uckert, and L. Steinberg. 2011. Peers increase adolescent risk taking by enhancing activity in the brain's reward circuitry. *Developmental Science* 14(2):F1–F10.

Chen, H., Y. Fu, and B. M. Sharp. 2008. Chronic nicotine self-administration augments hypothalamic–pituitary–adrenal responses to mild acute stress. *Neuropsychopharmacology* 33(4):721–730.

Choi, K., L. Fabian, N. Mottey, A. Corbett, and J. Forster. 2012. Young adults' favorable perceptions of snus, dissolvable tobacco products, and electronic cigarettes: Findings from a focus group study. *American Journal of Public Health* 102(11):2088–2093.

Cialdini, R. B., R. R. Reno, and C. A. Kallgren. 1990. A focus theory of normative conduct: Recycling the concept of norms to reduce littering in public places. *Journal of Personality and Social Psychology* 58(6):1015–1026.

Cortese, D. K., M. J. Lewis, and P. M. Ling. 2009. Tobacco industry lifestyle magazines targeted to young adults. *Journal of Adolescent Health* 45(3):268–280.

Counotte, D. S., A. B. Smit, T. Pattij, and S. Spijker. 2011. Development of the motivational system during adolescence, and its sensitivity to disruption by nicotine. *Developmental Cognitive Neuroscience* 1(4):430–443.

Crockett, L. J., and A. C. Petersen. 1987. Pubertal status and psychosocial development: Findings from the Early Adolescence Study. In R. M. Lerner and T. T. Foch, eds., *Biological–Psychosocial Interactions in Early Adolescence* (pp. 173–188). Hillsdale, NJ: Lawrence Erlbaum Associates.

Crone, E. A., and R. E. Dahl. 2012. Understanding adolescence as a period of social–affective engagement and goal flexibility. *Nature Reviews Neuroscience* 13(9):636–650.

Dal Cin, S., M. Stoolmiller, and J. D. Sargent. 2012. When movies matter: Exposure to smoking in movies and changes in smoking behavior. *Journal of Health Communication* 17(1):76–89.

Davis, K. C., M. C. Farrelly, P. Messeri, and J. Duke. 2009. The impact of national smoking prevention campaigns on tobacco-related beliefs, intentions to smoke and smoking initiation: Results from a longitudinal survey of youth in the united states. *International Journal of Environmental Research and Public Health* 6(2):722–740.

DiFranza, J. R., J. A. Savageau, K. Fletcher, L. Pbert, J. O'Loughlin, A. D. McNeill, J. K. Ockene, K. Friedman, J. Hazelton, and C. Wood. 2007. Susceptibility to nicotine dependence: The Development and Assessment of Nicotine Dependence in Youth 2 study. *Pediatrics* 120(4):e974–e983.

Donny, E., A. Caggiula, P. Rowell, M. Gharib, V. Maldovan, S. Booth, M. Mielke, A. Hoffman, and S. McCallum. 2000. Nicotine self-administration in rats: Estrous cycle effects, sex differences and nicotinic receptor binding. *Psychopharmacology* 151(4):392–405.

Duncan, G. J., J. Boisjoly, M. Kremer, D. M. Levy, and J. Eccles. 2005. Peer effects in drug use and sex among college students. *Journal of Abnormal Child Psychology* 33(3):375–385.

Elliot, A. J. 1999. Approach and avoidance motivation and achievement goals. *Educational Psychologist* 34(3):169–189.

Emery, S., Y. Kim, Y. K. Choi, G. Szczypka, M. Wakefield, and F. J. Chaloupka. 2012. The effects of smoking-related television advertising on smoking and intentions to quit among adults in the United States: 1999–2007. *American Journal of Public Health* 102(4):751–757.

Etcheverry, P. E., and C. R. Agnew. 2008. Romantic partner and friend influences on young adult cigarette smoking: Comparing close others' smoking and injunctive norms over time. *Psychology of Addictive Behaviors* 22(3):313–325.

Etter, J. F., L. T. Kozlowski, and T. V. Perneger. 2003. What smokers believe about light and ultralight cigarettes. *Preventive Medicine* 36(1):92–98.

Farrelly, M. C., K. C. Davis, M. L. Haviland, P. Messeri, and C. G. Healton. 2005. Evidence of a dose–response relationship between "truth" antismoking ads and youth smoking prevalence. *American Journal of Public Health* 95(3):425–431.

Farrelly, M. C., J. Nonnemaker, K. C. Davis, and A. Hussin. 2009. The influence of the national truth campaign on smoking initiation. *American Journal of Preventive Medicine* 36(5):379–384.

Feighery, E. C., K. M. Ribisl, N. Schleicher, R. E. Lee, and S. Halvorson. 2001. Cigarette advertising and promotional strategies in retail outlets: Results of a statewide survey in California. *Tobacco Control* 10(2):184–188.

Fischhoff, B., W. Bruine de Bruin, A. M. Parker, S. G. Millstein, and B. L. Halpern-Felsher. 2010. Adolescents' perceived risk of dying. *Journal of Adolescent Health* 46(3):265–269.

Fishbein, M. 1979. A theory of reasoned action: Some applications and implications. *Nebraska Symposium on Motivation* 27:65–116.

Fry, R. 2014. A rising share of young adults live in their parents' home. Pew Research Centers Social Demographic Trends Project. http://www.pewsocialtrends.org/2013/08/01/a-rising-share-of-young-adults-live-in-their-parents-home (accessed February 7, 2015).

Ganz, O., J. Cantrell, J. Moon-Howard, A. Aidala, T. R. Kirchner, and D. Vallone. 2015. Electronic cigarette advertising at the point-of-sale: A gap in tobacco control research. *Tobacco Control* 24:e110–e112.

Gardner, M., and L. Steinberg. 2005. Peer influence on risk taking, risk preference, and risky decision making in adolescence and adulthood: An experimental study. *Developmental Psychology* 41(4):625–635.

Giedd, J. N. 2008. The teen brain: Insights from neuroimaging. *Journal of Adolescent Health* 42(4):335–343.

Gilpin, E. A., S. Emery, M. M. White, and J. P. Pierce. 2002. Does tobacco industry marketing of "light" cigarettes give smokers a rationale for postponing quitting? *Nicotine & Tobacco Research* 4(Suppl 2):S147–S155.

Glantz, S. A., A. Iaccopucci, K. Titus, and J. R. Polansky. 2013. Smoking in top-grossing U.S. movies, 2012. *Preventing Chronic Disease* 9:120170. http://www.cdc.gov/pcd/issues/2012/12_0170.htm (accessed February 7, 2015).

Gogtay, N., J. N. Giedd, L. Lusk, K. M. Hayashi, D. Greenstein, A. C. Vaituzis, T. F. Nugent, D. H. Herman, L. S. Clasen, and A. W. Toga. 2004. Dynamic mapping of human cortical development during childhood through early adulthood. *Proceedings of the National Academy of Sciences of the United States of America* 101(21):8174–8179.

Goldstein, R. Z., and N. D. Volkow. 2002. Drug addiction and its underlying neurobiological basis: Neuroimaging evidence for the involvement of the frontal cortex. *American Journal of Psychiatry* 159(10):1642–1652.

Grana, R. A., and P. M. Ling. 2014. "Smoking revolution": A content analysis of electronic cigarette retail websites. *American Journal of Preventive Medicine* 46(4):395–403.

Halpern-Felsher, B. L., and E. Cauffman. 2001. Costs and benefits of a decision: Decision-making competence in adolescents and adults. *Journal of Applied Developmental Psychology* 22(3):257–273.

Halpern-Felsher, B. L., M. Biehl, R. Y. Kropp, and M. L. Rubinstein. 2004. Perceived risks and benefits of smoking: Differences among adolescents with different smoking experiences and intentions. *Preventive Medicine* 39(3):559–567.

Hanewinkel, R., B. Isensee, J. D. Sargent, and M. Morgenstern. 2011. Cigarette advertising and teen smoking initiation. *Pediatrics* 127(2):e271–e278.

Henriksen, L. 2012. Comprehensive tobacco marketing restrictions: Promotion, packaging, price and place. *Tobacco Control* 21(2):147–153.

Henriksen, L., N. C. Schleicher, E. C. Feighery, and S. P. Fortmann. 2010. A longitudinal study of exposure to retail cigarette advertising and smoking initiation. *Pediatrics* 126(2):232–238.

HHS (Department of Health and Human Services). 2012. *Preventing tobacco use among youth and young adults: A report of the Surgeon General*. Atlanta GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

IOM and NRC (Institute of Medicine and National Research Council). 2004. *Reducing underage drinking: A collective responsibility*. Edited by R. J. Bonnie. Washington, DC: The National Academies Press.

———. 2011. *The science of adolescent risk-taking: Workshop report*. Washington, DC: The National Academies Press.

———. 2014. *Investing in the health and well-being of young adults*. Edited by R. J. Bonnie, C. Stroud, and H. Breiner. Washington, DC: The National Academies Press.

Jamner, L. D., C. K. Whalen, S. E. Loughlin, R. Mermelstein, J. Audrain-McGovern, S. Krishnan-Sarin, J. K. Worden, and F. M. Leslie. 2003. Tobacco use across the formative years: A road map to developmental vulnerabilities. *Nicotine & Tobacco Research* 5(Suppl 1):S71–S87.

Johnson, S. B., R. W. Blum, and J. N. Giedd. 2009. Adolescent maturity and the brain: The promise and pitfalls of neuroscience research in adolescent health policy. *Journal of Adolescent Health* 45(3):216–221.

Kallgren, C. A., R. R. Reno, and R. B. Cialdini. 2000. A focus theory of normative conduct: When norms do and do not affect behavior. *Personality and Social Psychology Bulletin* 26(8):1002–1012.

Klausner, K. 2011. Menthol cigarettes and smoking initiation: A tobacco industry perspective. *Tobacco Control* 20(Suppl 2):ii12–ii19.

Kornfield, R., J. Huang, L. Vera, and S. L. Emery. 2015. Rapidly increasing promotional expenditures for e-cigarettes. *Tobacco Control* 24(2):110–111.

Kosten, T. A., S. A. Ball, and B. J. Rounsaville. 1994. A sibling study of sensation seeking and opiate addiction. *Journal of Nervous and Mental Disease* 182(5):284–289.

Kozlowski, L. T., M. E. Goldberg, B. A. Yost, E. L. White, C. T. Sweeney, and J. L. Pillitteri. 1998. Smokers' misperceptions of light and ultra-light cigarettes may keep them smoking. *American Journal of Preventive Medicine* 15(1):9–16.

Kropp, R. Y., and B. L. Halpern-Felsher. 2004. Adolescents' beliefs about the risks involved in smoking "light" cigarettes. *Pediatrics* 114(4):e445–e451.

Kuther, T. L. 2003. Medical decision-making and minors: Issues of consent and assent. *Adolescence* 38(150):343–358.

Lewis, C. C. 1981. How adolescents approach decisions: Changes over grades seven to twelve and policy implications. *Child Development* 52(2):538–544.

Ling, P. M., and S. A. Glantz. 2002. Why and how the tobacco industry sells cigarettes to young adults: Evidence from industry documents. *American Journal of Public Health* 92(6):908–916.

Luna, B., K. E. Garver, T. A. Urban, N. A. Lazar, and J. A. Sweeney. 2004. Maturation of cognitive processes from late childhood to adulthood. *Child Development* 75(5):1357–1372.

Luna, B., A. Padmanabhan, and K. O'Hearn. 2010. What has fMRI told us about the development of cognitive control through adolescence? *Brain and Cognition* 72(1):101–113.

Lydon, D. M., S. J. Wilson, A. Child, and C. F. Geier. 2014. Adolescent brain maturation and smoking: What we know and where we're headed. *Neuroscience and Biobehavioral Reviews* 45:323–342.

Martin, C., T. Logan, C. Leukefeld, R. Milich, H. Omar, and R. Clayton. 2001. Adolescent and young adult substance use: Association with sensation seeking, self esteem and retrospective report of early pubertal onset. A preliminary examination. *International Journal of Adolescent Medicine and Health* 13(3):211–219.

McCool, J., L. Cameron, and K. Petrie. 2004. Stereotyping the smoker: Adolescents' appraisals of smokers in film. *Tobacco Control* 13(3):308–314.

Mejia, A. B., and P. M. Ling. 2010. Tobacco industry consumer research on smokeless tobacco users and product development. *American Journal of Public Health* 100(1):78–87.

Mendle, J., and J. Ferrero. 2012. Detrimental psychological outcomes associated with pubertal timing in adolescent boys. *Developmental Review* 32(1):49–66.

Mendle, J., E. Turkheimer, and R. E. Emery. 2007. Detrimental psychological outcomes associated with early pubertal timing in adolescent girls. *Developmental Review* 27(2):151–171.

Michels, T. M., R. Y. Kropp, S. L. Eyre, and B. L. Halpern-Felsher. 2005. Initiating sexual experiences: How do young adolescents make decisions regarding early sexual activity? *Journal of Research on Adolescence* 15(4):583–607.

Millstein, S. G., and B. L. Halpern-Felsher. 2002. Judgments about risk and perceived invulnerability in adolescents and young adults. *Journal of Research on Adolescence* 12(4):399–422.

Morrell, H. E., A. V. Song, and B. L. Halpern-Felsher. 2010. Predicting adolescent perceptions of the risks and benefits of cigarette smoking: A longitudinal investigation. *Health Psychology* 29(6):610–617.

NAAG (National Association of Attorneys General). 1998. Master settlement agreement. http://publichealthlawcenter.org/sites/default/files/resources/master-settlement-agreement.pdf (accessed September 5, 2014).

Nelson, L. J., and C. M. Barry. 2005. Distinguishing features of emerging adulthood: The role of self-classification as an adult. *Journal of Adolescent Research* 20(2):242–262.

Nyman, A., T. Taylor, and L. Biener. 2002. Trends in cigar smoking and perceptions of health risks among Massachusetts adults. *Tobacco Control* 11(Suppl 2):ii25–ii28.

Øverland, S., J. Hetland, and L. E. Aarø. 2008. Relative harm of snus and cigarettes: What do Norwegian adolescents say? *Tobacco Control* 17(6):422–425.

Perkins, K. A., E. Donny, and A. R. Caggiula. 1999. Sex differences in nicotine effects and self-administration: Review of human and animal evidence. *Nicotine & Tobacco Research* 1(4):301–315.

Pokhrel, P., P. Fagan, L. Kehl, and T. A. Herzog. 2015. Receptivity to e-cigarette marketing, harm perceptions, and e-cigarette use. *American Journal of Health Behavior* 39(1):121–131.

Richardson, A. K., M. Green, H. Xiao, N. Sokol, and D. Vallone. 2010. Evidence for truth®: The young adult response to a youth-focused anti-smoking media campaign. *American Journal of Preventive Medicine* 39(6):500–506.

Rimal, R. N., and K. Real. 2005. How behaviors are influenced by perceived norms: A test of the theory of normative social behavior. *Communication Research* 32(3):389–414.

Rosenstock, I. M. 1974. Historical origins of the health belief model. *Health Education and Behavior* 2(4):328–335.

Sartor, C. E., C. N. Lessov-Schlaggar, J. F. Scherrer, K. K. Bucholz, P. A. Madden, M. L. Pergadia, J. D. Grant, T. Jacob, and H. Xian. 2010. Initial response to cigarettes predicts rate of progression to regular smoking: Findings from an offspring-of-twins design. *Addictive Behaviors* 35(8):771–778.

Scull, T. M., J. B. Kupersmidt, A. E. Parker, K. C. Elmore, and J. W. Benson. 2010. Adolescents' media-related cognitions and substance use in the context of parental and peer influences. *Journal of Youth and Adolescence* 39(9):981–998.

Sepe, E., P. M. Ling, and S. A. Glantz. 2002. Smooth moves: Bar and nightclub tobacco promotions that target young adults. *American Journal of Public Health* 92(3):414–419.

Settersten, R., and B. E. Ray. 2010. *Not quite adults*. New York: Bantam Books.

Shiffman, S., J. L. Pillitteri, S. L. Burton, J. M. Rohay, and J. G. Gitchell. 2001. Effect of health messages about "light" and "ultra light" cigarettes on beliefs and quitting intent. *Tobacco Control* 10(Suppl 1):i24–i32.

Shram, M. J., D. Funk, Z. Li, and A. D. Lê. 2006. Periadolescent and adult rats respond differently in tests measuring the rewarding and aversive effects of nicotine. *Psychopharmacology* 186(2):201–208.

Siegel, J. M., A. K. Yancey, C. S. Aneshensel, and R. Schuler. 1999. Body image, perceived pubertal timing, and adolescent mental health. *Journal of Adolescent Health* 25(2):155–165.

Simons-Morton, B., D. L. Haynie, A. D. Crump, P. Eitel, and K. E. Saylor. 2001. Peer and parent influences on smoking and drinking among early adolescents. *Health Education and Behavior* 28(1):95–107.

Slater, S. J., F. J. Chaloupka, M. Wakefield, L. D. Johnston, and P. M. O'Malley. 2007. The impact of retail cigarette marketing practices on youth smoking uptake. *Archives of Pediatrics and Adolescent Medicine* 161(5):440–445.

Slotkin, T. A. 2002. Nicotine and the adolescent brain: Insights from an animal model. *Neurotoxicology and Teratology* 24(3):369–384.

Sly, D. F., R. S. Hopkins, E. Trapido, and S. Ray. 2001. Influence of a counteradvertising media campaign on initiation of smoking: The Florida "truth" campaign. *American Journal of Public Health* 91(2):233–238.

Smith, A. R., J. Chein, and L. Steinberg. 2013. Impact of socio-emotional context, brain development, and pubertal maturation on adolescent risk-taking. *Hormones and Behavior* 64(2):323–332.

Soldz, S., and X. Cui. 2002. Pathways through adolescent smoking: A 7-year longitudinal grouping analysis. *Health Psychology* 21(5):495–504.

Song, A. V., S. A. Glantz, and B. L. Halpern-Felsher. 2009a. Perceptions of second-hand smoke risks predict future adolescent smoking initiation. *Journal of Adolescent Health* 45(6):618–625.

Song, A. V., H. E. Morrell, J. L. Cornell, M. E. Ramos, M. Biehl, R. Y. Kropp, and B. L. Halpern-Felsher. 2009b. Perceptions of smoking-related risks and benefits as predictors of adolescent smoking initiation. *American Journal of Public Health* 99(3):487–492.

Sowell, E. R., P. M. Thompson, C. J. Holmes, T. L. Jernigan, and A. W. Toga. 1999. In vivo evidence for post-adolescent brain maturation in frontal and striatal regions. *Nature Neuroscience* 2(10):859–861.

Steinberg, L. 2004. Risk taking in adolescence: What changes, and why? *Annals of the New York Academy of Sciences* 1021:51–58.

———. 2007. Risk taking in adolescence: New perspectives from brain and behavioral science. *Current Directions in Psychological Science* 16(2):55–59.

———. 2008. A social neuroscience perspective on adolescent risk-taking. *Developmental Review* 28(1):78–106.

———. 2013. The influence of neuroscience on U.S. Supreme Court decisions about adolescents' criminal culpability. *Nature Reviews Neuroscience* 14(7):513–518.

Steinberg, L., and K. C. Monahan. 2007. Age differences in resistance to peer influence. *Developmental Psychology* 43(6):1531–1543.

Steinberg, L., and A. S. Morris. 2001. Adolescent development. *Annual Review of Psychology* 52:83–110.

Steinberg, L., D. Albert, E. Cauffman, M. Banich, S. Graham, and J. Woolard. 2008. Age differences in sensation seeking and impulsivity as indexed by behavior and self-report: Evidence for a dual systems model. *Developmental Psychology* 44(6):1764–1778.

Steinberg, L., E. Cauffman, J. Woolard, S. Graham, and M. Banich. 2009a. Are adolescents less mature than adults?: Minors' access to abortion, the juvenile death penalty, and the alleged APA "flip-flop." *American Psychologist* 64(7):583–594.

Steinberg, L., S. Graham, L. O'Brien, J. Woolard, E. Cauffman, and M. Banich. 2009b. Age differences in future orientation and delay discounting. *Child Development* 80(1):28–44.

Susman, E. J., R. M. Houts, L. Steinberg, J. Belsky, E. Cauffman, G. Dehart, S. L. Friedman, G. I. Roisman, B. L. Halpern-Felsher, and Eunice Kennedy Shriver NICHD Early Child Care Research Network. 2010. Longitudinal development of secondary sexual characteristics in girls and boys between ages 9½ and 15½ years. *Archives of Pediatrics and Adolescent Medicine* 164(2):166–173.

Swanson, L. W. 2000. Cerebral hemisphere regulation of motivated behavior. *Brain Research* 886(1–2):113–164.

Swanson, L. W., and G. D. Petrovich. 1998. What is the amygdala? *Trends in Neurosciences* 21(8):323–331.

Teague, C. 1973. Research planning memorandum on some thoughts about new brands of cigarettes for the youth market. http://legacy.library.ucsf.edu/tid/iiu91f00 (accessed January 28, 2015).

Teichman, M., Z. Barnea, and G. Ravav. 1989. Personality and substance use among adolescents: A longitudinal study. *British Journal of Addiction* 84(2):181–190.

Thompson, R. A., and C. A. Nelson. 2001. Developmental science and the media: Early brain development. *American Psychologist* 56(1):5–15.

Tindle, H. A., N. A. Rigotti, R. B. Davis, E. M. Barbeau, I. Kawachi, and S. Shiffman. 2006. Cessation among smokers of "light" cigarettes: Results from the 2000 National Health Interview Survey. *American Journal of Public Health* 96(8):1498–1504.

Toll, B., and P. Ling. 2005. The Virginia Slims identity crisis: An inside look at tobacco industry marketing to women. *Tobacco Control* 14(3):172–180.

Torres, O. V., H. A. Tejeda, L. A. Natividad, and L. E. O'Dell. 2008. Enhanced vulnerability to the rewarding effects of nicotine during the adolescent period of development. *Pharmacology, Biochemistry and Behavior* 90(4):658–663.

Vitulano, M. L., P. J. Fite, and J. L. Rathert. 2010. Delinquent peer influence on childhood delinquency: The moderating effect of impulsivity. *Journal of Psychopathology and Behavioral Assessment* 32(3):315–322.

Ward, L. M., K. M. Day, and M. Epstein. 2006. Uncommonly good: Exploring how mass media may be a positive influence on young women's sexual health and development. *New Directions for Child and Adolescent Development* 2006(112):57–70.

Watson, N., J. Clarkson, R. Donovan, and B. Giles-Corti. 2003. Filthy or fashionable? Young people's perceptions of smoking in the media. *Health Education Research* 18(5):554–567.

Weinberger, D. R., B. Elvevåg, and J. N. Giedd. 2005. *The adolescent brain: A work in progress*. Washington, DC: The National Campaign to Prevent Teen Pregnancy.

Zimring, F. E. 2000. *American youth violence*. New York: Oxford University Press.

Zuckerman, M. 1979. *Sensation seeking: Beyond the optimal level of arousal*. Hillsdale, NJ: Lawrence Erlbaum Associates.

———. 2007. *Sensation seeking and risk*. Washington, DC: American Psychological Association.

4

The Effects of Tobacco Use on Health

The scope of the burden of disease and death that cigarette smoking imposes on the public's health is extensive. Cigarette smoking is the major focus of this chapter because it is the central public health problem, but the topics of secondhand smoke exposure, smoking of other combustible tobacco products, smokeless tobacco, and electronic nicotine delivery systems (ENDS) are also considered. The magnitude of the public health threat posed by cigarette smoking stems from two factors: (1) the prevalence of cigarette smoking is so high, and (2) smoking causes so many deleterious health effects. A policy change that reduces the prevalence of cigarette smoking will result in a commensurate reduction in the population burden of disease and death caused by cigarette smoking. The associations between cigarette smoking and the adverse health effects caused by smoking are dose-dependent (HHS, 2014). Thus, a public health benefit would be realized if a policy change led to reduced exposure to cigarette smoke via means other than reducing the prevalence of smoking. For example, additional reduction in the population burden of smoking-caused disease and death will be generated if the policy also results in delayed initiation of cigarette smoking. The population health benefit from delayed initiation, although potentially large, will be less than the benefit from a commensurate reduction in smoking prevalence because delayed initiation is associated with reduced exposure to cigarette smoking rather than with the complete prevention of the exposure. A decrease in the prevalence of cigarette smoking will have additional downstream benefits by reducing the potential for nonsmokers to be exposed to secondhand tobacco smoke.

TIME HORIZON FOR THE HEALTH EFFECTS OF CIGARETTE SMOKING

Cigarette smoking causes chronic diseases that appear at older ages, such as lung cancer, as well as adverse health effects that occur in the short run. The immediate and short-term adverse health effects of cigarette smoking are less likely to be directly fatal than the long-term health effects. Nevertheless, they are important public health indicators because they lead to suboptimal health status throughout the life course in smokers and because many of the short-term physiologic effects mechanistically contribute to the etiology of smoking-caused diseases that usually do not become clinically apparent until later adulthood.

The short-term adverse health effects caused by cigarette smoking can be observed in smokers immediately or soon after they begin smoking. The health effects of cigarette smoking thus begin at or near the age of initiation of cigarette smoking, which is usually in adolescence. To highlight the immediacy of the adverse impact of smoking on health, this report uses a life-course perspective by considering health effects of smoking according to the various stages of life, which include childhood, adolescence, and young adulthood as well as middle and late adulthood, when most of the chronic disease burden imposed by smoking occurs. A particularly vulnerable time during the life course is pregnancy (for both mother and fetus) and the months following birth (for the infant); for this reason, this stage of life is considered separately. In this report, the term "immediate health effects" refers to effects that occur within days of cigarette smoking, while "long-term health effects" refers to the clinical morbidity and mortality that occur primarily in middle and late adulthood, and the term "intermediate health effects" is used to refer broadly to the health outcomes that occur between the immediate and long-term health effects.

SPECTRUM OF HEALTH EFFECTS

Cigarette smoke contains more than 7,000 chemicals (HHS, 2010). Inhaling cigarette smoke exposes the cigarette smoker to these numerous toxins, which include the various tobacco constituents and the products of pyrolysis. As summarized below, exposure to this complex chemical mixture causes immediate adverse physiologic effects shortly after the exposure occurs (HHS, 2010).

The ultimate harm caused by exposure to the toxic agents in cigarette smoke is determined in large part by the extent of the exposure, and most adult cigarette smokers tend to smoke many cigarettes per day for decades (HHS, 2014). This repeated inhalation of the complex mixture of cigarette smoke toxicants at high daily doses, often sustained over the course of

TABLE 4-1 Immediate Adverse Health Outcomes Causally Associated with Cigarette Smoking Based on Surgeon General's Reports

	Stage of Life			
Health Outcome	Childhood/ Adolescence	Young Adulthood	Middle Adulthood	Older Adulthood
Oxidative Stress	✓	✓	✓	✓
Depletion of Antioxidant Micronutrients	✓	✓	✓	✓
Increased Inflammation	✓	✓	✓	✓
Compromised Immune Status	✓	✓	✓	✓
Altered Lipid Metabolism	✓	✓	✓	✓
Lower Self-Rated Health Status	✓	✓	✓	✓
Respiratory Symptoms (coughing, phlegm, wheezing, dyspnea)	✓	✓	✓	✓
Nicotine Addiction	✓	✓	✓	✓

NOTE: The health outcomes are organized in Tables 4-1 through 4-3 according to whether they are immediate, intermediate, or long term and by the stages of life affected.

many years, causes a broad spectrum of short-term and long-term health effects that affect most major organ systems (see Tables 4-1 through 4-3). In the short run, cigarette smoking causes the smoker to have overall diminished health status as measured by a diverse array of indices, including biomarkers of physiologic disadvantage, lower self-reported health, susceptibility to acute illnesses and respiratory symptoms, and absence from school and work. Among the long-term health effects are smoking-caused diseases that are the major causes of death in middle- and upper-income nations: coronary heart disease, cancer, and chronic obstructive pulmonary disease, or COPD (HHS, 2014).

The net result of the broad spectrum of short-term and long-term deleterious health effects caused by cigarette smoking and the substantial prevalence of smoking is that cigarette smoking is the single most important cause of preventable disease and premature mortality in the United States

TABLE 4-2 Intermediate Adverse Health Outcomes Causally Associated with Cigarette Smoking Based on Surgeon General's Reports

	Stage of Life			
Health Outcome	Childhood/ Adolescence	Young Adulthood	Middle Adulthood	Older Adulthood
Increased Absence from School[a]/Work		✓	✓	✓
Increased Use of Medical Services		✓	✓	✓
Subclinical Atherosclerosis		✓	✓	✓
Impaired Lung Development/ Function				
Impaired lung growth	✓			
Accelerated lung function decline		✓	✓	✓
Increased Risk of Lung Infections (tuberculosis, pneumonia)		✓	✓	✓
Diabetes		✓	✓	✓
Periodontitis		✓	✓	✓
Exacerbation of Asthma		✓	✓	✓
Subclinical Organ Injury		✓	✓	✓
Adverse Surgical Outcomes		✓	✓	✓

[a]Health outcome not included in the 2014 Surgeon General's report.

and in many other high-income nations (Thun et al., 2012). For example, in the United States cigarette smoking is estimated to account for at least 480,000 deaths per year (HHS, 2014). The magnitude of this burden is a direct function of two key facts: (1) cigarette smoking causes an incredibly broad spectrum of short-term and long-term deleterious health effects, and (2) a large proportion of the population is exposed (i.e., the prevalence of smoking is very high).

TABLE 4-3 Long-Term Adverse Health Outcomes Causally Associated with Cigarette Smoking Based on Surgeon General's Reports

	Stage of Life			
Health Outcome	Childhood/ Adolescence	Young Adulthood	Middle Adulthood	Older Adulthood
Cancer (colorectal, liver, lung, bladder, cervical, esophageal, kidney, laryngeal, pancreatic, gastric, oral, and pharynx; acute myeloid leukemia)				✓
Precancerous Lesions (colorectal adenomatous polyps)				✓
Cardiovascular Disease (coronary heart disease, stroke, abdominal aortic aneurysm)				✓
Respiratory Diseases (COPD)				✓
Eye Disease (age-related macular degeneration, nuclear cataracts)				✓
Rheumatoid Arthritis				✓
Reduced Effectiveness of Tumor Necrosis Factor-Alpha Inhibitors				✓
Bone Health (hip fractures, low bone density in postmenopausal women)				✓

In assessing the potential public health impact of enacting a new tobacco policy such as raising the minimum age of legal access to tobacco products (MLA), it is worth keeping in mind that this lengthy catalogue of well-established consequences of cigarette smoking will continue to expand as scientific knowledge advances and more definitive evidence is generated concerning additional health outcomes. Thus, the characterization of the potential impact of a policy change that reduces exposure to cigarette smoke is a conservative estimate of the true public health impact. For example, in addition to the many adverse health outcomes established as causally related to tobacco smoke and summarized in Tables 4-1, 4-2, and 4-3, Tables 4-4 and 4-5 summarize health outcomes for which the evidence summarized in the 2014 Surgeon General's report is currently considered strong enough to be considered suggestive of a causal association but not yet strong enough to be rated as causal. These are outcomes for which the currently existing body of evidence falls short of being definitive, but the association between cigarette smoking and these outcomes remains under active investigation.

MORBIDITY

Tables 4-1 through 4-3 summarize the preclinical health effects and morbidity caused by cigarette smoking, organized according to whether the effects occur in the immediate, intermediate, or long-term time horizon and by the stages of life usually affected by the health outcome.

Immediate Health Effects

Cigarette smoking causes a constellation of subclinical health effects that occur shortly after initiation of smoking. As described below, these immediate adverse health effects include increased oxidative stress; depletion of selected bioavailable antioxidant micronutrients; increased inflammation; impaired immune status; altered lipid profiles; poorer self-rated health status; respiratory symptoms, including coughing, phlegm, wheezing, and dyspnea; and nicotine addiction. Taken in combination, these detrimental effects detract from a smoker's overall health status and lead to what has been referred to as "diminished health status" (HHS, 2004). Physiologic markers of diminished health status include subclinical outcomes such as increased oxidative stress, reduced antioxidant defenses, increased inflammation, impaired immune status, and altered lipid profiles (see Tables 4-1 through 4-3). Smoking's impacts on such short-term physiologic outcomes impair the smoker's overall health status, which in turn renders the smoker more susceptible to various adverse health outcomes, such as developing acute illnesses, respiratory symptoms, and a lessened capacity to heal wounds. One downstream marker of the diminished health status induced by cigarette smoking is that smokers are more likely to miss school and work. In short, soon after the initiation of smoking, an array of smoking-induced short-term deleterious health effects sets in motion a lifelong trajectory that leaves persistent smokers highly disadvantaged com-

TABLE 4-4 Intermediate Adverse Health Outcomes with Evidence Suggestive of a Causal Association with Cigarette Smoking Based on Surgeon General's Reports

	Stage of Life			
Health Outcome	Childhood/ Adolescence	Young Adulthood	Middle Adulthood	Older Adulthood
	Behavioral			
Substance use (risk factor for use of marijuana and other substances)	✓			
Behavioral and learning disorders (disruptive behavioral disorders, attention deficit hyperactivity disorder)	✓			
	Dental			
Dental caries	✓	✓	✓	✓
Root-surface caries	✓	✓	✓	✓
Failure of dental implants				✓
	Respiratory			
Incidence of asthma	✓	✓	✓	✓
Exacerbation of asthma	✓			
Recurrent tuberculosis infection[a]		✓		
Idiopathic pulmonary fibrosis				✓
Nonspecific bronchial hyper-responsiveness			✓	✓

[a]Health outcome not included in the 2014 Surgeon General's report.

pared to their counterparts who never smoked. By looking at the immediate and intermediate adverse health effects of cigarette smoking, it is clear that cigarette smoking contributes in important ways to suboptimal health beginning shortly after smoking initiation—long before the chronic diseases that smoking causes at older ages become clinically apparent (HHS, 2004).

TABLE 4-5 Long-Term Adverse Health Outcomes with Evidence Suggestive of a Causal Association with Cigarette Smoking Based on Surgeon General's Reports

	Stage of Life			
Health Outcomes	Childhood/ Adolescence	Young Adulthood	Middle Adulthood	Older Adulthood
Cancer (fatal prostate cancer, higher risk of advanced stage cancer, and disease progression in men who have prostate cancer; noncardia gastric cancers; breast cancer)				✓
Bone Health (low bone density in men)				✓
Eye Disease (opthalmopathy associated with Graves' disease)				✓
Peptic Ulcer Complications				✓

Physiologic Markers of Diminished Health Status

Increased oxidative stress Cigarette smoke contains free radicals and other oxidants in abundance. A single puff of a cigarette exposes the smoker to more than 10^{15} free radicals in the gas phase and additional radicals and oxidants in the tar phase (Pryor and Stone, 1993).

The biological impacts of the oxidative stress induced by cigarette smoking have been extensively documented in humans (HHS, 2004). These include oxidative injury to proteins, DNA, and lipids. Assaying protein carbonyls is one method of measuring oxidative damage to proteins, and protein carbonyl concentrations have been observed to be significantly higher in smokers than in nonsmokers (Kapaki et al., 2007; Marangon et al., 1999; Padmavathi et al., 2010). One way of quantifying the oxidative damage to DNA is to measure the DNA damage in peripheral white blood cells induced by the hydroxyl radical at the C8 position of guanine, 8-hydroxydeoxyguanosine (8-OH-dG). Most of the available evidence indicates that current smokers have concentrations of 8-OH-dG in peripheral leukocytes that are at least 20 percent higher than nonsmokers (HHS, 2004). Studies of 8-OH-dG in DNA extracted from urine provide corroborative evidence, with 8-OH-dG concentrations that are 6 to 50 percent higher in smokers than in nonsmokers (Campos et al., 2011; HHS, 2004; Lowe et al., 2009; Seet et al., 2011). Measures of lipid peroxidation include F2-isoprostanes and malondialdehyde (MDA). Many studies have demonstrated that current smokers have substantially higher concentrations of isoprostanes in both plasma and urine than nonsmokers (Bloomer et al., 2008; HHS, 2004; Kocyigit et al., 2011; Ozguner et al., 2005; Seet et al., 2011; Taylor et al., 2008). The results of several studies indicate that MDA concentrations are 30 percent more abundant in current-versus-nonsmokers, suggesting cigarette smoking directly increases MDA concentrations (Bloomer et al., 2008; Jain et al., 2009; Kocyigit et al., 2005; Ozguner et al., 2005). This is further corroborated by evidence from several studies that have found concentrations of thiobarbituric acid–reactive substances (TBARS) found in MDA range from 6 percent to 118 percent more in smokers than in people who have never smoked (HHS, 2004).

Cigarette smoking clearly generates substantial quantities of oxidative stress, as indicated by a consistent body of evidence indicating that cigarette smoking significantly increases biomarkers of oxidative damage to proteins, DNA, and lipids. Cigarette smokers experience measurable and immediate oxidative damage. This oxidative damage, experienced over long periods of time, is one pathway contributing to smoking-caused disease and death (HHS, 2010).

Depletion of circulating antioxidant micronutrient concentrations Cigarette smoking exposes the smoker to potential oxidative damage not experienced by the nonsmoker. One direct result of the exposure to oxidative stress is the depletion of the body's defenses against oxidative stress. For example, the antioxidant defense system is partly comprised of antioxidant micronutrients (Evans and Halliwell, 2001). Antioxidant status provides a biomarker of health status because oxidative damage is thought to be centrally involved in the aging process as well as in enhanced susceptibility to a wide range of specific diseases. Evidence from a number of studies firmly establishes that smokers have circulating concentrations of ascorbic acid and provitamin A carotenoids such as a-carotene, b-carotene, and cryptoxanthin that are more than 25 percent lower than nonsmokers (Alberg, 2002). Considered in total, a strong and diverse body of evidence consistently implicates oxidative stress from cigarette smoking in the depletion of antioxidant micronutrients in circulation. Furthermore, the results across studies are consistent with a dose–response relationship, with the amount of smoking being inversely related to the circulating concentrations of vitamin C and provitamin A carotenoids (HHS, 2004).

The immediate effects of cigarette smoking on these concentrations have been examined with measurements of circulating micronutrient concentrations taken before and after a smoker stops smoking. One such study, for example, found substantially increased concentrations of vitamin C and provitamin A carotenoids after 84 hours without a cigarette (Brown, 1996). In another study, the exposure of plasma to the equivalent of six puffs of cigarette smoke completely depleted the ascorbic acid present in the serum (Eiserich et al., 1995). In yet another, measurements taken at baseline and 20 minutes after smoking a cigarette found decreased circulating micronutrient concentrations (Yeung, 1976). Results such as these highlight the immediate impact that smoking a cigarette can have on health status. Cigarette smoking causes depletion of antioxidant micronutrients, leading smokers to have lower circulating concentrations of these antioxidant micronutrients than nonsmokers. The direct immediate result on the smoker's lower concentrations of antioxidant micronutrients such as vitamin C is to reduce the smoker's antioxidant defenses, and thus the smoker's cells throughout the body are more prone to the damaging effects of oxidative stress. Oxidative stress is hypothesized to be associated with premature aging and greater risk of disease (Laher, 2014).

Increased inflammation The direct pro-oxidant effects of cigarette smoke are further exacerbated by additional endogenous oxidant formation via the smoking-induced inflammatory-immune response (van der Vaart et al., 2004; Yao and Rahman, 2011). Another measure of smokers' poorer health is the chronically higher level of inflammatory response experienced by smokers compared to nonsmokers. Chronic inflammation is hypothesized to play a role in the pathogenesis of numerous chronic diseases (Pawelec et al., 2014; Prasad et al., 2012).

For example, cigarette smoking is strongly and consistently associated with higher leukocyte concentrations (HHS, 2004); this suggests that smoking induces a sustained, long-term inflammatory response. Compared to nonsmokers, current smokers have been uniformly found, across many studies, to have approximately 20 percent higher leucocyte counts. Furthermore, leucocyte counts increase with a greater degree of smoking, measured either by the number of cigarettes smoked per day or the depth of inhalation (HHS, 2004). Prospective cohort studies that evaluate how changes in smoking status relate to changes in leucocyte counts provide evidence that eliminating cigarette smoking leads to reductions in leucocyte counts (HHS, 2004). Leucocytes are a marker of chronic inflammation, but cigarette smoking is also associated with markers of the acute inflammatory response, such as C-reactive protein (HHS, 2014).

Impaired immune status The 2014 Surgeon General's report was the first report of the Surgeon General to review thoroughly the contribution of cigarette smoking to impaired immune status. Cigarette smoking was found to adversely impact the two major immune pathways, innate immunity and adaptive immunity. Recognizing the extreme complexity of the immune system, with its built-in compensatory mechanisms, the conclusion of the Surgeon General's report was that the evidence is sufficient to infer that cigarette smoking compromises the immune system and compromises immune homeostasis by diminishing both innate and adaptive immunity (HHS, 2014). The impact of the adverse effects on immune status would be to make smokers more susceptible to disease, which in turn contributes to the etiology of acute infectious and chronic diseases above and beyond the way in which cigarette smoking contributes to acute and chronic inflammation.

Altered lipid profiles Cigarette smoking causes altered lipid metabolism (HHS, 2010). The alterations in the lipid profile induced by cigarette smoking create a higher risk profile: Compared with nonsmokers, cigarette smokers have significantly higher serum cholesterol, triglyceride, and low-density lipoprotein (LDL) levels and lower high-density lipoprotein (HDL) levels (Ambrose and Barua, 2004). In a meta-analysis of 54 epidemiologic studies, smokers were found to have serum concentrations of cholesterol, triglycerides, and very low density lipoprotein (VLDL) cholesterol that were 3 percent, 9 percent, and 10 percent higher, respectively, and HDL cholesterol concentrations that were 6 percent lower than nonsmokers (Craig et al., 1989). Furthermore, clear dose–response associations were observed, with these associations growing stronger as the number of cigarettes smoked per day increased. The alteration of the lipid profile in the direction of increased cardiovascular disease risk has been extensively documented not only in adults but also in children and adolescents. In a meta-analysis of studies in which study participants ranged from 8 to 19 years of age, adolescents who smoked cigarettes had serum LDL cholesterol and triglyceride concentrations that were significantly higher than in nonsmokers, whereas smokers had lower serum concentrations of HDL cholesterol than nonsmokers (Craig et al., 1990). These differences are likely due to a direct effect of cigarette smoking. In a cohort of middle school students in Germany, those who initiated smoking had significantly lower HDL cholesterol levels than nonsmokers after 2 years of follow-up despite there having been similar baseline levels of HDL cholesterol in the two groups—those who would remain nonsmokers and those who would go on to begin smoking (Dwyer et al., 1988).

Poorer Self-Rated Health Status

The adverse impact of smoking on health status has been directly measured by comparing self-rated health in smokers versus nonsmokers. Studies of varying design have uniformly shown that smokers tend to rate their overall health status lower than nonsmokers do (HHS, 2004, 2014). The consistent reporting of poorer self-rated health among smokers compared to nonsmokers across numerous dimensions of health status provides direct evidence that smoking impairs the health of cigarette smokers in ways that are perceptible to the smoker even in the absence of clinical disease.

Respiratory Symptoms: Coughing, Phlegm, Wheezing, Dyspnea

The immediate adverse health effects of cigarette smoking are not limited to subclinical measures; they can also result in physical symptoms. In reviewing the evidence separately for children/adolescents and adults, the 2004 Surgeon General's report concluded that cigarette smoking was causally associated with all major respiratory symptoms in both age groups (HHS, 2004). The specific symptoms caused by cigarette smoking are coughing, phlegm, wheezing, and dyspnea. The consistent presence of the causal association across the life course supports the classification of these symptoms as an immediate health effect based on the definition used in this report.

Nicotine Addiction

Another clinical, immediate adverse health effect of cigarette smoking is nicotine addiction. The 2012 Surgeon General's report concluded that cigarette smoking was causally associated with nicotine addiction, beginning in adolescence (HHS, 2012). The onset of nicotine addiction begins soon after smoking initiation.

The importance of nicotine addiction as an immediate adverse health effect cannot be underestimated. Nicotine addiction, via its role in propagating sustained smoking, assumes a role as a central determinant of the entire catalogue of downstream health effects of cigarette smoking. The often long-term, sustained addiction to nicotine is the underlying factor driving the long-term, sustained exposure to the toxins in tobacco smoke that drive the adverse health effects of cigarette smoking.

> *Finding 4-1: Cigarette smoking is causally associated with a broad spectrum of adverse health effects that begin soon after the onset of regular smoking and that, in total, significantly diminish the health status of the smoker compared to nonsmokers.*

Intermediate-Term Effects on Morbidity

The health effects included in the category of "intermediate adverse health effects" consist largely of health outcomes that are not dependent on having smoked a cigarette in the immediate past but rather require a more extensive smoking history for the adverse outcome to become manifest. For example, intermediate adverse health effects are often direct sequellae of some of the immediate health effects of smoking, such as absenteeism and medical care utilization, or else they are diagnoses that are precursors of subsequent, more severe disease endpoints, such as type 2 diabetes and subclinical atherosclerosis. Cigarette smoking cessation diminishes the risk of experiencing these intermediate adverse health effects, but individuals with a past history of cigarette smoking still have greater risks than those who never smoked.

Absenteeism

Another indicator of diminished health status is absence from work. Among the many factors that contribute to attendance, health status is clearly a major determinant. Thus, attendance patterns are potential markers of health status (Alberg et al., 2003).

Cigarette smoking is a determinant of absence. A substantial body of evidence on the association in adults between cigarette smoking and absence from work consistently demonstrates that smokers are significantly more likely to have greater workplace absenteeism (HHS, 2004). The likelihood of workplace absence increases with the number of cigarettes smoked per day (HHS, 2004). Furthermore, smoking cessation is associated with reduced absence rates (HHS, 2004). In addition to smokers having more episodes of absence than nonsmokers, smokers tend to stay out longer when they are sick than nonsmokers. Thus, smokers miss more cumulative work time than nonsmokers (HHS, 2004).

A strong and consistent body of evidence demonstrates that cigarette smoking is associated with a greater likelihood of absence from work. This association could be at least partially due to smoking being a marker for other causes of absenteeism, such as mental illness and abuse of other substances. In considering the societal toll of cigarette smoking, attendance is not only a useful marker of diminished health status, but also a marker of other downstream costs. On the individual level, workplace absenteeism can lead to problems on the job and even result in unemployment. At the societal level, absenteeism decreases productivity and is a drain on the economy.

Increased Utilization of Medical Services

Utilization of medical services provides an additional indicator of health status. Despite the complexities inherent in studying the association between cigarette smoking and use of medical services, the evidence reviewed in the 2004 and 2014 Surgeon General's reports yields a clear signal indicating that cigarette smokers generate higher medical care costs and have more inpatients and outpatient visits than those who do not smoke (HHS, 2004, 2014). Among patients admitted to the hospital, smokers have longer lengths of stay and incur greater expenses per admission than nonsmokers.

Subclinical Atherosclerosis

Atherosclerosis is a cardiovascular disease precursor that begins early in life; it is the underlying pathogenic mechanism that ultimately leads to many cardiovascular disease endpoints. The epidemiologic evidence has been consistent in demonstrating a strong, dose-dependent association between cigarette smoking and subclinical atherosclerosis as measured by carotid intimal–medial thickness. Consequently, cigarette smoking has been established as a cause of atherosclerosis (HHS, 2004). Establishing the link between cigarette smoking and atherosclerosis provides a strong, biologically plausible rationale for the role of cigarette smoking in the pathogenesis of clinical cardiovascular endpoints that occur as a consequence of atherosclerosis.

Impaired Lung Development and Accelerated Decline in Function

In addition to smoking's long-term health effects on the respiratory system from diseases such as lung cancer and COPD, some adverse respiratory effects experienced by adolescent cigarette smokers manifest themselves shortly after smoking initiation. Compared to nonsmokers, adolescents who smoke cigarettes are more likely to experience impaired lung growth, early onset in the decline of lung function, and asthma-related symptoms (HHS, 2004). Among adults who smoke cigarettes, lung function begins to decline at younger ages, and the age-related decline in lung function occurs faster (HHS, 2004).

Increased Susceptibility to Infectious Lung Diseases

Due at least in part to its adverse impact on immune status, cigarette smoking predisposes the smoker to developing acute infectious respiratory illnesses such as pneumonia. Established effects of cigarette smoking on the immune system provide a clear biological basis for the increased likelihood that has been observed among smokers of developing an infection after exposure to microbes that cause respiratory infections and also of developing a clinically apparent disease once infected (HHS, 2004). Further, impaired cilia function in the trachea and bronchi also contributes to the increased risk of respiratory infections in smokers (Simet et al., 2010). Thus, it is no surprise that cigarette smokers have an increased susceptibility to respiratory infections.

Cigarette smoking is causally associated with an increased risk of pneumonia (HHS, 2004). The 2014 Surgeon General's report was the first to review the evidence on the association between cigarette smoking and tuberculosis. A strong statistical association has been observed between cigarette smoking and risk of *M. tuberculosis* infection and also the risk, once infected, of progressing to tuberculosis disease, but showing a clear causal connection between smoking and risk of tuberculosis has been challenging because cigarette smokers often have a much higher risk profile than nonsmokers for these outcomes because of other social determinants of health. These challenges notwithstanding, the evidence has now coalesced to the point that cigarette smoking is causally associated with tuberculosis disease and tuberculosis mortality (HHS, 2014).

Diabetes

Type 2 diabetes mellitus is a leading underlying cause of mortality from cardiovascular disease, and it also leads to other adverse consequences such as kidney failure and blindness (HHS, 2014). Obesity has long been established as a major risk factor for diabetes, but the association between cigarette smoking and diabetes has only more recently been elucidated. The results of a meta-analysis of 51 prospective cohort studies in the 2014 Surgeon General's report demonstrated that cigarette smokers have a 30–40 percent greater risk of diabetes than nonsmokers and that there is a strong dose–response relationship, with the risk increasing with the number of cigarettes smoked per day (HHS, 2014). In addition to having an increased risk of developing diabetes, evidence also indicates that, among patients with diabetes, cigarette smokers are more likely to suffer cardiovascular complications and to have higher mortality rates. Based on this body of evidence, the 2014 Surgeon General's report concluded that cigarette smoking is a cause of diabetes (HHS, 2014).

Periodontitis

A synthesis of the evidence in the 2004 Surgeon General's report revealed a strong, consistent, and dose-dependent relationship between cigarette smoking and the risk of periodontitis. Based on this evidence, cigarette smoking was judged to be causally associated with periodontitis. Approximately one-half of all diagnoses of adult periodontitis are attributable to cigarette smoking (HHS, 2004).

Asthma Exacerbation

The fact that cigarette smoking is causally associated with so many outcomes that are relevant to asthma has long raised suspicions that cigarette smoking is a risk factor for asthma. Examples of these asthma-relevant factors are persistent inflammation, diminished immune status, and the respiratory symptoms of coughing, phlegm, wheezing, and dyspnea. At the present time, the evidence is considered suggestive but not sufficient to infer a causal association between cigarette smoking and the risk of developing asthma in adolescents or adults or between smoking and the risk of asthma exacerbations in adolescents (HHS, 2014). However, the 2014 Surgeon General's report did conclude that cigarette smoking is causally associated with asthma exacerbation in adults (HHS, 2014).

Adverse Surgical Outcomes: Wound Healing and Respiratory Complications

The fact that smoking causes diminished health status by impairing factors such as immune response and lung function provides a strong reason to believe that cigarette smoking could be associated with a worse prognosis after surgical procedures. Based on a large and diverse body of evidence with outcomes that ranged from short- and long-term complications of surgery to survival, the 2004 Surgeon General's report concluded that cigarette smoking is a cause of adverse surgical outcomes (HHS, 2004).

> *Finding 4-2: Cigarette smoking causes many adverse health effects classified as "intermediate," which include increased absence from work, the increased use of medical services, subclinical atherosclerosis, impaired lung development and function, an increased risk of lung infections, diabetes, periodontitis, the exacerbation of asthma in adults, subclinical organ injury, and adverse surgical outcomes.*

Long-Term Morbidity

Cigarette smoking contributes to a major portion of the population burden of many of the chronic diseases that typically occur in middle and late adulthood, such as cancer, cardiovascular disease, and COPD (HHS, 2004). As noted below, the full scope of long-term morbidity attributable to cigarette smoking also extends to numerous other disease endpoints. Cessation of cigarette smoking diminishes the risk of experiencing these long-term adverse health effects, but a past history of cigarette smoking is still associated with increased risk compared to never having smoked (HHS, 2014).

Cancer

Cigarette smoking is causally associated with 12 different types of malignancy and is responsible for approximately 30 percent of all cancer deaths in the United States (ACS, 2007; HHS, 2014). Cigarette smoking has been known for many years to be a cause of cancers of the lung, oral cavity, larynx, esophagus, bladder, pancreas, kidney, uterine cervix, and stomach, and of acute myeloid leukemia. The conclusions of the 2014 report of the Surgeon General indicate that cigarette smoking is also causally associated with colorectal cancer and liver cancer. Furthermore, cigarette smoking is causally associated with clinical precursors of cancer lesions, such as colorectal adenomatous polyps (HHS, 2014).

Vascular Disease

Cigarette smoking is associated with numerous clinical cardiovascular disease endpoints, including coronary heart disease, stroke, and abdominal aortic aneurism. Coronary heart disease is a leading cause of death in the United States and most high-income countries. Cigarette smoking has been established as a major cause of coronary heart disease for decades. The impact of cigarette smoking is particularly strong among younger age groups, as it causes 40 percent of ischemic heart disease deaths in 35- to 64-year-olds (HHS, 2004).

Cigarette smoking has long been identified as a major cause of cerebrovascular disease. As with coronary heart disease, the impact of cigarette smoking is proportionally larger in relatively younger adults. Among 35- to 64-year-olds, more than 40 percent of all cerebrovascular disease deaths are attributable to cigarette smoking (HHS, 2004).

Cigarette smoking is an established cause of abdominal aortic aneurysm (HHS, 2004). This condition is often fatal and accounts for more than 10,000 deaths per year in the United States.

COPD

The process of inhaling cigarette smoke brings the smoker's respiratory system into direct contact with heavy doses of tobacco toxins. Given these profound levels of exposure, it is not surprising that cigarette smoking's deleterious effects on the respiratory system extend well beyond lung cancer. Cigarette smoking is estimated to have caused 7.5 million prevalent cases of COPD in the United States in 2009 (Rostron et al., 2014). More than 138,000 Americans died from COPD in 2010, making it the third leading cause of death in the United States (Heron, 2013). As the predominant cause of COPD, cigarette smoking is responsible for approximately 80 percent of the mortality burden from COPD (HHS, 2004).

Eye Disease: Age-Related Macular Degeneration and Nuclear Cataracts

Cigarette smoking also adversely affects eye health, causing nuclear cataracts (HHS, 2004). The body of evidence linking cigarette smoking with age-related macular degeneration that was accumulated over the past two decades has now been judged to be strong and consistent enough to prove a causal association between the two (HHS, 2014).

Rheumatoid Arthritis

Cigarette smoking also causes joint disease. More than 1 million Americans have been diagnosed with rheumatoid arthritis, a disease linked to immune dysregulation. Enough supportive evidence has been accumulated to indicate a clear link between cigarette smoking and rheumatoid arthritis. The conclusions of the 2014 Surgeon General's report contained the conclusion that a causal association has been established between cigarette smoking and rheumatoid arthritis (HHS, 2014).

Bone Health: Hip Fractures and Bone Density

Cigarette smoking has adverse consequences for bone health. Cigarette smoking is causally associated with hip fractures. In postmenopausal women, a causal association has been established between cigarette smoking and low bone density (HHS, 2004).

Finding 4-3: Cigarette smoking is causally associated with a broad spectrum of adverse long-term health effects which cause suffering, impaired quality of life, and death.

Maternal/Fetal and Infancy Health Effects

Pregnancy represents a particularly vulnerable time of life for both the mother and the developing fetus, and this critical time window extends into the neonatal period and infancy. Because of the unique features of this period of enhanced vulnerability and its critical public health importance, the topic is considered separately. Cigarette smoking is an established cause of a broad spectrum of health effects to the mother, fetus, and infant, including decreased likelihood of becoming pregnant, increased risk of experiencing adverse pregnancy outcomes, and adverse effects on the newborn that can range from organ impairment to congenital malformations to death, as summarized in Table 4-6. Table 4-6 also includes the immediate physiologic effects of smoking from Table 4-1 to emphasize the point that pregnant women who smoke incur the same short-term adverse health effects incurred by all cigarette smokers. It is estimated that more than 400,000 infants are exposed each year to maternal smoking in utero. Furthermore, recent data indicate that more than 1.2 million births each year in the

TABLE 4-6 Maternal, Fetal, and Infant Adverse Health Outcomes Causally Associated with Cigarette Smoking Based on Surgeon General's Reports

Health Outcome	Maternal	Fetal	Infant/Child
Immediate Health Effects on All Smokers, Including During Pregnancy (selected)			
Oxidative Stress	✓		
Depletion of Antioxidant Micronutrients	✓		
Increased Inflammation	✓		
Compromised Immune Status	✓		
Altered Lipid Metabolism	✓		
Lower Self-Rated Health Status	✓		
Likelihood of Becoming Pregnant			
Reduced Fertility (maternal and paternal)	✓		
Pregnancy Complications			
Complications of Pregnancy (ectopic pregnancy, premature rupture of the membranes, placenta previa, and placental abruption)		✓	
Shortened Pregnancy (pre-term delivery and shortened gestation)		✓	
Outcomes of Childbirth and Survival			
Impaired Fetal Growth (fetal growth restriction or low birth weight)		✓	✓
Congenital Malformations (orofacial clefts)			✓
Impaired Organ Function (reduced lung function)		✓	✓
Death (stillbirth, infant mortality, sudden infant death syndrome)		✓	✓

United States occur among mothers under 25 years of age. In the United States in 2012, 31 percent of all births were to mothers less than 25 years old (1,225,871/3,952,841); of these, 90,095 were to mothers less than 18 years old, 85,310 were to mothers who were 18 years old, and 1,050,466 were to mothers who were 19–24 years old (Martin et al., 2013).

Decreased Likelihood of Conception

Cigarette smoking is associated with a decreased likelihood of pregnancy because of smoking's adverse effects on the female and the male reproductive systems. Cigarette smoking is causally associated with reduced fertility in women (HHS, 2004). Further, the 2014 Surgeon General's report pointed to a diverse body of research evidence supported by a strong biologic rationale to conclude that cigarette smoking is a cause of erectile dysfunction in men.

Pregnancy Complications

Maternal smoking during pregnancy reduces the likelihood of a full-term gestational period with optimal fetal growth. Cigarette smoking by pregnant women adversely affects pregnancy by making it more likely they will experience ectopic pregnancies, complications of pregnancy such as premature rupture of the membranes, placenta previa, and placental abruption. Furthermore, cigarette smoking in expectant mothers causes preterm delivery and shortened gestation (HHS, 2004).

Outcomes: Childbirth, Infancy, and Survival

Maternal cigarette smoking during pregnancy directly harms the fetus and, later, the infant in several ways (HHS, 2004). Cigarette smoking is causally associated with stunted fetal growth and is an important cause of shortened gestation. In combination, stunted fetal growth and premature delivery are major determinants of low birth weight. Cigarette smoking causes congenital malformations, specifically orofacial clefts. Cigarette smoking is also associated with impaired organ function, specifically reduced lung function (HHS, 2014).

Based on these many severe effects, it is logical to infer that cigarette smoking negatively affects the viability of the fetus and child. Specifically, smoking is causally associated with fetal deaths, or stillbirths; furthermore, among live births smoking is an established cause of overall infant mortality. That is, compared with infants of mothers who do not smoke, infants with mothers who smoke during or after pregnancy experience higher rates of death before reaching 1 year of age. One specific cause of increased mortality of infants whose mothers smoke is sudden infant death syndrome, which is more likely to strike those infants than infants whose mothers do not smoke (HHS, 2004).

After birth, children who are exposed to secondhand smoke (SHS) via parental smoking suffer numerous adverse health effects as a consequence. In infants, symptoms associated with SHS exposure include increased lower respiratory illnesses, otitis media, middle ear effusion, reduced lung function, and the respiratory symptoms of coughing, phlegm, wheezing, and dyspnea (HHS, 2006). In addition to the increased risk of symptoms, infants of smoking mothers are more likely to experience subclinical immediate adverse health effects of cigarette smoke exposure as well. For example, evidence indicates that infant exposure to parental smoking is associated with physiologic markers of diminished health status, such as increased oxidative damage to DNA and lipids. As noted above, 8-OH-dG can be used as a measure of oxidative damage to DNA, and neonatal levels of urinary 8-OH-dG have been found to be significantly associated with exposure to the toxicants from tobacco smoke due to the mother's smoking (Hong et al., 2001). Newborns with mothers who smoked had concentrations of 8-OH-dG that were 333 percent higher than newborns whose mothers did not smoke (Hong et al., 2001).

Finding 4-4: Maternal smoking during pregnancy and secondhand smoke exposure during infancy are causally associated with many adverse health outcomes. This not only leaves exposed infants prone to short- and long-term health risks but also can result in death.

Age of Initiation and Health Outcomes

The following four factors were used to assess the effects that the age of initiation had on an individual's cigarette smoking trajectory and subsequent health effects: (1) nicotine dependence, (2) the number of cigarettes smoked per day (smoking intensity), (3) the likelihood of smoking cessation (or, conversely, the likelihood of remaining a smoker), and (4) health outcomes. These four factors are closely interrelated. Nicotine dependence is associated with smoking intensity (Hu et al., 2006), and both of these measures are in turn associated with the likelihood of remaining a smoker in the long term. The interrelationships among the factors involve both smoking intensity (number of cigarettes per day) and smoking duration (number of years smoked) and hence also the effects of the lifetime cumulative exposure to cigarette smoking. Many of the established deleterious health effects of cigarette smoking are dose-dependent, thus providing a mechanistic explanation for how earlier age of initiation could exert a powerful contribution on smoking-caused health effects that is mediated by leading to increased doses of exposure to cigarette smoke.

In particular, the mechanistic basis for a powerful influence of the age of initiation on smoking-caused adverse health outcomes is grounded in the evidence, reviewed in Chapter 3, that those who start smoking earlier are more likely to (1) have a greater degree of nicotine dependence (Breslau and Peterson, 1996; Buchmann et al., 2013; HHS, 2012; Hu et al., 2006; Lando et al., 1999; Park et al., 2004), (2) smoke cigarettes more frequently (Breslau, 1993; Buchmann et al., 2013; Chen and Millar, 1998; D'Avanzo et al., 1994; Escobedo et al., 1993; Everett et al., 1999; Fernandez et al., 1999; Hu et al., 2006; Lando et al., 1999; Reidpath et al., 2014; Taioli and Wynder, 1991), and (3) remain smokers for longer periods of time (Breslau and Peterson, 1996; Chen and Millar, 1998; D'Avanzo et al., 1994; Eisner et al., 2000; Everett et al., 1999; Khuder et al., 1999). These associations all point toward an association between a younger age of initiation and greater exposure to the toxicants in cigarette smoke, which because of well-established dose–response relationships would therefore be expected to lead to higher risk of smoking-caused disease and death. A further negative consequence of starting to smoke at younger ages is that tissues and organ systems that are still in the growth and maturation phase may be particularly vulnerable to the toxicants in smoke, so that even a given exposure dose to cigarette smoke may be more harmful when exposure occurs during childhood and adolescence than during adulthood.

Younger age of initiation has been found to be associated with one short-term health effect in particular: an increased risk of hospital inpatient stay during the previous year (Lando et al., 1999). Concerning long-term health effects, the lung is exquisitely sensitive to the adverse consequences of cigarette smoke because it is directly exposed to inhaled cigarette smoke and is further exposed to harmful smoke toxicants via the circulation of those toxicants in the blood. In a prospective cohort study, a strong association was observed between an earlier age of smoking initiation and an increased risk of respiratory disease (Kenfield et al., 2008). Compared to people who have never smoked, the relative odds (and 95 percent confidence intervals) of contracting respiratory disease were 7.0 (3.9–12.4) for those who started smoking at 26 years old or older; 8.1 (5.5–11.9) for those who started between 22 and 25; 10.2 (9.9–13.2) for smoking initiation between 18 and 21; and 13.4 (9.8–18.2) for those who started smoking at 17 or younger; the age trend is highly statistically significant (a p-value of 0.001). The same study also observed a statistically significant trend for the risk of lung cancer, which was not grouped under respiratory disease (Kenfield et al., 2008); this finding was also observed in another population-based cohort study (Prizment et al., 2014). The strong association between an earlier age of starting to smoke and increased lung cancer risk was summarized in a meta-analysis of 69 studies, which estimated that the summary odds ratio for lung cancer was 10.3 (95 percent confidence interval of 8.0–13.3) for starting to smoke around the age of 14 years; 7.5 (5.9–9.4) for starting to smoke at approximately 18 years; and 3.9 (3.3–4.6) for starting to smoke at age 26 years (Lee et al., 2012). Thus, an earlier age of initiation is strongly associated with an increased risk of respiratory diseases (primarily COPD) and lung cancer.

The evidence for cardiovascular disease has been mixed. The risk of cardiovascular disease increased significantly with younger age of initiation in the ARIC prospective cohort study (Huxley et al., 2012), but the results of the Nurses' Health Study did not find a significant effect (Kenfield et al., 2008). In another study, younger age of initiation was significantly associated with peripheral artery disease (Planas et al., 2002).

Overall, the evidence is consistent in finding that the younger the age of initiation, the greater the risk of nicotine dependence, smoking intensity, and persistent smoking/reduced likelihood of cessation. The associations between a younger age of initiation and these outcomes holds true even after accounting for time from first cigarette to first daily smoking. The findings consistently show a dose–response trend, with younger ages of initiation associated with a higher likelihood of nicotine dependence, greater smoking intensity, and reduced likelihood of cessation. The absence of any apparent age threshold on these associations or any diminution of the associations across the age continuum indicates that any delay in initiation, regardless of the ages affected (e.g., late childhood to early adolescence, early to mid-adolescence, or adolescence to young adulthood) would be expected to have measurable benefits in reducing the lifetime consumption of cigarettes and hence in reducing the risk for smoking-caused disease and death. The adverse consequences of a younger age of initiation appear to manifest at young ages and be sustained over the life course.

Finding 4-5: A younger age of initiation is associated with an increased risk of many adverse health outcomes, such as a hospital inpatient stay in the past year and lifetime risk of respiratory disease, especially chronic obstructive pulmonary disease and lung cancer.

Other Tobacco Products and Sources of Exposure

So far, the discussion has focused specifically on cigarette smoking. SHS exposure and other tobacco products and nicotine delivery devices are discussed below.

Secondhand Smoke Exposure

The health effects of cigarette smoking are not limited to the adverse health effects on the smoker; they also include the health consequences that exposure to SHS has on nonsmokers (HHS, 2014). SHS exposure has now been linked with a host of adverse health effects in addition to the long-established causal associations with lung cancer and heart disease.

As cigarette smokers, parents who smoke cigarettes increase their personal risk for all of the adverse health outcomes described above. If parents smoke in the presence of their children, they also negatively affect the health of their children by exposing them to SHS. The health effects of SHS exposure are not limited to long-term enhanced susceptibility to chronic diseases, but, as in the case of cigarette smoking, they also include immediate and substantial effects that leave SHS-exposed individuals prone to short-term health risks (see Table 4-7).

Thus, as is the case with cigarette smoking, SHS exposure is associated with diminished health status. Exposure to SHS is associated with increased oxidative damage to DNA and lipids. As noted above, MDA can be used as a measure of lipid peroxidation, and children exposed to SHS have been found to have significantly higher circulating levels of MDA and also significantly lower levels of glutathione peroxidase (Zalata et al., 2007). Concerning antioxidant micronutrients, the evidence for SHS exposure mirrors the evidence for smoking. Compared to nonsmokers not exposed to SHS, nonsmokers exposed to SHS have significantly reduced circulating concentrations of vitamin C and provitamin A carotenoids, indicating that even low-dose cigarette smoke exposures lower circulating antioxidant micronutrient concentrations. Evidence of lowered circulating antioxidant micronutrient concentrations has also been observed in children of smokers (Wilson et al., 2011; Yilmaz et al., 2009; Zalata et al., 2007). Children whose mothers were smokers had 29 percent and 26 percent lower circulating concentrations of vitamin E and vitamin A, respectively, than children whose mothers did not smoke (Yilmaz et al., 2009).

Nonsmokers exposed to SHS have also been found to have lessened immune status (HHS, 2010). The body of evidence firmly indicates that among nonsmokers, SHS exposure is associated with greater oxidative damage, lower circulating antioxidant micronutrient concentrations, and lessened immune status. Given the consistent body of evidence and the clear biological rationale based on the causal associations seen with cigarette smoking these associations are likely to be rated as causal in the future, but the evidence base has not yet reached the standard for these associations to be judged as causal in the Surgeon General's report.

Consistent with the health effects observed for cigarette smoking, the health effects of SHS exposure also include reduced lung function and the respiratory symptoms of coughing, phlegm, wheezing, and dyspnea. SHS exposure in children causes numerous adverse health effects, including lower respiratory illnesses, otitis media, and middle ear effusion (HHS, 2006).

In adults, SHS exposure is also causally associated with increased risk of long-term chronic diseases, just as in the case of cigarette smoking. These diseases include lung cancer, coronary heart disease, stroke, and inflammatory bowel disease.

As expected, based on the lower-exposure doses of exposure to tobacco toxins that result from secondhand smoke, the health risks of SHS exposure for most health outcomes tend to be less than the risks of cigarette smoking. Nevertheless, the fact that these risks are incurred even at very low doses indicates that there is no safe threshold for exposure to cigarette smoke. The importance of this public health challenge is accentuated by the fact that these health risks are incurred as the result of smoking by others rather by the affected individuals themselves.

Finding 4-6: Secondhand smoke exposure is causally associated with adverse health effects.

It is worth keeping in mind that this lengthy catalogue of well-established consequences of SHS exposure will continue to grow as more definitive evidence coalesces for additional health outcomes. For example, Table 4-8 summarizes health outcomes for which the evidence summarized in the 2014 Surgeon General's report is currently considered strong enough to be considered suggestive of a causal association but not yet strong enough to be rated as causal.

Smoking of Pipes, Cigars, and Other Combustible Tobacco Products

Combustible tobacco products other than cigarettes are also associated with the same sort of chronic disease outcomes associated with cigarette smoking, such as cancer and cardiovascular disease. Pipe and cigar smoke contain similar profiles of harmful toxins to those found in cigarette smoke (HHS, 2014). A key distinction in the health risks is that the doses of toxins delivered to the smoker are often less for pipes and cigars than for cigarettes because pipes and cigars are usually smoked less frequently and the smoke tends to be inhaled less deeply (HHS, 1998). For example, pipe and cigar smoking pose risks for malignancies of the larynx, oral cavity, and esophagus that are similar to the risks associated with smoking cigarettes (HHS, 1998). Pipes and cigars are causally associated with lung cancer, even though the risks are less than observed for cigarette smoking because compared to cigarette smoking pipes and cigars are smoked on average

TABLE 4-7 Adverse Health Outcomes Causally Associated with Secondhand Smoke Exposure Based on Surgeon General's Reports

	Stage of Life				
Health Outcome	Infancy	Childhood/ Adolescence	Young Adulthood	Middle Adulthood	Older Adulthood
Short-Term and Intermediate-Term Health Effects					
Maternal/Fetal Development (low birth weight)	✓				
Ear					
Ear Problems	✓	✓			
Middle Ear Disease		✓			
Respiratory					
Acute Respiratory Infections	✓	✓			
Slower Lung Growth	✓	✓			
Respiratory Tract Injury	✓	✓	✓	✓	✓

Coughing, Phlegm, Wheezing, Breathlessness		✓			
Lower Respiratory Illness	✓	✓			
Wheeze Illnesses		✓			
Lower Level of Lung Function		✓			
Odor Annoyance		✓	✓	✓	✓
Nasal Irritation		✓	✓	✓	✓
Long-Term Health Effects					
Inflammatory Bowel Disease (Crohn's disease)		✓	✓		✓
Cancer (lung)					✓
Cardiovascular					✓
Stroke, Coronary Heart Disease					✓
Endothelial Cell Dysfunctions	✓	✓	✓	✓	✓

TABLE 4-8 Adverse Health Outcomes with Evidence Suggestive of a Causal Association with Secondhand Smoke Exposure Based on Surgeon General's Reports

	Stage of Life					
Health Outcome	Pregnancy	Infancy	Childhood/ Adolescence	Young Adulthood	Middle Adulthood	Older Adulthood
Diminished Immune Function (immune activating and suppressive effects)				✓		
Maternal/Fetal Development (pre-term delivery)	✓					
Dental Carries			✓			
Respiratory						
Incidence of asthma			✓	✓	✓	✓
Worsening of asthma control and symptoms			✓	✓	✓	✓
Coughing, wheezing, chest tightness, and breathlessness			✓	✓	✓	✓
COPD						✓
Chronic respiratory symptoms			✓	✓	✓	✓
Small decrement in lung function			✓	✓	✓	✓
Cardiovascular (angina, sudden coronary death, stroke, atherosclerosis)						✓
Cancer						
Breast cancer						✓
Childhood leukemias			✓			
Childhood lymphomas			✓			
Childhood brain tumors			✓			
Nasal sinus cancer						✓

less frequently and the smoke is inhaled less deeply (Alberg et al., 2013). The available evidence indicating that pipe and cigar smoking have similar adverse health effects to cigarette smoking thus supports the conclusion that the impact of a policy change that resulted in lower uptake or delayed initiation of pipes or cigars would have a significant impact on public health but would be expected to be less than a similar reduction in cigarette smoking because of the lower exposure to tobacco toxins due to the manner in which pipes and cigars are smoked.

Another way to smoke tobacco is with a hookah, or waterpipe. From an exposure assessment perspective, the distinctive features of this tobacco smoke delivery system are that the tobacco is sometimes indirectly heated and that the smoke passes through a water column prior to inhalation (Akl et al., 2010). Hookah use is becoming more common throughout the world, including in the United States (Cobb et al., 2010; Jawad et al., 2013). In a study comparing the urinary concentrations of the tobacco-specific nitrosamine 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanol (NNAL) in cigarette smokers, hookah smokers, and nonsmokers, it was found that hookah smokers had significantly higher NNAL concentrations than nonsmokers but significantly lower concentrations than cigarette smokers (Radwan et al., 2013). In a study in which urine samples were collected from hookah smokers before and after they smoked from the hookah, significant post-smoking increases were noted in the urinary concentrations of nicotine, cotinine, NNAL, and volatile organic compounds (St. Helen et al., 2014). Expired carbon monoxide concentrations (Jacob et al., 2011) and benzene exposure (Jacob et al., 2013) tend to be much higher for hookah smoking than for cigarette smoking. Studies have assessed the association between hookah smoking and selected health outcomes, but there is a paucity of evidence available on this topic, and the body of evidence is generally of low quality (Akl et al., 2010). In a meta-analysis of data from four studies, hookah smoking was significantly associated with an increased lung cancer risk (odds ratio, 2.1; 95 percent confidence interval, 1.3–3.4) (Akl et al., 2010). In this same systematic review, only one study each was identified to assess the association between hookah smoking and cancers of the bladder, esophagus, and nasopharynx, and none of the observed associations were statistically significant (Akl et al., 2010). With respect to pregnancy outcomes, three studies found hookah smoking to be associated with a significantly increased risk of low birth weight (2.1; 1.1–4.2) (Akl et al., 2010). In one study, hookah smoking was found to be associated with a significantly increased risk of respiratory illness (2.3; 1.1–5.1) (Akl et al., 2010). Definitive conclusions on the risks associated with hookah smoking versus cigarette smoking are not possible with the limited quality and quantity of the evidence currently available.

Little evidence on the health effects of newer combustible tobacco products has been generated. In attempting to estimate risks, it is important to account for the specific product features. For example, the 2014 Surgeon General's report points out that when considering the emergence of small cigarette-like cigars, the health risks may more closely parallel those of cigarettes than of the traditional cigar because of the way that small cigarette-like cigars are used (HHS, 2014). This line of reasoning emphasizes that the health risks of tobacco use are directly linked to doses of exposure to disease-causing toxins, which is a function not only of the tobacco product but also of the frequency and duration of and the manner in which the product is smoked, when factors such as depth of inhalation are accounted for. This concept is also critical to thinking about the health risks of dual use or poly-use of combustible tobacco products and ENDS, an exposure pattern that will likely increase in the future but for which data on health risks are needed.

Finding 4-7: Smoking of combustible tobacco products other than cigarettes, such as pipes and cigars, is causally associated with a broad spectrum of adverse health effects.

Smokeless Tobacco Products

The marketplace for smokeless tobacco products has diversified considerably in recent years. In addition to the traditional smokeless tobacco products of chewing tobacco and snuff, a number of new products have been introduced, such as snus and dissolvable tobacco products.

The 1986 Surgeon General's report examined the evidence concerning smokeless tobacco and concluded that it was a cause of cancer of the oral cavity. Smokeless tobacco use can also lead to oral leukoplakia, gingival recession, and nicotine addiction. A 2007 monograph of the International Agency for Research on Cancer (IARC) that focused on smokeless tobacco concluded that smokeless tobacco is a Group 1 carcinogen, meaning that it is a human carcinogen (IARC, 2007). The IARC review of the evidence led to the conclusion, "Smokeless tobacco causes cancers of the oral cavity and pancreas" (IARC, 2007, p. 370). Smokeless tobacco may also be linked to an increased risk of esophageal cancer (IARC, 2012).

These earlier reviews of the evidence concerning the health effects of smokeless tobacco use were primarily based on evidence related to traditional smokeless tobacco products and did not take into account the newer products. A more recent review of the epidemiologic evidence for Swedish-type snus, a moist snuff, suggests that the use of snus may be less harmful than cigarette smoking (Lee, 2011). How the health risks of Swedish-type snus differ from the more traditional smokeless tobacco products has yet to be precisely characterized; furthermore, direct epidemiologic evidence is not yet available on the health effects of the Swedish-type snus products presently marketed in the United States.

Finding 4-8: The use of smokeless tobacco products is causally associated with oral cancer.

ENDS

The marketplace for tobacco products and devices that deliver nicotine has recently expanded in response to the smoking bans that have increasingly limited the locations where traditional cigarette smoking is allowed (Jawad et al., 2013; Kamerow, 2013; Popova and Ling, 2013; Schuster et al., 2013). Electronic nicotine delivery systems, or ENDS, have experienced a rapid upsurge in use and are now marketed by the major U.S. tobacco companies (Dockrell et al., 2013; Kamerow, 2013; Li et al., 2013; Popova and Ling, 2013).

Monitoring this expansion in products and how the products are used is important to tobacco control. An ENDS product that decreases the delivery of tobacco toxins would ostensibly also reduce the risk of developing smoking-caused disease if current cigarette smokers were to switch from cigarettes to exclusive use of the ENDS. On the other hand, the risk of smoking-caused disease could be increased if the ENDS maintained nicotine addiction and its users continued to smoke cigarettes and to use multiple products that deliver nicotine. Furthermore, these alternative products, particularly those that involve flavorings attractive to adolescents, may serve as a gateway for adolescents to initiate smoking and thus start on a path that eventually leads to tobacco addiction. Currently there is a paucity of data on issues such as these; along with the direct adverse health effects associated with use of these alternative products, these remain important lines of inquiry for future research. Definitive evidence on the long-term health effects of ENDS products will not be available for many years because any long-term health effects associated with these products will take decades to emerge. Furthermore, generating the needed evidence base will be complicated by the facts that there are so many different ENDS products and the products and their contents are evolving.

IMPACT OF CIGARETTE SMOKING ON MORTALITY

Cigarette smoking contributes significantly to the population burden of many of the leading causes of chronic disease deaths that typically occur in middle and late adulthood, such as cancer, cardiovascular disease, and COPD (HHS, 2004).

The combined death toll linked to cigarette smoking is staggering. Cigarette smoking is estimated to account for approximately 480,000 deaths per year in the United States (HHS, 2014). In 2010 the four leading causes of death in the United States were heart disease (597,700 deaths), cancer (574,700 deaths), chronic lower respiratory diseases (138,100 deaths), and stroke and cerebrovascular disease (129,500) (Heron, 2013). Cigarette smoking is a major cause of all four of these diseases. Furthermore, smoking is also a cause of the seventh (diabetes, 69,000 deaths) and eighth (influenza/pneumonia, 50,100 deaths) leading causes of death (Heron, 2013).

Cancer

As a cause of 12 different types of malignancy, cigarette smoking is responsible for 163,700 cancer deaths per year in the United States (HHS, 2014; NCHS, 2013). Most of this mortality burden (130,700 deaths) is due to lung cancer, but cigarette smoking also caused 36,000 deaths from other malignancies (HHS, 2014).

Cardiovascular Disease

Cigarette smoking is estimated to cause 160,600 cardiovascular disease deaths per year in the United States (HHS, 2014). The majority of the smoking-caused cardiovascular deaths (99,300 deaths) are due to coronary heart disease, but smoking also causes 25,500 deaths from other forms of heart disease. Furthermore, cigarette smoking causes 15,300 deaths from cerebrovascular disease and 11,500 deaths from other forms of vascular disease.

Diabetes

Type 2 diabetes mellitus is a leading underlying cause of mortality from cardiovascular disease, and it also leads to other adverse consequences such as kidney failure and blindness (HHS, 2014). It is the seventh leading cause of death in the United States (Heron, 2013). Cigarette smoking is estimated to cause 9,000 deaths from type 2 diabetes per year in the United States (HHS, 2014).

COPD

More than 138,000 Americans died from COPD in 2010 (Heron, 2013), making it the third leading cause of death in the United States. Cigarette smoking is the predominant cause of COPD. Estimates indicate that 100,600 COPD deaths per year in the United States are attributable to cigarette smoking (HHS, 2014).

Increased Susceptibility to Infectious Lung Diseases

Cigarette smoking is causally associated with an increased risk of pneumonia (HHS, 2004) and tuberculosis mortality (HHS, 2014). Cigarette smoking is estimated to cause 12,500 deaths from these infectious diseases per year.

IMPACT OF EXPOSURE TO SECONDHAND SMOKE ON MORTALITY

Due to its causal associations with coronary heart disease and lung cancer, secondhand smoke exposure is estimated to cause more than 41,300 deaths per year in the United States (HHS, 2014). The majority of these (almost 34,000 deaths) are due to coronary heart disease, while more than 7,000 deaths per year are from lung cancer (HHS, 2014). Furthermore, parental smoking is estimated to cause approximately 600 deaths per year from prenatal conditions and 400 deaths per year from sudden infant death syndrome (HHS, 2014).

Finding 4-9: Tobacco use is causally associated with premature mortality from a variety of causes, such as lung infections, chronic obstructive pulmonary disease, coronary heart disease, and a variety of cancers.

REFERENCES

ACS (American Cancer Society). 2007. *Cancer facts & figures 2007*. Atlanta, GA: American Cancer Society.

Akl, E. A., S. Gaddam, S. K. Gunukula, R. Honeine, P. A. Jaoude, and J. Irani. 2010. The effects of waterpipe tobacco smoking on health outcomes: A systematic review. *International Journal of Epidemiology* 39(3):834–857.

Alberg, A. J. 2002. The influence of cigarette smoking on circulating concentrations of antioxidant micronutrients. *Toxicology* 180(2):121–137.

Alberg, A. J., G. B. Diette, and J. G. Ford. 2003. Attendance and absence as markers of health status—The example of active and passive cigarette smoking. *American Journal of Epidemiology* 157(10):870–873.

Alberg, A. J., M. V. Brock, J. G. Ford, J. M. Samet, and S. D. Spivack. 2013. Epidemiology of lung cancer: Diagnosis and management of lung cancer, 3rd ed.: American College of Chest Physicians evidence-based clinical practice guidelines. *Chest* 143(5 Suppl):e1S–e29S.

Ambrose, J. A., and R. S. Barua. 2004. The pathophysiology of cigarette smoking and cardiovascular disease: An update. *Journal of the American College of Cardiology* 43(10):1731–1737.

Bloomer, R. J., A. D. Solis, K. H. Fisher-Wellman, and W. A. Smith. 2008. Postprandial oxidative stress is exacerbated in cigarette smokers. *British Journal of Nutrition* 99(5):1055–1060.

Breslau, N. 1993. Daily cigarette consumption in early adulthood: Age of smoking initiation and duration of smoking. *Drug and Alcohol Dependence* 33(3):287–291.

Breslau, N., and E. L. Peterson. 1996. Smoking cessation in young adults: Age at initiation of cigarette smoking and other suspected influences. *American Journal of Public Health* 86(2):214–220.

Brown, A. J. 1996. Acute effect of smoking cessation on antioxidant status. *Journal of Nutritional Biochemistry* 7(1):29–39.

Buchmann, A. F., D. Blomeyer, C. Jennen-Steinmetz, M. H. Schmidt, G. Esser, T. Banaschewski, and M. Laucht. 2013. Early smoking onset may promise initial pleasurable sensations and later addiction. *Addiction Biology* 18(6):947–954.

Campos, C., R. Guzman, E. Lopez-Fernandez, and A. Casado. 2011. Urinary biomarkers of oxidative/nitrosative stress in healthy smokers. *Inhalation Toxicology* 23(3):148–156.

Chen, J., and W. J. Millar. 1998. Age of smoking initiation: Implications for quitting. *Health Reports* 9(4):39–46.

Cobb, C., K. D. Ward, W. Maziak, A. L. Shihadeh, and T. Eissenberg. 2010. Waterpipe tobacco smoking: An emerging health crisis in the United States. *American Journal of Health Behavior* 34(3):275–285.

Craig, W. Y., G. E. Palomaki, and J. E. Haddow. 1989. Cigarette smoking and serum lipid and lipoprotein concentrations: An analysis of published data. *BMJ* 298(6676):784–788.

Craig, W. Y., G. E. Palomaki, A. M. Johnson, and J. E. Haddow. 1990. Cigarette smoking-associated changes in blood lipid and lipoprotein levels in the 8- to 19-year-old age group: A meta-analysis. *Pediatrics* 85(2):155–158.

D'Avanzo, B., C. La Vecchia, and E. Negri. 1994. Age at starting smoking and number of cigarettes smoked. *Annals of Epidemiology* 4(6):455–459.

Dockrell, M., R. Morison, L. Bauld, and A. McNeill. 2013. E-cigarettes: Prevalence and attitudes in Great Britain. *Nicotine & Tobacco Research* 15(10):1737–1744.

Dwyer, J. H., G. E. Rieger-Ndakorerwa, N. K. Semmer, R. Fuchs, and P. Lippert. 1988. Low-level cigarette smoking and longitudinal change in serum cholesterol among adolescents. The Berlin-Bremen study. *JAMA* 259(19):2857–2862.

Eiserich, J. P., A. van der Vliet, G. J. Handelman, B. Halliwell, and C. E. Cross. 1995. Dietary antioxidants and cigarette smoke-induced biomolecular damage: A complex interaction. *American Journal of Clinical Nutrition* 62(6 Suppl):1490S–1500S.

Eisner, M. D., E. H. Yelin, P. P. Katz, S. C. Shiboski, J. Henke, and P. D. Blanc. 2000. Predictors of cigarette smoking and smoking cessation among adults with asthma. *American Journal of Public Health* 90(8):1307–1311.

Escobedo, L. G., S. E. Marcus, D. Holtzman, and G. A. Giovino. 1993. Sports participation, age at smoking initiation, and the risk of smoking among U.S. high school students. *JAMA* 269(11):1391–1395.

Evans, P., and B. Halliwell. 2001. Micronutrients: Oxidant/antioxidant status. *British Journal of Nutrition* 85(Suppl 2):S67–S74.

Everett, S. A., C. W. Warren, D. Sharp, L. Kann, C. G. Husten, and L. S. Crossett. 1999. Initiation of cigarette smoking and subsequent smoking behavior among U.S. high school students. *Preventive Medicine* 29(5):327–333.

Fernandez, E., A. Schiaffino, C. La Vecchia, J. M. Borras, M. Nebot, E. Salto, R. Tresserras, L. Rajmil, J. R. Villalbi, and A. Segura. 1999. Age at starting smoking and number of cigarettes smoked in Catalonia, Spain. *Preventive Medicine* 28(4):361–366.

Heron, M. 2013. Deaths: Leading causes for 2010. *National Vital Statistics Reports* 62(6):1–96.

HHS (Department of Health and Human Services). 1998. *Smoking and tobacco control monograph 9: Cigars: Health effects and trends.* Bethesda, MD: U.S. Department of Health and Human Services; Office on Smoking and Health; National Cancer Institute. Original edition, Bethesda, MD.

———. 2004. *The health consequences of smoking: A report of the Surgeon General.* Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

———. 2006. *The health consequences of involuntary exposure to tobacco smoke: A report of the Surgeon General.* Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, Coordinating Center for Health Promotion, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

———. 2010. *How tobacco smoke causes disease: The biology and behavioral basis for smoking-attributable disease: A report of the Surgeon General.* Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

———. 2012. *Preventing tobacco use among youth and young adults: A report of the Surgeon General.* Atlanta GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

———. 2014. *The health consequences of smoking—50 years of progress: A report of the Surgeon General.* Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

Hong, Y. C., H. Kim, M. W. Im, K. H. Lee, B. H. Woo, and D. C. Christiani. 2001. Maternal genetic effects on neonatal susceptibility to oxidative damage from environmental tobacco smoke. *Journal of the National Cancer Institute* 93(8):645–647.

Hu, M. C., M. Davies, and D. B. Kandel. 2006. Epidemiology and correlates of daily smoking and nicotine dependence among young adults in the United States. *American Journal of Public Health* 96(2):299–308.

Huxley, R. R., H. Yatsuya, P. L. Lutsey, M. Woodward, A. Alonso, and A. R. Folsom. 2012. Impact of age at smoking initiation, dosage, and time since quitting on cardiovascular disease in African Americans and whites: The Atherosclerosis Risk in Communities Study. *American Journal of Epidemiology* 175(8):816–826.

IARC (International Agency for Research on Cancer). 2007. Smokeless tobacco and some tobacco-specific n-nitrosamines. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans* Vol. 89.

———. 2012. Personal habits and indoor combustions. Volume 100e. A review of human carcinogens. *IARC Monographs on the Evaluation of Carcinogenic Risks to Humans* 100(Pt E).

Jacob, P., III, A. H. Abu Raddaha, D. Dempsey, C. Havel, M. Peng, L. Yu, and N. L. Benowitz. 2011. Nicotine, carbon monoxide, and carcinogen exposure after a single use of a water pipe. *Cancer Epidemiology, Biomarkers and Prevention* 20(11):2345–2353.

———. 2013. Comparison of nicotine and carcinogen exposure with water pipe and cigarette smoking. *Cancer Epidemiology, Biomarkers and Prevention* 22(5):765–772.

Jain, A., B. K. Agrawal, M. Varma, and A. A. Jadhav. 2009. Antioxidant status and smoking habits: Relationship with diet. *Singapore Medical Journal* 50(6):624–627.

Jawad, M., A. McEwen, A. McNeill, and L. Shahab. 2013. To what extent should waterpipe tobacco smoking become a public health priority? *Addiction* 108(11):1873–1884.

Kamerow, D. 2013. Big tobacco lights up e-cigarettes. *BMJ* 346:f3418.

Kapaki, E., I. Liappas, L. Lyras, G. P. Paraskevas, I. Mamali, I. Theotoka, N. Bourboulis, I. Liosis, O. Petropoulou, and K. Soldatos. 2007. Oxidative damage to plasma proteins in patients with chronic alcohol dependence: The effect of smoking. *In Vivo* 21(3):523–528.

Kenfield, S. A., M. J. Stampfer, B. A. Rosner, and G. A. Colditz. 2008. Smoking and smoking cessation in relation to mortality in women. *JAMA* 299(17):2037–2047.

Khuder, S. A., H. H. Dayal, and A. B. Mutgi. 1999. Age at smoking onset and its effect on smoking cessation. *Addictive Behaviors* 24(5):673–677.

Kocyigit, A., H. Keles, S. Selek, S. Guzel, H. Celik, and O. Erel. 2005. Increased DNA damage and oxidative stress in patients with cutaneous leishmaniasis. *Mutation Research* 585(1–2):71–78.

Kocyigit, A., S. Selek, H. Celik, and M. Dikilitas. 2011. Mononuclear leukocyte DNA damage and oxidative stress: The association with smoking of hand-rolled and filter cigarettes. *Mutation Research* 721(2):136–141.

Laher, I. 2014. *Systems biology of free radicals and antioxidants*. Berlin: Springer Reference.

Lando, H. A., D. T. Thai, D. M. Murray, L. A. Robinson, R. W. Jeffery, N. E. Sherwood, and D. J. Hennrikus. 1999. Age of initiation, smoking patterns, and risk in a population of working adults. *Preventive Medicine* 29(6 Part 1):590–598.

Lee, P. N. 2011. Summary of the epidemiological evidence relating snus to health. *Regulatory Toxicology and Pharmacology* 59(2):197–214.

Lee, P. N., B. A. Forey, and K. J. Coombs. 2012. Systematic review with meta-analysis of the epidemiological evidence in the 1900s relating smoking to lung cancer. *BMC Cancer* 12:385.

Li, J., C. Bullen, R. Newcombe, N. Walker, and D. Walton. 2013. The use and acceptability of electronic cigarettes among New Zealand smokers. *New Zealand Medical Journal* 126(1375):48–57.

Lowe, F. J., E. O. Gregg, and M. McEwan. 2009. Evaluation of biomarkers of exposure and potential harm in smokers, former smokers and never-smokers. *Clinical Chemistry and Laboratory Medicine* 47(3):311–320.

Marangon, K., S. Devaraj, and I. Jialal. 1999. Measurement of protein carbonyls in plasma of smokers and in oxidized LDL by an ELISA. *Clinical Chemistry* 45(4):577–578.

Martin, J. A., B. E. Hamilton, M. J. K. Osterman, S. C. Curtin, and T. J. Mathews. 2013. Births: Final data for 2012. *National Vital Statistics Reports* 64(1):1–65.

NCHS (National Center for Health Statistics). 2013. *Faststats: Leading causes of death*. http://www.cdc.gov/nchs/fastats/leading-causes-of-death.htm (accessed January 7, 2015).

Ozguner, F., A. Koyu, and G. Cesur. 2005. Active smoking causes oxidative stress and decreases blood melatonin levels. *Toxicology and Industrial Health* 21(1–2):21–26.

Padmavathi, P., V. D. Reddy, G. Kavitha, M. Paramahamsa, and N. Varadacharyulu. 2010. Chronic cigarette smoking alters erythrocyte membrane lipid composition and properties in male human volunteers. *Nitric Oxide* 23(3):181–186.

Park, S. M., K. Y. Son, Y. J. Lee, H. C. Lee, J. H. Kang, Y. J. Lee, Y. J. Chang, and Y. H. Yun. 2004. A preliminary investigation of early smoking initiation and nicotine dependence in Korean adults. *Drug and Alcohol Dependence* 74(2):197–203.

Pawelec, G., D. Goldeck, and E. Derhovanessian. 2014. Inflammation, ageing and chronic disease. *Current Opinion in Immunology* 29:23–28.

Planas, A., A. Clara, J. Marrugat, J. M. Pou, A. Gasol, A. de Moner, C. Contreras, and F. Vidal-Barraquer. 2002. Age at onset of smoking is an independent risk factor in peripheral artery disease development. *Journal of Vascular Surgery* 35(3):506–509.

Popova, L., and P. M. Ling. 2013. Alternative tobacco product use and smoking cessation: A national study. *American Journal of Public Health* 103(5):923–930.

Prasad, S., B. Sung, and B. B. Aggarwal. 2012. Age-associated chronic diseases require age-old medicine: Role of chronic inflammation. *Preventive Medicine* 54(Suppl):S29–S37.

Prizment, A. E., H. Yatsuya, P. L. Lutsey, J. H. Lubin, M. Woodward, A. R. Folsom, and R. R. Huxley. 2014. Smoking behavior and lung cancer in a biracial cohort: The Atherosclerosis Risk in Communities Study. *American Journal of Preventive Medicine* 46(6):624–632.

Pryor, W. A., and K. Stone. 1993. Oxidants in cigarette smoke: Radicals, hydrogen peroxide, peroxynitrate, and peroxynitrite. *Annals of the New York Academy of Sciences* 686:12–27.

Radwan, G., S. S. Hecht, S. G. Carmella, and C. A. Loffredo. 2013. Tobacco-specific nitrosamine exposures in smokers and nonsmokers exposed to cigarette or waterpipe tobacco smoke. *Nicotine & Tobacco Research* 15(1):130–138.

Reidpath, D. D., T. M. Davey, A. Kadirvelu, I. N. Soyiri, and P. Allotey. 2014. Does one cigarette make an adolescent smoker, and is it influenced by age and age of smoking initiation? Evidence of association from the U.S. Youth Risk Behavior Surveillance System (2011). *Preventive Medicine* 59:37–41.

Rostron, B. L., C. M. Chang, and T. F. Pechacek. 2014. Estimation of cigarette smoking–attributable morbidity in the United States. *JAMA Internal Medicine* 174(12):1922–1928.

Schuster, R. M., A. W. Hertel, and R. Mermelstein. 2013. Cigar, cigarillo, and little cigar use among current cigarette-smoking adolescents. *Nicotine & Tobacco Research* 15(5):925–931.

Seet, R. C. S., C.Y. Lee, W. M. Loke, S. H. Huang, H. Huang, W. F. Looi, E. S. Chew, A. M. Quek, E. C. Lim, and B. Halliwell. 2011. Biomarkers of oxidative damage in cigarette smokers: Which biomarkers might reflect acute versus chronic oxidative stress? *Free Radical Biology and Medicine* 50(12):1787–1793.

Simet, S. M., J. H. Sisson, J. A. Pavlik, J. M. DeVasure, C. Boyer, X. Liu, S. Kawasaki, J. G. Sharp, S. I. Rennard, and T. A. Wyatt. 2010. Long-term cigarette smoke exposure in a mouse model of ciliated epithelial cell function. *American Journal of Respiratory Cell and Molecular Biology* 43(6):635–640.

St. Helen, G., N. L. Benowitz, K. M. Dains, C. Havel, M. Peng, and P. Jacob III. 2014. Nicotine and carcinogen exposure after water pipe smoking in hookah bars. *Cancer Epidemiology, Biomarkers & Prevention* 23(6):1055–1066.

Taioli, E., and E. L. Wynder. 1991. Effect of the age at which smoking begins on frequency of smoking in adulthood. *New England Journal of Medicine* 325(13):968–969.

Taylor, A. W., R. S. Bruno, and M. G. Traber. 2008. Women and smokers have elevated urinary F(2)-isoprostane metabolites: A novel extraction and LC-MS methodology. *Lipids* 43(10):925–936.

Thun, M., R. Peto, J. Boreham, and A. D. Lopez. 2012. Stages of the cigarette epidemic on entering its second century. *Tobacco Control* 21(2):96–101.

van der Vaart, H., D. S. Postma, W. Timens, and N. H. T. Ten Hacken. 2004. Acute effects of cigarette smoke on inflammation and oxidative stress: A review. *Thorax* 59(8):713–721.

Wilson, K. M., J. N. Finkelstein, A. K. Blumkin, D. Best, and J. D. Klein. 2011. Micronutrient levels in children exposed to secondhand tobacco smoke. *Nicotine & Tobacco Research* 13(9):800–808.

Yao, H., and I. Rahman. 2011. Current concepts on oxidative/carbonyl stress, inflammation and epigenetics in pathogenesis of chronic obstructive pulmonary disease. *Toxicology and Applied Pharmacology* 254(2):72–85.

Yeung, D. L. 1976. Relationships between cigarette smoking, oral contraceptives, and plasma vitamins A, E, C, and plasma triglycerides and cholesterol. *American Journal of Clinical Nutrition* 29(11):1216–1221.

Yilmaz, G., P. Isik Agras, S. Hizli, C. Karacan, H. T. Besler, K. Yurdakok, and T. Coskun. 2009. The effect of passive smoking and breast feeding on serum antioxidant vitamin (A, C, E) levels in infants. *Acta Paediatrica* 98(3):531–536.

Zalata, A., S. Yahia, A. El–Bakary, and H. M. Elsheikha. 2007. Increased DNA damage in children caused by passive smoking as assessed by comet assay and oxidative stress. *Mutation Research* 629(2):140–147.

5

Restrictions on Youth Access to Tobacco Products

Laws aiming to reduce underage access to tobacco include restrictions on both distribution of tobacco products to and purchase of tobacco products by underage individuals. Laws limiting distribution apply both to commercial tobacco sales and to other methods of provision, such as giving tobacco to a minor or buying tobacco on behalf of a minor (i.e., proxy sales). Restrictions on purchase are distinguished from the restrictions on distribution by the fact that they punish the underage buyer. Purchase laws are commonly accompanied by restrictions on underage tobacco use and possession and are therefore frequently referred to as purchase–use–possession (PUP) laws. There is vast variation and inconsistency across the United States in youth access laws and how they are implemented and enforced. Despite the profusion and complexity of these laws, there is a common thread, which is that the enforcement of these restrictions has focused primarily on curtailing youth access to tobacco from commercial sources. Accordingly, that is the focus of this analysis. This chapter summarizes youth access restrictions in the United States and their enforcement, and it describes survey data regarding where underage users obtain their tobacco products.

YOUTH TOBACCO ACCESS LAWS IN THE UNITED STATES

Federal Youth Tobacco Access Laws

In 1992 Congress enacted the Synar Amendment to reduce the availability of tobacco to underage individuals. This law requires states to enact and enforce laws prohibiting the sale and distribution of tobacco to underage persons or face the loss of federal block grant funding for substance abuse prevention and treatment programs. In 1996 the Food and Drug Administration (FDA) issued its Tobacco Rule, in which it asserted its authority to regulate tobacco products (HHS, 1996). As part of this effort, FDA issued regulations on the advertising and marketing of tobacco products to reduce the appeal of tobacco to children and adolescents and also issued restrictions on retail sales to underage persons to reduce youth access to tobacco. The tobacco industry challenged FDA's authority to regulate tobacco in court, and in 2000 the Supreme Court nullified FDA's rule on the grounds that Congress had not granted FDA explicit jurisdiction over tobacco (IOM, 2007).

At the same time that it was fighting federal efforts to regulate tobacco, the tobacco industry was also battling legal challenges brought by the attorneys general of individual states. In 1994 Mississippi Attorney General Michael Moore filed a lawsuit against the major tobacco companies to recoup state Medicaid expenditures on residents with tobacco-related diseases (IOM, 2007). Attorneys general from every state soon followed suit, and on November 23, 1998, the attorneys general from 46 states, the District of Columbia, and several U.S. territories signed the Master Settlement Agreement (MSA) with the major tobacco companies (NAAG, 1998). (Four states had previously reached a separate settlement with the tobacco companies, which awarded them $40 billion.) Although the primary aim of these suits and the resulting agreement focused on the tobacco companies' payment of $206 billion to the states, distributed from 2000 to 2025, as a reimbursement for health care costs that the states had incurred because of tobacco-related health issues, the terms of the agreement also included the establishment of a national charitable foundation (now known as the American Legacy Foundation) devoted to reducing adolescent and young adult smoking and to preventing tobacco-related diseases. The agreement also included tobacco sales and marketing provisions aimed at reducing youth access to tobacco. These provisions included bans on gifts to underage individuals in exchange for proof of purchase of tobacco products, gifts through the mail without proof of the recipient's age, and distribution of free samples except in locations restricted to adults. The MSA also restricted cigarette pack size to a minimum of 20 cigarettes and prohibited tobacco companies from opposing legislation restricting cigarette pack size through 2001. The MSA further prohibited tobacco companies from legally challenging the enforceability or constitutionality of state and local tobacco control laws enacted before June 1, 1998, including state and local youth access laws that may have been enacted in compliance with Synar.

In 2009 President Barack Obama signed the Family Smoking Prevention and Tobacco Control Act (hereafter referred to as the Tobacco Control

Act) into law, granting FDA broad authority to regulate the manufacture, marketing, and sales of tobacco products to protect the public's health and to reduce adolescent tobacco use.[1] In pursuit of these goals, the act directs FDA to reissue its 1996 Tobacco Rule along with its advertising and access regulations. FDA regulations issued under the act currently apply to cigarettes, cigarette tobacco, and smokeless tobacco. They do not yet cover other tobacco and nicotine products, such as electronic nicotine delivery systems (ENDS), or e-cigarettes; cigars; snus; etc. However, FDA has formally proposed to "deem" e-cigarettes, little cigars, and other products to be "tobacco products" subject to its regulatory jurisdiction under the Tobacco Control Act (FDA, 2014a). When the final rule is issued and goes into effect, it will almost certainly extend federal youth access restrictions to these other products.

The advertising and marketing regulations issued under the Tobacco Control Act include federal bans complementing the MSA provisions at the state level: banning the sale of cigarette packs containing fewer than 20 cigarettes and prohibiting the distribution of free samples. The act authorizes FDA to restrict tobacco sales to minors, including requiring face-to-face sales, with exceptions for vending machines and self-service displays in adult-only facilities, and requiring age verification for all over-the-counter sales by checking a driver's license or other form of photographic identification of anyone under age 27. The Tobacco Control Act also grants FDA the authority to enforce these restrictions, provides a set of sanctions for violations, and directs FDA to contract with states to assist with retailer compliance checks—random, unannounced inspections of tobacco retailers—to determine whether retailers are illegally selling tobacco to underage individuals. In compliance with the congressional direction, FDA reissued its 1996 Tobacco Rule in 2010 (FDA, 2010).

The Tobacco Control Act also sets limits on FDA's authority. Limits relevant to youth access include prohibiting FDA from banning face-to-face sales by any specific type of tobacco retailer (i.e., FDA cannot ban all pharmacies or convenience stores from selling tobacco) and from raising the federal minimum age of legal access to tobacco products (MLA). The act does, however, establish a federal MLA of 18 without preempting existing state laws or penalties while allowing states and localities to establish a higher MLA.

[1] Family Smoking Prevention and Tobacco Control Act of 2009, Public Law 111-31 111th Cong. (June 22, 2009).

State and Local Youth Access Laws

Although federal law requires an MLA of 18, some states and localities have experimented with higher MLAs. Currently, 46 states have an MLA of 18, while 4 states (Alabama, Alaska, New Jersey, and Utah) have an MLA of 19. (See Appendix A for a list of select U.S. jurisdictions with an MLA of 19.) In the past decade, a number of localities have also adopted an MLA over 18. In 2005, Needham, Massachusetts, became the first location in the United States to establish an MLA of 21. The Needham Board of Health enacted a town regulation raising the age under a Massachusetts state provision that allows local boards of health to make "reasonable health regulations."[2] Since 2005 numerous Massachusetts towns have followed suit; as of November 2014, 6 towns had an MLA of 19, 22 had an MLA of 21, and another 9 towns were considering proposals to raise the MLA to ages higher than 18. Outside of Massachusetts, Nassau, Onondaga, and Westchester counties in New York State have an MLA of 19, and Hawaii County (the big island in Hawaii), Suffolk County in New York State, and, most notably, New York City have also recently raised the MLA to 21. (See Appendix A for a list of select U.S. jurisdictions with an MLA of 21.) A number of states and localities, including Colorado, Maryland, New Jersey, Texas, Utah, and several localities in California, New Jersey, and Washington State have also considered proposals to raise the MLA to 21. These differing MLAs have not been in place long enough, however, for any differential effects on tobacco use to be detected. (See Appendix A for select states and localities with either proposed or enacted MLAs over 18.)

In compliance with the Synar Amendment, all 50 states and the District of Columbia (51 jurisdictions total) have enacted laws prohibiting the sale or distribution of tobacco products to underage persons. All 51 jurisdictions prohibit commercial transfers, while 48 states and the District of Columbia also prohibit noncommercial transfers (e.g., giving, exchanging, bartering, furnishing, or otherwise distributing tobacco). At least 18 states explicitly differentiate between commercial and noncommercial tobacco transfers for penalty purposes. Penalties vary significantly: 28 jurisdictions authorize license revocation or suspension for sales to minors; about two-thirds of the jurisdictions classify the offense as a criminal offense; and, of the 37 jurisdictions that increase the penalty for repeat violations, 25 authorize substantial fines of $1,000 or more. Currently, all 51 jurisdictions cover cigarettes and smokeless and roll-your-own tobacco, while 31 jurisdictions prohibit the distribution of ENDS. Appendix B provides full details on the laws regarding commercial and noncommercial tobacco transfers to underage individuals for the 50 states and the District of Columbia.

[2] MASS. GEN. LAWS ch. 111 § 31.

Currently, the youth access laws of 44 states and the District of Columbia penalize underage individuals for the purchase, use, or possession of tobacco. (Maryland, Massachusetts, Nevada, New Jersey, and New York have no PUP prohibitions.) In the vast majority of states, the offense is punishable as a civil infraction. Sanctions for violations of PUP laws include confiscation of the tobacco product, notifying parents of the violation, community service, participation in a tobacco prevention education program, and fines ranging from $5 to $300. In addition, in nine states underage users caught in violation of PUP laws may be subject to having their driver's license suspended or revoked or to having limits placed on their driving privileges (e.g., only from home to work or school and back). Appendix C provides more details on PUP laws for tobacco in the 50 states and the District of Columbia.

Finding 5-1: Although most states currently set the minimum age of legal access to tobacco products at 18, 4 states set it at 19, and New York City and several other localities around the country have raised the minimum legal access age to 21.

Finding 5-2: All 51 jurisdictions prohibit commercial transfers, while 48 states and the District of Columbia also prohibit noncommercial transfers (e.g., giving, exchanging, bartering, furnishing, or otherwise distributing tobacco).

Finding 5-3: All 51 jurisdictions cover cigarettes, smokeless tobacco, and roll-your-own tobacco, while 31 jurisdictions currently prohibit the distribution of electronic nicotine delivery systems.

Finding 5-4: The great majority of jurisdictions (47) prohibit underage individuals from purchasing, attempting to purchase, possessing, or using covered tobacco products. Sanctions typically include a fine or community service.

ENFORCEMENT OF YOUTH ACCESS LAWS

This section summarizes current enforcement policies and practices at the federal, state, and local levels pertaining to youth access restrictions. Because enforcement of these restrictions is largely focused on assuring compliance by licensed tobacco retailers, the committee's review and analysis is also focused here. However, this section also summarizes what little is known about the enforcement of MLA restrictions against Internet vendors and black market sellers as well as the noncommercial distribution of tobacco by so-called social sources.

Enforcing Restrictions Against Licensed Retailers

States and localities in the United States did not seriously enforce youth access laws in the early 1990s, when these laws were first being implemented (IOM, 1994). Evidence from the United States and abroad further suggests that retailers are not likely to comply with MLA laws if there is no meaningful enforcement (e.g., compliance checks and sanctions for violations) (CDC, 1993; Cismoski and Sheridan, 1993; DiFranza, 1999, 2000; DiFranza and Coleman, 2001; Erickson et al., 1993; Kuendig, 2011; Rigotti et al., 1997; Schensky et al., 1996; Verdonk-Kleinjan et al., 2008).

Federal Support for Retailer Enforcement

The federal government oversees two comprehensive programs to enforce the MLA for tobacco products: the Synar program of the Substance Abuse and Mental Health Services Administration (SAMHSA) and FDA's tobacco retail compliance inspection contracts, which are implemented by states and localities.

The Synar program The 1992 Synar Amendment requires states to enact and enforce laws prohibiting the sale or distribution of tobacco to persons under age 18 or face the loss of 40 percent of federal Substance Abuse Prevention and Treatment Block Grants. SAMHSA, charged with implementing the amendment, issued regulations in 1996 to provide further guidance to states. These regulations stipulate that, in addition to enacting laws restricting underage access to tobacco, states must also enforce these laws "in a manner that can reasonably be expected to reduce the extent to which tobacco products are available to individuals under the age of 18" (SAMHSA, 1996, p. 1492); must develop a strategy to reduce the rate of illegal tobacco sales to underage persons to 20 percent or less by 2003; and must conduct annual compliance checks of retailers selling tobacco both over the counter and from vending machines to ensure compliance with the law. Moreover, because Synar primarily aims to survey the rate of illegal tobacco sales to underage persons, it requires states to demonstrate that their compliance checks include a statistically representative sample of tobacco retail outlets accessible to children and adolescents. These compliance checks may (but are not required to) include a state-level enforcement component. Thus, some programs may not have sanctions for violations and may instead use other measures, such as education programs targeted at retailers and mass media campaigns, to ensure high levels of compliance. Despite the lack of a regulatory requirement, a study of Synar implementation (DiFranza and Dussault, 2005) found that the Department of Health and Human Services pressured some states to adopt compliance checks as an instrument of enforcement instead of using those checks as a basis for retailer education alone. Furthermore, although federal block grants are conditioned on state enforcement of their youth access laws, states are explicitly prohibited from using the block grant funds to finance Synar compliance checks. The regulation also requires states to submit an annual report to SAMHSA detailing activities they conducted to reduce illegal sales of tobacco to underage persons (including methods used to conduct compliance checks), progress achieved, and plans for enforcing the youth tobacco access law in the next year. The Synar regulation applies to all 50 states, the District of Columbia, and 8 U.S. territories. It is not applicable to American Indian tribes.

FDA tobacco retail inspection contracts FDA's tobacco retail inspection contracts provide funding to state partners to conduct compliance check inspections specifically for enforcement purposes. As such, violations may lead to escalating fines, from warning letters to civil monetary penalties to suspension or revocation of retailers' licenses to sell tobacco. Unlike Synar, FDA only requires inspection of over-the-counter tobacco retailers because the Tobacco Control Act restricts vending machines to adult-only facilities, to which underage persons should not have access. Additionally, since the program is not intended for comprehensive surveillance, FDA contracts neither require a statistically valid survey of tobacco retailers nor set a performance target. However, FDA requires inspections using older decoys (ages 16–17) in neighborhoods considered to be at higher risk for violations, including neighborhoods with greater concentrations of populations with low socioeconomic status or of racial/ethnic minorities; these communities tend to have a greater density of tobacco retailers or have traditionally been targeted by the tobacco industry (CTP, 2014). Furthermore, states and territories may use FDA inspection contract funds to support Synar compliance checks so long as compliance check protocols and grant recipients meet the requirements of both programs. Moreover, because FDA contracts are narrowly restricted to enforcement activities, it is likely that states and localities will need to continue to conduct other youth tobacco access prevention activities, such as mass media campaigns and community and retailer education programs, to meet the Synar performance target (i.e., an 80 percent rate of compliance). FDA is authorized to contract with all states, the District of Columbia, five U.S. territories (American Samoa, Commonwealth of the Northern Mariana Islands, Guam, Puerto Rico, and the U.S. Virgin Islands), and—unlike Synar—also with American Indian tribes.

State and Local Enforcement Strategies Against Licensed Retailers

Under the two federal programs, enforcement activities are required to include compliance check inspections. However, because they are implemented at the state and local levels, enforcement activities and penalties for violations range considerably. A standard compliance check protocol involves sending supervised underage individuals into tobacco retailers to attempt to purchase tobacco. The underage decoys are typically nonsmokers who have no visible tattoos or piercings and are sent alone or in pairs. The decoys range in age (from 13 to 17), gender, and race. Most decoys ask to purchase cigarettes, but some are instructed to ask for smokeless or other tobacco products. Some carry and are instructed to present their own genuine photographic identification, while others are instructed not to present identification and to tell clerks that they have forgotten it. Some decoys carry out purchases, while others refuse the sale once it is verified that vendors were willing to sell to underage users. In some inspections, supervisors are stationed discreetly in the store to observe and record details of the transaction. In others, supervisors wait outside for the decoys to report a list of details about the store and their transactions immediately following each purchase attempt. Each of these variations in compliance check protocol may influence a state's compliance rate.

In addition to the variation in the compliance check protocol, there is significant variation in the frequency of inspections, whether and how often violators are reinspected, how and when violators are prosecuted, which (if any) agency has authority over enforcement, how much funding is available for enforcement, and the penalties for violations. Thus, although there is general agreement that youth tobacco access laws must be actively enforced to reduce illegal tobacco sales to minors, there remains a profusion of enforcement strategies and little evidence about the relative effectiveness and efficiency of these various activities. In an effort to identify best practices, a study by DiFranza (2005) examined 26 enforcement strategies in the 10 states with the highest retailer compliance rates and the 10 states with the lowest retailer compliance rates that had been reported to Synar. DiFranza concluded that the strategies essential for achieving high compliance include having a plan to enforce the state's MLA law, designating a single state agency to oversee and coordinate enforcement, conducting ongoing compliance check inspections, allocating state funding for enforcement inspections, prosecuting violators, setting penalties for violations, and practicing effective merchant education. He also identified a number of strategies that were recommended, but not essential, and also listed strategies that were not recommended because they waste resources or hinder enforcement. There were also a number of other strategies that could not be rated due to insufficient evidence. Indeed, despite the multitude of enforcement practices, relatively few of these practices have been evaluated, and there is little evidence about which specific enforcement practices successfully reduce the availability of tobacco to underage individuals.

Trends in Illegal Tobacco Retail Sales to Minors

Both the Synar Amendment and FDA's compliance testing program have resulted in considerable strengthening of state and local enforcement practices. Since the 1990s, all states have adopted youth access laws and have seen significant improvements in retailer compliance. In 1997, immediately following the implementation of Synar, the national average rate of illegal tobacco sales to minors reported to Synar was greater than 40 percent, with a high of 72.7 percent in one state (SAMHSA, 2014). By 2006 all states and the District of Columbia achieved compliance with the Synar requirements, including achieving the target sales rate of 20 percent or less (within the 3 percent margin of error), and they have continued to be in compliance since then (SAMHSA, 2014). In 2013 the national average rate of tobacco sales to minors for all states and the District of Columbia was 9.6 percent, and it ranged from the highest reported rate of 22.5 percent in Oregon to 1.0 percent in Minnesota and Nevada (SAMHSA, 2014). Since establishing its tobacco retail inspection contracts in 2010, FDA has granted more than $100 million in contracts in all 50 states, the District of Columbia, and five American territories (FDA, 2014b), which has resulted in more than 249,000 inspections of tobacco retailers, 12,600 warning letters, and 1,160 civil money penalties (Lindblom, 2014). Since FDA's program does not measure program performance, the degree to which these contracts have increased retailer compliance with MLA laws is unknown. Finally, although most data on illegal tobacco sales to underage individuals come from cigarette sales, some evidence suggests that rates of illegal sales of other tobacco products (e.g., smokeless tobacco, snus, and snuff) to underage adolescents are comparable to, if not higher than, those for cigarettes (Choi et al., 2014; Clark et al., 2000; Hanson et al., 2000).

> *Finding 5-5: Although the intensity of retailer enforcement continues to vary widely among the states, federal support has strengthened state and local enforcement practices across the country.*

> *Finding 5-6: According to data collected by the federally supported compliance testing program, the average rate of tobacco sales to minors (i.e., noncompliance in all of the states) in 2013 was 9.6 percent nationally and ranged from 1 percent to more than 20 percent in the individual states.*

Penalties for Violations

Youth access laws vary widely in the range of sanctions prescribed for tobacco retailers who sell tobacco to underage individuals. Violations can be designated as either civil or criminal offenses. Minimum penalties for first offenses range from a warning letter to fines up to $1,000, while maximum penalties for subsequent offenses range from license revocation to fines up to $15,000. As noted above, criminal penalties are prescribed for violations in about two-thirds of the jurisdictions. However, the committee has been unable to identify systematic information about the nature and severity of the sanctions actually imposed in practice.

Enforcing Restrictions Against Internet Sellers

Although the evidence suggests that very few underage persons obtain tobacco from the Internet (Johnston et al., 2014b), Internet tobacco vendors are a new and growing potential source of tobacco for underage individuals, especially among the youngest smokers (Johnston et al., 2014b). Accordingly, there have been some efforts to curtail Internet sales to minors. A survey of Internet cigarette vendors (Ribisl et al., 2002) found that, while the majority of vendors had minimum age warnings on some part of their website, age verification procedures were generally weak, the most common being to ask users to check a box affirming that they were of legal age or to type their birth date. In 2002, California passed legislation requiring Internet cigarette vendors to verify the age of purchasers upon both purchase transaction and delivery (Williams et al., 2006). Unfortunately, an evaluation of this law found zero compliance (Williams et al., 2006). Although it was targeted at reducing illicit sales of untaxed cigarettes and only incidentally affected underage access, in 2005 the Bureau of Alcohol, Tobacco, Firearms and Explosives, in conjunction with several state attorneys general, entered into a voluntary agreement with major credit card and private shipping companies to ban payment transfers and the delivery of cigarettes purchased on the Internet. As with the California legislation, this effort was unsuccessful, and a study of Internet cigarette vendors and sales following these agreements found that despite increases in the proportion of vendors complying with these agreements, the overall number of Internet cigarette vendors increased, leading to a net increase in Internet cigarette sales (Ribisl et al., 2011). FDA's authority under the Family Smoking Prevention and Tobacco Control Act extends to online tobacco retailers, but as of September 2014 FDA's Center for Tobacco Products has issued only four warning letters to Internet vendors found selling to underage customers, and it is unclear to what extent the center will pursue these violations (FDA, 2014c).

Finding 5-7: Limited evidence suggests that youth access restrictions against Internet sellers are weakly enforced, and that tobacco products are relatively easily available to underage individuals.

Enforcing Restrictions Against Non-Licensed Sellers and Social Distributors

An expected effect of restricting the retail sale of tobacco to minors is that underage persons will seek tobacco from alternative sources. These would include both alternative commercial sources (e.g., non-licensed dealers in illegal markets) and so-called social sources, such as proxy sales (i.e., tobacco purchases on behalf of an underage person) and gifts from peers, relatives, and strangers (Fichtenberg and Glantz, 2002; Glantz, 1996; Ling et al., 2002). Indeed, there is some evidence that when access from retail sources is restricted, there is a corresponding increase in recourse to the use of non-retail sources (Cummings et al., 2003; DiFranza and Coleman, 2001; Rigotti et al., 1997; Rimpela and Rainio, 2004). It is to curb these transactions that almost all state youth access laws prohibit non-retail sources of tobacco to underage individuals. These laws restrict other commercial sales, such as illegal suppliers (i.e., street vendors and those selling untaxed cigarettes), as well as noncommercial distribution. Unfortunately, there is little information on the enforcement of laws against sales and distribution by these other sources, much less the effects of such enforcement.

Black Market Sellers

Aside from the occasional study on the purchase of single cigarettes, or "loosies," from street vendors (e.g., Smith et al., 2007), there is little information available on the frequency of youth purchases on the illegal market (i.e., from commercial sellers other than retail stores) or on enforcement activities aiming to curtail sales to underage individuals. At the same time, there is little evidence that underage individuals are obtaining tobacco from the illegal commercial market. A recent report (NRC, 2015) estimates that underage individuals constitute at most 1 percent of the illicit market.

Finding 5-8: Although there is an illicit market for tobacco products diverted from legal channels, there is little evidence that underage persons are obtaining tobacco from the illegal commercial market.

Social Sources

Despite the facts that underage persons obtain most of their tobacco products from "social sources" (see next section) and that most state laws prohibit noncommercial distribution, there is no evidence indicating that youth access restrictions against noncommercial distributors are enforced. As is discussed in Chapter 6, similar prohibitions against the noncommercial distribution of alcohol are sometimes enforced—for example, against parents who facilitate underage drinking and against adults who agree to purchase alcohol for underage persons who recruit them to do so outside liquor stores (the so-called shoulder taps) (IOM and NRC, 2004). However, equivalent restrictions against tobacco transfers appear to be unenforced.

Finding 5-9: There is no evidence indicating that bans on noncommercial distribution of tobacco by friends, proxy purchasers, and other "social sources" are enforced.

Summary

Although the intensity of retailer enforcement continues to vary widely among the states, federal support has strengthened state and local enforcement practices across the country. According to data collected by the federally supported compliance testing program, the national average rate of tobacco sales to minors (i.e., noncompliance) was 9.6 percent in 2013 and ranged from 1 percent to 20 percent in the individual states. Limited evidence suggests that youth access restrictions against Internet sellers are weakly enforced and that tobacco products are relatively easily available to underage individuals who have credit cards. Although there is an illicit market for tobacco products diverted from legal channels, there is little evidence that underage individuals are obtaining tobacco from the illegal commercial market. Although almost all states ban noncommercial distribution to minors, there is no indication in the literature that these restrictions are being enforced, and the committee strongly suspects that these restrictions are essentially unenforced throughout the country. As discussed in Chapter 9, the committee does not expect that situation to change, whether or not the legal purchase age is raised.

SOURCES OF CIGARETTES FOR UNDERAGE INDIVIDUALS

Having described the scope and enforcement of underage access restrictions, this section reviews survey data indicating where underage persons obtain tobacco, whether use of these sources varies by age of the user, whether these sources have changed over time, and whether inferences can be drawn from these data regarding the effects of enforcing MLA restrictions on the availability of tobacco to underage users. As discussed above, underage users obtain tobacco from both commercial and social sources. Table 5-1 lists the primary sources considered in this report from which

TABLE 5-1 Sources of Tobacco for Underage Persons

Source	Definition	Common Indicators
Licensed tobacco retailers	Licensed commercial dealers on legal markets	I bought a pack of cigarettes myself …
Face-to-face	Stores (e.g., gas station, convenience store, supermarket) with tobacco located behind the counter	… in a store where the clerk has to hand you the pack or carton.
Self-service	Stores where one can pick up a pack or carton and bring it to a checkout counter	… in a store where you pick up the pack and bring it to the checkout counter.
Vending machine	Stores and other facilities (e.g., sports arenas, music venues) with tobacco located in vending machines	… from vending machines.
Internet vendors	Online vendors who mail tobacco to an individual's home (or other physical location)	I bought a pack (or carton) of cigarettes myself: … from a website; … over the Internet.
Social sources	Non-licensed non-commercial distributors	
Casual distributors	Relatives, friends, and strangers who give tobacco to underage users	I asked someone to give me a cigarette; Someone offered me a cigarette
Proxy sources	Relatives, friends, and strangers who purchase tobacco for underage users and are paid a small fee (e.g., a few dollars or a portion of tobacco); gray market	I had someone else buy a pack of cigarettes for me; I bought cigarettes from another person
Illicit tobacco dealers/Black market sellers	Non-licensed dealers on illegal markets (e.g., sellers of untaxed cigarettes, $5 man, single or "loosie" cigarettes); black market	

adolescents obtain tobacco. Although new patterns of tobacco use suggest that adolescents and young adults are increasingly using new and other types of tobacco products (Arrazola et al., 2013; Eaton et al., 2012), most empirical data about underage acquisition behaviors are largely restricted to cigarettes. Two national surveys of adolescent tobacco use provide some detailed information on how and where adolescents obtain their cigarettes: the National Youth Tobacco Survey (NYTS) and the Monitoring the Future (MTF) survey.

Table 5-2 provides the responses by current smokers in the 2012 NYTS survey, broken down by age group and gender, to the question: "During the past 30 days, how did you get your own cigarettes?"

Among all high school students, the most commonly reported answers to the question of where they got their tobacco were: Someone offered me a cigarette (40.2 percent); I asked someone to give me a cigarette (32.0 percent); I had someone else buy a pack of cigarettes for me (30.6 percent); and I bought a pack of cigarettes myself (27.9 percent). Less common responses were: I bought cigarettes from another person (8.3 percent); and I took cigarettes from a store or another person (9.9 percent). Sixteen percent said they got cigarettes some other way.

Responses varied considerably by age. The youngest age group (9 to 14 years old) was the most varied in the types of methods used to obtain cigarettes and included 40.1 percent who answered "some other way." The oldest age group (18 and older), who can legally purchase cigarettes, cited fewer methods, with 71.1 percent saying they bought their own cigarettes. Responses did not vary greatly by gender.

Table 5-3 summarizes the responses by current smokers in NYTS, by age group and gender, to the question, "During the past 30 days, where did you buy your own cigarettes?" Among the students who said that they had purchased their own cigarettes, the most commonly cited specific source was "a gas station or convenience store" (45.8 percent of high school students). This was true even among the youngest age group (9 to 14 years old), although relatively few of these students (10.8 percent, as indicated in Table 5-2) actually purchased their own cigarettes. Responses did not vary greatly by gender.

MTF surveys ask two questions about the sources of cigarettes for current smokers: (1) "During the last 30 days, about how many times (if any) have you bought cigarettes?" with a list of possible methods for purchasing offered as potential answers, and (2) "During the last 30 days, about how many times (if any) did you buy cigarettes for your own use?" with a list of possible places for purchasing offered as potential answers. Tables 5-4a and 5-4b provide the responses by grade and by year group. Among 12th graders, the responses are provided separately for those under age 18, who cannot legally purchase cigarettes, versus those 18 and older who

TABLE 5-2 Methods for Obtaining Cigarettes Among High School Students, by Age and Gender, National Youth Tobacco Survey, 2012

	Percent of Smokers					
		Age group			Gender	
	All ages	9–14	15–17	18+	Female	Male
19. During the past 30 days, how did you get your own cigarettes?						
(CHOOSE ALL THAT APPLY)						
a. I did not get cigarettes during the past 30 days	—	—	—	—	—	—
b. I bought a pack of cigarettes myself	27.9	10.8	20.3	71.1	21.7	32.4
c. I had someone else buy a pack of cigarettes for me	30.6	31.4	36.6	9.9	35.3	27.3
d. I asked someone to give me a cigarette	32.0	32.3	34.4	23.8	38.3	27.5
e. Someone offered me a cigarette	40.2	46.9	41.0	30.8	46.8	35.5
f. I bought cigarettes from another person	8.3	14.2	7.6	4.8	8.4	8.2
g. I took cigarettes from a store or another person	9.9	26.2	6.2	5.2	10.8	9.2
h. I got cigarettes some other way	16.0	40.1	12.0	4.8	14.0	17.5

SOURCE: Committee analysis of CDC, 2014.

TABLE 5-3 Sources of Purchased Cigarettes Among High School Students, by Age and Gender, National Youth Tobacco Survey, 2012

	Percent of Smokers					
		Age group			Gender	
	Total	9–14	15–17	18+	Female	Male
20. During the past 30 days, where did you buy your own cigarettes?						
(CHOOSE ALL THAT APPLY)						
a. I did not buy cigarettes during the past 30 days	—	—	—	—	—	—
b. A gas station or convenience store	45.8	28.5	43.1	72.3	45.6	46.0
c. A grocery store	7.2	9.5	4.7	13.4	6.6	7.7
d. A drugstore	7.6	8.5	6.2	11.3	7.6	7.6
e. A vending machine	3.6	8.2	2.2	3.8	2.3	4.6
f. Over the Internet	2.1	4.5	1.0	3.5	1.8	2.3
g. Through the mail	1.1	1.4	0.7	2.3	0.7	1.4
h. Some other place not mentioned here	19.3	39.8	17.0	5.9	16.5	21.2

SOURCE: Committee analysis of CDC, 2014.

TABLE 5-4a Trends in Sources of Cigarettes Among Current Smokers, 8th and 10th Grades, MTF, 1997–2013

	8th Grade				10th Grade			
	1997–2001	2002–2005	2006–2009	2010–2013	1997–2001	2002–2005	2006–2009	2010–2013
During the past 30 days, about how many times (if any) have you bought cigarettes …								
a. By having a friend or relative buy them for you	61.9	60.8	59.6	58.3	66.9	63.3	65.0	61.9
b. On your own from vending machines	16.6	12.4	12.3	10.2	11.0	6.5	5.4	4.5
c. Through the mail	4.0	4.5	6.0	6.5	1.9	2.6	2.2	2.5
d. In a store where you pick up the pack (or carton) and bring it to the checkout counter	16.6	15.3	14.3	12.0	25.9	15.3	13.2	14.8
e. In a store where the clerk has to hand you the pack or carton	20.4	17.1	18.1	14.6	35.9	27.8	23.4	24.2
f. Bought them in some other way	—	52.9	53.3	53.2	—	37.1	38.8	36.6
During the past 30 days, about how many times (if any) did YOU buy cigarettes for your own use …								
a. At a big supermarket	10.0	9.3	9.3	6.9	10.9	8.3	7.4	6.1
b. At a small grocery store	22.2	19.6	16.8	15.2	25.3	20.1	16.2	16.0
c. At a drugstore	13.2	12.4	13.8	13.4	12.1	10.4	11.3	13.1
d. At a convenience store (like a Hop-In or 7-Eleven) or a gas station	36.0	31.0	30.3	24.8	48.1	40.2	38.3	37.5
e. From a website	—	4.4	5.2	6.0	—	2.1	1.9	2.6

NOTE: Entries are percentages of current smokers reporting source of cigarettes.
SOURCE: Committee analysis of Johnston et al., 2014a.

TABLE 5-4b Trends in Sources of Cigarettes Among Current Smokers, 12th Grade, MTF, 1997–2013

	12th Grade, <18				12th Grade, 18+			
	1997–2001	2002–2005	2006–2009	2010–2013	1997–2001	2002–2005	2006–2009	2010–2013
During the past 30 days, about how many times (if any) have you bought cigarettes …								
a. By having a friend or relative buy them for you	59.9	59.7	56.3	55.8	20.4	21.8	17.7	21.4
b. On your own from vending machines	10.3	7.1	3.6	4.1	7.1	5.8	5.8	4.4
c. Through the mail	1.3	1.9	1.5	2.5	0.5	2.4	1.8	1.8
d. In a store where you pick up the pack (or carton) and bring it to the checkout counter	32.5	21.9	17.0	17.1	60.4	35.4	31.9	27.5
e. In a store where the clerk has to hand you the pack or carton	52.7	47.3	42.8	47.4	82.6	80.6	79.8	75.6
f. Bought them in some other way	—	20.2	21.1	25.3	—	13.3	12.7	11.7
During the past 30 days, about how many times (if any) did YOU buy cigarettes for your own use …								
a. At a big supermarket	16.3	14.2	9.7	9.3	35.3	28.8	19.7	17.9
b. At a small grocery store	29.1	26.0	17.7	15.4	46.8	39.6	33.7	27.9
c. At a drugstore	14.8	13.6	12.9	15.5	23.8	22.1	19.1	19.9
d. At a convenience store (like a Hop-In or 7-Eleven) or a gas station	58.7	57.2	49.2	53.3	81.1	77.3	77.6	72.5
e. From a website	—	2.5	2.2	2.8	—	2.2	1.7	2.5

NOTE: Entries are percentages of current smokers reporting source of cigarettes.
SOURCE: Committee analysis of Johnston et al., 2014a.

can. "Having a friend or relative buy them for you" was the most often cited method of access for 12th-grade smokers under the age of 18. For 12th graders who were 18 or older, the most cited method was to purchase cigarettes for themselves. Twelfth graders under the age of 18 were less likely than those 18 or older to say they purchased their own cigarettes, but a considerable proportion did say they purchased their own cigarettes. For example, in 2010–2013, 47.4 percent purchased cigarettes in a store where the clerk had to hand them the pack or carton. With respect to the places where students purchased their own cigarettes, convenience stores and gas stations were clearly the most common, particularly for those 18 and older.

In both NYTS and MTF, a considerable portion of younger adolescents reported obtaining cigarettes in "some other way." These responses likely include adolescents who are given cigarettes by family members but who are reluctant to disclose this and thereby inculpate their relatives (CDC, 2014; Johnston et al., 2014b). Among adolescents who reported buying cigarettes and were asked where (e.g., Table 5-3), the high rates of obtaining cigarettes "from some other place not mentioned here" likely refers to superstores (e.g., Kmart, Target, Walmart), which have proliferated recently and do not fall into the other survey response categories (CDC, 2014).

With respect to trends, Tables 5-4a and 5-4b show that self-service (i.e., purchasing cigarettes in a store where one can pick up a pack or carton and bring it to a checkout counter) has declined considerably since 1997–2001 among all three grade levels. Purchases from vending machines are also down, by about half in all groups. Purchasing cigarettes at a big supermarket or at a small grocery store has declined considerably over time. Purchases from a website have not changed noticeably and remain at very low levels.

In addition to trends observed in survey data, limited empirical evidence suggests that the relative reliance on different types of sources has also changed over time. An analysis of access to cigarettes in the Minnesota Adolescent Community Cohort (Widome et al., 2007) found that between 2000 and 2003 the likelihood of having obtained cigarettes from a commercial source in the past month declined, while the likelihood of having obtained cigarettes from a social source in the past month increased. A New Zealand study (Gendall et al., 2014) of adolescents' main source of tobacco supply between 2006 and 2011, which further differentiated by type of social source (friend, caregiver, or other), found a significant decline in the percentage of adolescents ages 14 to 15 reporting friends as a main source of cigarettes, significant increases in the percent reporting caregivers and others as a main source, and no significant change in the percentage who reported purchasing from a shop. This shift in sources likely reflects the success of youth access restrictions at decreasing adolescents' access to tobacco from commercial retailers. The mechanism by which this may be occurring is elaborated on in Chapter 6.

Unlike the case with cigarettes, adolescents were most likely to purchase other tobacco products for themselves, followed by someone else offering tobacco to adolescents. Table 5-5 shows the responses to the question in the 2012 NYTS: "During the past 30 days, how did you get your own cigars, cigarillos, or little cigars?" Among high school students who reported smoking cigars, cigarillos, or little cigars in the past 30 days, the most commonly reported answers were: I bought them myself (31.4 percent); someone offered it to me (26.6 percent); I had someone else buy them for me (25.5 percent); and I asked someone to give me one (14.4 percent). Very few younger students reported smoking cigars, cigarillos, or little cigars in the past 30 days, so data are not reported by age.

Table 5-6 summarizes the responses by current smokers in the 2012 NYTS, by gender, to the question, "During the past 30 days, where did you buy your own cigars, cigarillos, or little cigars?" As was the case with cigarettes, by far the most commonly cited specific source among all the current smokers was a gas station or convenience store (44.0 percent). No other specific source was cited by more than 6 percent of respondents. Responses did not vary much by gender.

TABLE 5-5 Methods for Obtaining Cigars, Cigarillos, or Little Cigars Among High School Students, by Gender, NYTS, 2012

	Percent of Smokers		
	Total	Female	Male
26. During the past 30 days, how did you get your own cigars, cigarillos, or little cigars? (CHOOSE ALL THAT APPLY)			
a. I did not get cigars, cigarillos, or little cigars during the past 30 days	—	—	—
b. I bought them myself	31.4	25.1	34.7
c. I had someone else buy them for me	25.5	25.6	25.4
d. I asked someone to give me one	14.4	20.2	11.4
e. Someone offered it to me	26.6	33.9	22.7
f. I bought them from another person	4.9	5.8	4.5
g. I took them from a store or another person	4.8	3.5	5.5
h. I got them some other way	8.6	7.5	9.2

SOURCE: Committee analysis of CDC, 2014.

TABLE 5-6 Sources of Purchased Cigars, Cigarillos, or Little Cigars Among High School Students, by Gender, NYTS, 2012

	Percent of Smokers		
	Total	Female	Male
27. During the past 30 days, where did you buy your own cigars, cigarillos, or little cigars? (CHOOSE ALL THAT APPLY)			
a. I did not buy cigars, cigarillos, or little cigars during the past 30 days	—	—	—
b. A gas station or convenience store	44.0	39.5	46.3
c. A grocery store	5.1	4.8	5.3
d. A drugstore	5.6	5.1	5.9
e. A vending machine	1.9	1.2	2.3
f. Over the Internet	2.1	1.7	2.3
g. Through the mail	1.1	1.5	0.9
h. Some other place not listed here	17.3	18.3	16.7

SOURCE: Committee analysis of CDC, 2014.

Table 5-7 shows the responses to the question in the 2012 NYTS: "During the past 30 days, how did you get your own chewing tobacco, snuff, or dip?" Among high school students who reported using chewing tobacco, snuff, or dip in the past 30 days, the most commonly reported answers were: I bought it myself (32.0 percent); someone offered it to me (27.7 percent); I had someone else buy it for me (26.4 percent); and I asked someone to give me some (23.9 percent). Very few younger students reported using chewing tobacco, snuff, or dip in the past 30 days, so the data are not reported by age.

Table 5-8 summarizes the responses by current users of chewing tobacco, snuff, or dip in the 2012 NYTS, by gender, to the question, "During the past 30 days, where did you buy your own chewing tobacco, snuff, or dip?" Among all the current users, and similar to the case for both cigarette and cigar purchases, by far the most commonly cited specific source was a gas station or convenience store (43.4 percent).

TABLE 5-7 Methods for Obtaining Chewing Tobacco, Snuff, or Dip Among High School Students, by Gender, NYTS, 2012

	Percent of Users		
	Total	Female	Male
32. During the past 30 days, how did you get your own chewing tobacco, snuff, or dip? (CHOOSE ALL THAT APPLY)			
a. I did not get chewing tobacco, snuff, or dip during the past 30 days	—	—	—
b. I bought it myself	32.0	23.9	33.5
c. I had someone else buy it for me	26.4	20.9	27.4
d. I asked someone to give me some	23.9	28.0	23.2
e. Someone offered it to me	27.7	30.4	27.2
f. I bought it from another person	8.6	12.2	7.9
g. I took it from a store or another person	7.0	12.5	6.0
h. I got it some other way	11.7	16.5	10.8

SOURCE: Committee analysis of CDC, 2014.

TABLE 5-8 Sources of Purchased Chewing Tobacco, Snuff, or Dip Among High School Students, by Gender, NYTS, 2012

	Percent of Users		
	Total	Female	Male
33. During the past 30 days, where did you buy your own chewing tobacco, snuff, or dip? (CHOOSE ALL THAT APPLY)			
a. I did not buy chewing tobacco, snuff, or dip during the past 30 days	—	—	—
b. A gas station or convenience store	43.4	31.2	45.6
c. A grocery store	7.9	9.9	7.5
d. A drugstore	7.3	14.5	6.0
e. A vending machine	5.5	11.2	4.4
f. Over the Internet	3.4	7.4	2.7
g. Through the mail	3.2	5.1	2.8
h. Some other place not listed here	20.1	33.0	17.6

SOURCE: Committee analysis of CDC, 2014.

Finding 5-10: The proportion of underage youth reporting that they obtained cigarettes from vending machines and from self-service displays has declined substantially since these practices were outlawed.

Finding 5-11: The proportion of underage youth reporting that they obtained cigarettes in a face-to-face retail transaction has declined significantly since 1997, while the proportion of underage users relying primarily on social sources has increased since 1997, probably reflecting increased retailer compliance with age verification requirements and sales prohibitions.

Finding 5-12: Although twelfth graders and 16- to 17-year-olds find it easier than younger teenagers to obtain cigarettes from a commercial retailer, the proportion who are able to do so has steadily declined in all age groups since 1997.

REFERENCES

Arrazola, R. A., S. Dube, and B. A. King. 2013. Tobacco product use among middle and high school students—United States, 2011 and 2012. *Morbidity and Mortality Weekly Report* 62(45):893–897.

CDC (Centers for Disease Control and Prevention). 1993. Minors' access to tobacco—Missouri, 1992, and Texas, 1993. *Morbidity and Mortality Weekly Report* 42(7):125–128.

———. 2014. National Youth Tobacco Survey. CDC, Office on Smoking and Health, National Center for Chronic Disease Prevention and Health Promotion. http://www.cdc.gov/tobacco/data_statistics/surveys/nyts (accessed February 7, 2015).

Choi, K., L. E. Fabian, B. Brock, K. H. Engman, J. Jansen, and J. L. Forster. 2014. Availability of snus and its sale to minors in a large Minnesota city. *Tobacco Control* 23(5):449–451.

Cismoski, J., and M. Sheridan. 1993. Availability of cigarettes to under-age youth in Fond du Lac, Wisconsin. *Wisconsin Medical Journal* 92(11):626–630.

Clark, P. I., S. L. Natanblut, C. L. Schmitt, C. Wolters, and R. Iachan. 2000. Factors associated with tobacco sales to minors: Lessons learned from the FDA compliance checks. *JAMA* 284(6):729–734.

CTP (Center for Tobacco Products). 2014. Compliance and enforcement report. http://www.fda.gov/TobaccoProducts/GuidanceComplianceRegulatoryInformation/ucm396171.htm (accessed January 16, 2015).

Cummings, K. M., A. Hyland, J. Perla, and G. A. Giovino. 2003. Is the prevalence of youth smoking affected by efforts to increase retailer compliance with a minors' access law? *Nicotine & Tobacco Research* 5(4):465–471.

DiFranza, J. R. 1999. Are the federal and state governments complying with the Synar Amendment? *Archives of Pediatrics and Adolescent Medicine* 153(10):1089–1097.

———. 2000. State and federal compliance with the Synar Amendment: Federal fiscal year 1997. *Archives of Pediatrics and Adolescent Medicine* 154(9):936–942.

———. 2005. Best practices for enforcing state laws prohibiting the sale of tobacco to minors. *Journal of Public Health Management and Practice* 11(6):559–565.

DiFranza, J. R., and M. Coleman. 2001. Sources of tobacco for youths in communities with strong enforcement of youth access laws. *Tobacco Control* 10(4):323–328.

DiFranza, J. R., and G. F. Dussault. 2005. The federal initiative to halt the sale of tobacco to children—The Synar Amendment, 1992–2000: Lessons learned. *Tobacco Control* 14(2):93–98.

Eaton, D. K., L. Kann, S. Kinchen, S. L. Shanklin, K. H. Flint, J. Hawkins, W. A. Harris, R. Lowry, T. McManus, D. Chyen, L. Whittle, C. Lim, and H. Wechsler. 2012. Youth risk behavior surveillance—United States, 2011. *Morbidity and Mortality Weekly Report* 61(4):1–162.

Erickson, A. D., S. I. Woodruff, M. B. Wildey, and E. Kenney. 1993. A baseline assessment of cigarette sales to minors in San Diego, California. *Journal of Community Health* 18(4):213–224.

FDA (Food and Drug Administration). 2010. 21 CFR, part 1140. Final rule. *Federal Register* 75(53):13225–13232.

———. 2014a. 21 CFR, parts 1100, 1140, and 1143. Proposed rule. *Federal Register* 79(80): 23142–23207.

———. 2014b. FDA tobacco retail inspection contracts. http://www.fda.gov/TobaccoProducts/ResourcesforYou/ucm228914.htm (accessed October 31, 2014).

———. 2014c. Inspections, compliance, enforcement and criminal investigations. http://www.fda.gov/ICECI/EnforcementActions/WarningLetters/default.htm (accessed October 31, 2014).

Fichtenberg, C. M., and S. A. Glantz. 2002. Youth access interventions do not affect youth smoking. *Pediatrics* 109(6):1088–1092.

Gendall, P., J. Hoek, L. Marsh, R. Edwards, and B. Healey. 2014. Youth tobacco access: Trends and policy implications. *BMJ Open* 4(4):e004631. http://bmjopen.bmj.com/content/4/4/e004631.full (accessed February 8, 2015).

Glantz, S. A. 1996. Preventing tobacco use—The youth access trap. *American Journal of Public Health* 86(2):156–158.

Hanson, K., D. Hatsukami, R. Boyle, and S. Brown. 2000. Minors' access to snuff: Purchase outcomes at corporate owned and independently owned convenience stores. *Addictive Behaviors* 25(2):289–293.

HHS (Department of Health and Human Services). 1996. 21 CFR, parts 801, 803, 804, 807, 820, and 897: Regulations restricting the sale and distribution of cigarettes and smokeless tobacco to protect children and adolescents; final rule. *Federal Register* 61(168): 44396–44618.

IOM (Institute of Medicine). 1994. *Growing up tobacco free: Preventing nicotine addiction in children and youths*. Edited by B. S. Lynch and R. J. Bonnie. Washington, DC: National Academy Press.

———. 2007. *Ending the tobacco problem: A blueprint for the nation*. Edited by R. J. Bonnie. Washington, DC: The National Academies Press.

IOM and NRC (Institute of Medicine and National Research Council). 2004. *Reducing underage drinking: A collective responsibility*. Edited by R. J. Bonnie. Washington, DC: The National Academies Press.

Johnston, L. D., P. M. O'Malley, J. G. Bachman, J. E. Schulenberg, and R. A. Miech. 2014a. *Monitoring the Future: National survey results on drug use 1975–2013. Volume 1: Secondary school students*. Ann Arbor: Institute for Social Research, University of Michigan.

Johnston, L. D., P. M. O'Malley, R. A. Miech, J. G. Bachman, and J. E. Schulenberg. 2014b. *Monitoring the Future: National survey results on drug use: 1975–2013: Overview, key findings on adolescent drug use*. Ann Arbor: Institute for Social Research, University of Michigan.

Kuendig, H. 2011. Enforcement of regional bans on tobacco sales to minors in Switzerland—Example of missed opportunity? *European Journal of Public Health* 21(6):750–752.

Lindblom, E. 2014. The health implications of raising the minimum age for purchasing tobacco products. Presentation at Committee on the Health Implications of Raising the Minimum Age for Purchasing Tobacco Products, February 4, 2014. Washington, DC. http://www.iom.edu/Activities/PublicHealth/TobaccoMinimumAge/2014-FEB-04.aspx (accessed February 25, 2015).

Ling, P. M., A. Landman, and S. A. Glantz. 2002. It is time to abandon youth access tobacco programmes. *Tobacco Control* 11(1):3–6.

NAAG (National Association of Attorneys General). 1998. Master settlement agreement. http://publichealthlawcenter.org/sites/default/files/resources/master-settlement-agreement.pdf (accessed September 5, 2014).

NRC (National Research Council). 2015. *Understanding the U.S. illicit tobacco market: Characteristics, policy context, and lessons from international experiences*. Washington, DC: The National Academies Press.

Ribisl, K. M., A. E. Kim, and R. S. Williams. 2002. Are the sales practices of Internet cigarette vendors good enough to prevent sales to minors? *American Journal of Public Health* 92(6):940–941.

Ribisl, K. M., R. S. Williams, Z. Gizlice, and A. H. Herring. 2011. Effectiveness of state and federal government agreements with major credit card and shipping companies to block illegal Internet cigarette sales. *PLoS ONE* 6(2):e16754.

Rigotti, N. A., J. R. DiFranza, Y. Chang, T. Tisdale, B. Kemp, and D. E. Singer. 1997. The effect of enforcing tobacco-sales laws on adolescents' access to tobacco and smoking behavior. *New England Journal of Medicine* 337(15):1044–1051.

Rimpela, A. H., and S. U. Rainio. 2004. The effectiveness of tobacco sales ban to minors: The case of Finland. *Tobacco Control* 13(2):167–174.

SAMHSA (Substance Abuse and Mental Health Services Administration). 1996. 45 CFR, part 96. Final rule. *Federal Register* 61(13):1492–1509.

———. 2014. *FFY 2013 annual Synar reports: Tobacco sales to youth*. http://www.samhsa.gov/sites/default/files/synar-annual-report-2013.pdf (accessed October 30, 2014).

Schensky, A. E., S. S. Smith, D. L. Icenogle, and M. C. Fiore. 1996. Youth tobacco sale compliance checks: Impact on vendor practices and community policy. *Wisconsin Medical Journal* 95(11):775–778.

Smith, K. C., F. Stillman, L. Bone, N. Yancey, E. Price, P. Belin, and E. E. Kromm. 2007. Buying and selling "loosies" in Baltimore: The informal exchange of cigarettes in the community context. *Journal of Urban Health* 84(4):494–507.

Verdonk-Kleinjan, W. M. I., R. A. Knibbe, B. Bieleman, H. N. De Groot, and H. De Vries. 2008. The tobacco sales ban and tobacco purchases by adolescents: A general population study in the Netherlands. *European Journal of Public Health* 18(5):498–503.

Widome, R., J. L. Forster, P. J. Hannan, and C. L. Perry. 2007. Longitudinal patterns of youth access to cigarettes and smoking progression: Minnesota Adolescent Community Cohort (MACC) study (2000–2003). *Preventive Medicine* 45(6):442–446.

Williams, R. S., K. M. Ribisl, and E. C. Feighery. 2006. Internet cigarette vendors' lack of compliance with a California state law designed to prevent tobacco sales to minors. *Archives of Pediatrics and Adolescent Medicine* 160(9):988–989.

6

Evidence on the Effects of Youth Access Restrictions

Ultimately, the salient policy question concerning the minimum age of legal access to tobacco products (MLA) is whether and to what extent raising the MLA would reduce underage tobacco use. Although several U.S. localities have raised the MLA to 19 and 21 years, most of these actions have been done only very recently, and to date none has been systematically evaluated.[1] Furthermore, there have been only a handful of natural experiments in which the MLA for tobacco has been raised to 16 or 18, and they have taken place in other countries. Indeed, most of the relevant literature pertains not to raising the MLA but rather to enforcing an existing MLA more stringently. Therefore, conclusions about raising the MLA to ages higher than 18 must be extrapolated from review of other evidence on MLA laws and their enforcement as well as from analogous policy interventions.

To address the question whether and to what extent raising the MLA would reduce underage tobacco use, this chapter first reviews the limited international studies investigating the effect of raising the MLA for tobacco and then reviews evidence relating to the effects of raising the minimum legal drinking age for alcohol as an analogous policy intervention in a parallel domain. The remainder of the chapter reviews the body of literature

[1] Although Needham, Massachusetts, the first jurisdiction in the United States to raise the MLA to 21, has been cited as having seen significant declines in tobacco use and tobacco-related disease, there are no published data on these outcomes. In addition, the little available data that exist (EDC, 2010a,b; NPHD, 2008, 2012) have no baseline measurements and are confounded by the presence of other tobacco control measures that occurred in the town and throughout the state of Massachusetts at the same time the MLA was increased.

investigating the effects of enforcing current youth access restrictions in the United States. Although these studies are beset by many challenges and limitations, they enabled the committee to reach some general conclusions about the nature and direction of the effects of enacting and enforcing a tobacco MLA, even though they do not provide a basis for estimating the precise magnitude of such effects. As an aid to interpreting this body of research, the committee developed a logic model identifying the behavioral mechanisms through which an MLA policy and its enforcement against commercial retailers would be expected to affect underage tobacco use. The committee believes that this body of scientific literature provides a reasonable predicate for policy making in the absence of direct evidence regarding the effectiveness of raising the MLA. It is used in Chapter 7 to inform the committee's judgment about the probable effects of raising the MLA on the initiation of tobacco use by underage youth.

THE IMPACT OF ENACTING OR RAISING THE MINIMUM LEGAL AGE TO PURCHASE TOBACCO PRODUCTS

Only a small number of studies have examined the effects of enacting or raising an MLA on underage tobacco use. All of these studies have come from international experience: one from Finland (Rimpela and Rainio, 2004) and two from the United Kingdom (Fidler and West, 2010; Millett et al., 2011).[2] All of the studies that investigated the effect of the policy on tobacco use reported decreases in underage smoking prevalence.

Rimpela and Rainio (2004) examined the effect in Finland of enacting an MLA of 16 in 1977 and increasing it to 18 in 1995. Adolescent tobacco outcomes were assessed using a biennial, nationally representative postal survey of adolescents (ages 12, 14, 16, and 18) for 1977–2003 as well as an annual postal survey of eighth and ninth graders (ages 14–16) for 1996–2003. Following implementation of the original MLA legislation in 1977, there was a significant—but small and short-term—decrease both in tobacco purchases from commercial sources and in tobacco use. After the MLA increased to 18 in 1995, there was no immediate effect on tobacco use. However, after a 2000 revision of the MLA policy requiring tobacco retailers to develop and implement an enforcement plan to prevent sales to underage persons, experimental smoking and later daily smoking decreased significantly among adolescents ages 14 and 16 (i.e.,

[2] Another small qualitative study (Borland and Amos, 2009) examined attitudes about raising the MLA from 16 to 18 in Scotland among 16- to 17-year-old regular smokers who had dropped out of high school and were attending a work skills program. However, given the small sample size and sample characteristics, these findings are likely not generalizable to larger or different populations. This study also provides no findings on the effect of raising the MLA on either reducing sales to adolescents or reducing underage tobacco use.

those targeted by the policy). Only experimental smoking decreased among 12-year-old adolescents, but the sample was too small for the daily smoking category. There was no change in either experimental or daily smoking observed among those ages 18 and older (i.e., those not targeted by the policy). In addition, Rimpela and Rainio (2004) found that purchases from commercial sources decreased, while obtaining tobacco from social sources (i.e., purchasing or being given tobacco from relatives, friends, or strangers) increased. Consistent with that finding, the frequency with which 18-year-olds, of legal age, also reported purchasing tobacco for friends was greater in 1999 than it had been in the 1970s. There were also changes in perceived access to tobacco: The proportion of adolescents reporting that it was rather difficult or very difficult to purchase tobacco was higher after the MLA increase, but the proportion of students reporting that it was very easy or fairly easy to purchase tobacco from commercial sources nevertheless remained high (72 percent in 2002–2003). In sum, these findings suggest that, among adolescents, raising the MLA decreased the amount of tobacco available from commercial sources, increased difficulty of obtaining tobacco, and reduced tobacco use despite adolescents having continued access to social sources.

Fidler and West (2010) assessed the effects on smoking prevalence of an increase in MLA from 16 to 18 in 2007 in England and Wales. Smoking outcomes were assessed using data from monthly cross-sectional household surveys of a representative sample of adults ages 16 and older. Following the 2007 increase in the MLA, smoking prevalence decreased significantly among all ages. This decline occurred against the background of a larger societal trend of an overall decrease in smoking prevalence, but the greatest percentage decrease during this period was seen among those of ages 16–17 (a 7.1 percent decrease) compared to those 18 and older (2.4 percent decrease), suggesting that raising the MLA did indeed decrease smoking prevalence beyond secular trends. Moreover, smoking prevalence was significantly higher among those 18 and over, and this difference in prevalence by age was significantly greater after the MLA increase than it had been before, suggesting that the MLA increase was successful in at least delaying initiation.

Millett and colleagues (2011) examined the effects of the same 2007 legislation that Fidler and West studied, but they looked at it in England, Scotland, and Wales, among younger ages (11–15) and by socioeconomic status (SES). Smoking outcomes were assessed using data from a national school-based survey of students in grades 7 to 11 from 2003 to 2008, excluding 2007, the year of the MLA increase. The effect of the policy on socioeconomic smoking disparities was assessed by comparing students who were eligible for free school meals (a proxy measure for low SES because eligibility for free school meals is assessed using parental employment and income) with those not eligible. The study found that the MLA increase was associated with a significant reduction in regular smoking among all adolescents, with no differences found between those eligible and ineligible for free school meals. The study also assessed the effects of raising the MLA on perceived access to tobacco from retailers. After the MLA increase, the proportion of students who smoked regularly and perceived that purchasing cigarettes from a shop was difficult did not increase among those eligible for free school meals, but it did increase significantly among those not eligible. At the same time, the percentage of students reporting that purchasing cigarettes from a shop was easy did not change from before the MLA increase to afterwards. These findings suggest that increasing the MLA decreased tobacco use overall and that the decrease was neutral with respect to SES.

LESSONS FROM ALCOHOL

Given the paucity of directly relevant data from prior experience with raising the minimum age for tobacco, the committee recognized the opportunity to look at similar domains, most obviously alcohol, to see what lessons might be learned. The United States had direct experience with raising the minimum legal drinking age (MLDA) for alcohol from roughly 18 (with some variation across states) to a national standard of 21 years of age, and that experience came recently enough that the country has not changed dramatically in the interim but long enough ago for there to be an extensive literature evaluating its consequences. Furthermore, different states implemented the change at different times, resulting in a stronger basis for causal inference than if all had acted simultaneously.

Tobacco is, of course, different from alcohol in myriad ways. Tobacco products are psychoactive, but they are not intoxicants. Alcohol has been embedded within human culture for millennia, whereas modern, mass-produced tobacco products (namely, cigarettes) are, comparatively speaking, a relatively recent phenomenon. And, of course, the mechanism of consumption, the neural pathways triggered, the patterns of use and cessation, and various other specific details differ in a variety of ways. So one could hardly observe a point estimate of the reduction in alcohol use following the raising of the MLDA for alcohol and imagine that same number would necessarily be a best estimate for the corresponding reduction one might expect from increasing the MLA for tobacco products.

Nevertheless, there are obvious similarities between the two products, their legal status, and their industries' practices. Both are dependence-inducing substances that are legal for adults but subject to legal and social constraints on underage use. Both are relatively inexpensive and widely used by both adults and underage users. Both cause very large numbers of premature deaths. Both are marketed aggressively by industries that have, at least in some product classes, a high degree of market concentration. (Beer and cigarettes have higher degrees of market concentration than do wine or cigars.[3]) And, as is being considered with tobacco, the MLDA for alcohol was increased to 21—not to other ages and, particularly, not to higher ages.

In brief, the experience with raising the MLDA for alcohol is highly suggestive with respect to the prospects that raising the MLA for tobacco will appreciably reduce smoking rates. Kypri et al. (2006, p. 126) go so far as to say, "No traffic safety policy, with the possible exception of motorcycle safety helmet laws, has more evidence for its effectiveness than do the minimum legal drinking age laws."

Of course, underage drinking still occurs, and it seems clear that if the MLA for tobacco is increased, there will still be some tobacco use by those under the legal age. Indeed, it would be unreasonable to expect that raising the MLA could completely eliminate all underage use. However, if the question is simply whether raising the MLA will noticeably reduce the use and use-related harms of tobacco among youth, then the academic literature evaluating the alcohol experience indicates that there will indeed be substantial benefits (e.g., Dejong and Blanchette, 2014; McCartt et al., 2010; Wagenaar and Toomey, 2002).

It is worth briefly mentioning the historical context. Following the repeal of national alcohol prohibition in 1933, MLDAs were set by the states, typically at 21. In the early 1970s, 29 states lowered their MLDAs to 18, 19, or 20. In response to increasing highway traffic fatalities, some states reversed course, and then in 1984 Congress passed the National Minimum Drinking Age Act (NMDAA). The NMDAA does not prescribe an MLDA of 21. Rather it encourages states to raise their MLDA to 21 by withholding a percentage of federal highway dollars if they fail to do so. By 1988 all states and the District of Columbia had an MLDA of 21.

By some measures, alcohol MLDAs are enforced fairly aggressively. For example, it is common for mere possession of alcohol to be an offense (known as a "minor in possession"). The severity of sanction for such offenses varies by state but can include fines and the loss of one's driver's license. Likewise, social host ordinances can lead to severe penalties for other individuals (not just businesses) who provide alcohol to underage drinkers. On the other hand, in many states parents are allowed to provide alcohol to their children. So comparisons between the intensity of the enforcement of alcohol MLDAs and the intensity of enforcement of either

[3] The Centers for Disease Control and Prevention reports that the market share of the dominant cigar firms is mostly below 20 percent even for specific types of cigars, and different firms dominate those different segments, whereas three companies control nearly 85 percent of the cigarette market (CDC, 2014a).

current or potential future tobacco MLAs are not straightforward, but on the whole, the severity of sanctions for the alcohol equivalent of purchase–use–possession (PUP) laws for tobacco may be greater than what might be contemplated under at least some scenarios involving raising the MLA for tobacco products.

The literature evaluating the effects of changing the MLDA for alcohol is large. DeJong and Blanchette (2014), McCartt et al. (2010), and Wagenaar and Toomey (2002) offer useful reviews. The trends that are observed in aggregate descriptive statistics are consistent with the idea that raising the MLDA has an effect on alcohol use. Specifically, the rates of drinking and binge drinking among those under 21 have been in sustained long-term decline since the MLA was raised, the death rates of 18- to 20-year-olds in nighttime driving accidents have fallen, and the rates of problem alcohol use are lower in the United States than they are in Europe, where drinking ages are lower. However, such correlations could be coincidental. The more persuasive comparisons involve looking at neighboring birth cohorts who reached an MLDA just before versus after the MLDA changed and looking at patterns of use by people who are just a little younger versus just a little older than a given MLDA (Carpenter and Dobkin, 2011). For example, the rates of binge drinking are appreciably higher for 21-year-olds than for 20-year-olds (SAMHSA, 2009).

A number of these studies have found that raising the MLDA for alcohol reduced consumption and consumption-related harms, with the estimate of nearly 1,000 premature deaths prevented per year being a typical number. Other studies have found no statistically significant effect (perhaps from a lack of statistical power), and a few outliers have found that consumption increased. For example, Wagenaar and Toomey (2002) reported that of 33 high-quality empirical analyses for which consumption was the outcome measure, 11 found that raising the MLDA decreased consumption, and only one found the opposite. The proportion of studies finding a favorable effect on traffic crashes was even greater (DeJong and Blanchette, 2014). An illustrative study, conducted by Shults et al. (2001), found that raising the MLDA reduced fatal and nonfatal crashes by 16 percent. Other studies identified less obvious outcomes. For example, Birckmayer and Hemenway (1999) estimated that raising the MLDA reduces teen suicide and, conversely, that lowering it from 21 back to 18 could lead to approximately 125 additional suicides per year among 18- to 20-year-olds.

DeJong and Blanchette's (2014) review includes international comparisons. Notably, New Zealand reduced its MLDA from 20 to 18 in 1999, and Huckle and Parker (2014) and Kypri et al. (2006) reported that this led to significantly more alcohol-related crashes among 15- to 19-year-olds. Conover and Scrimgeour (2013) found similar effects on alcohol-related hospitalizations among those newly eligible to purchase alcohol. International studies on the direct effect of MLDA on alcohol consumption come to comparable conclusions. The 2004 report by the National Academies on underage drinking (IOM and NRC, 2004) found that lower drinking ages in European countries were associated with higher rates of drinking, problem drinking, and drinking by underage individuals, despite common conceptions that underage users drink less in Europe.

The experience with alcohol also suggests that raising the MLDA may even affect patterns of consumption for people who are *over* the new MLDA (Norberg et al., 2009). For example, Plunk et al. (2013) argue that the ability to purchase alcohol before age 21 increases rates of binge drinking later in life, although the overall drinking frequency is not changed because the increase in binge drinking is accompanied by a reduction in non-heavy drinking. O'Malley and Wagenaar (1991), as reported in DeJong and Blanchette (2014), found that high school seniors and recent high school graduates drank less when the MLDA was 21 and that they also drank less throughout their early 20s, after they had reached the legal age.

Summary

Although alcohol and tobacco have considerable differences, they are similar products in many respects. As such, U.S. and international experience with enacting and raising the minimum legal drinking age may provide insights into the potential effects of raising the minimum age of legal access to tobacco products. In particular, experience with alcohol suggests that raising the MLDA has reduced consumption behaviors among adolescents and adults as well as reducing alcohol-related adverse events.

> *Finding 6-1: Evidence from U.S. experience with alcohol has shown that raising the minimum legal drinking age for alcohol, coupled with rigorous enforcement and penalties for violations, has been associated with lowered rates of alcohol consumption among adolescents and adults as well as with reduced rates of alcohol-related adverse events (e.g., traffic crashes and hospitalizations).*

A LOGIC MODEL FOR PREDICTING THE EFFECTS OF AN MLA

In light of the dearth of literature on the question of interest—whether raising the MLA for tobacco would reduce underage use—and acknowledging the indirect analogy of the U.S. experience with alcohol, the committee next focused on the scientific literature bearing on the effects of enforcing the existing MLA and other retailer interventions on underage access to and use of tobacco. In order to organize and interpret this literature, the committee developed a logic model to examine whether and to what extent laws restricting the commercial retail availability of tobacco products to underage persons, and MLA laws in particular, have the potential to reduce underage tobacco use. This logic model (see Figure 6-1), which draws on bodies of research on legal deterrence and behavioral economics, details the behavioral mechanisms by which an MLA policy is expected to reduce underage tobacco use. According to the most simplified form of the model, an MLA policy is expected to affect the behavior of potential users and distributors by declaring social norms and by deterring illegal behavior. Deterrence depends on an expectation among sellers that the law will be enforced. Enforcement is expected to increase retailer compliance with the MLA law. High levels of retailer compliance are expected to reduce retail tobacco availability to underage individuals, which in turn is expected to reduce underage tobacco use. The logic model is described in more detail below.

Declarative Effects and Deterrent Effects of Legal Restrictions

An MLA law can affect the behavior of tobacco retailers (and other sellers) in two ways. First, it may have a "declarative" effect on both retailers and potential underage users because they are disposed to comply with legal norms or because enactment of the law affects their beliefs and attitudes toward tobacco use by minors (Bonnie, 1982; IOM and NRC, 2004). Second, the law and its anticipated enforcement may deter potential violators from using or selling tobacco by communicating a credible threat of detection and punishment for violations. The variables that are expected to affect the likelihood of a violation by the targeted population are the probability of detection, the severity of the expected punishment (a function of the prescribed punishment and the probability of its imposition), and the swiftness with which the penalty is imposed. "General deterrence" refers to the effect of the perceived threat of enforcement and punishment on the target population of potential sellers or users. "Specific deterrence" refers to the effect of the imposition of sanctions on detected violators. Figure 6-2 shows a somewhat expanded view of the logic model detailing these enforcement mechanisms.

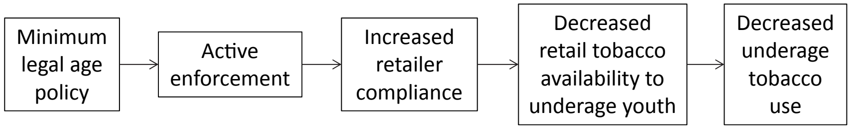


FIGURE 6-1 Simplified logic model of the effects of prescribing and enforcing a minimum age of legal access to tobacco products.

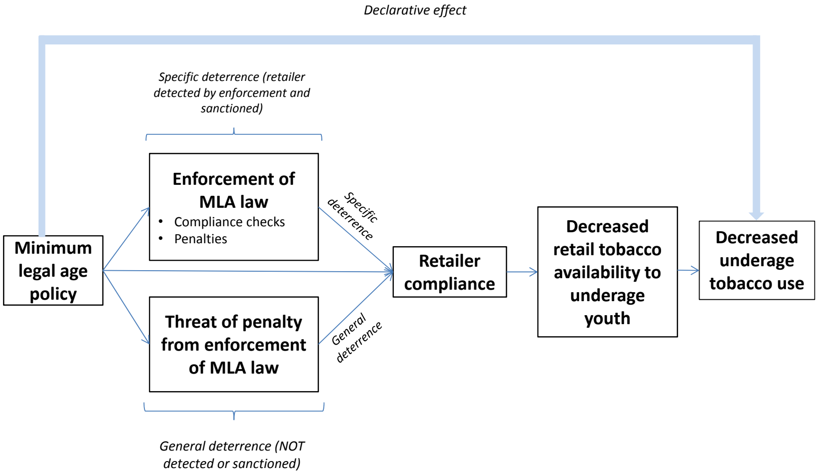


FIGURE 6-2 Expanded view of the logic model detailing enforcement mechanisms.

Deterrence will not occur unless potential violators perceive a credible threat of detection and punishment (hereafter, "enforcement"). Accordingly, any MLA law will need to be actively enforced using random compliance checks to maintain the retailers' perception that there is a significant risk that an illegal sale will be detected. The compliance checks are expected to have a "specific" deterrent effect on tobacco retailers caught selling to underage individuals, increasing the likelihood of future compliance by these retailers. In addition, an awareness of the possibility of such checks is expected to deter violations by the entire population of retailers who believe themselves to be at risk of compliance checks ("general deterrence"). If MLA laws achieve high rates of compliance (through the combined effect of declaring the legal norm and enforcing it), tobacco availability to underage consumers from commercial retail sources will likely be reduced. If these effects were complete, underage users would not be able to obtain tobacco from retailers. However, the more likely scenario is that enforcement increases the number of compliant retailers (or clerks) and increases the "search-time" costs incurred by underage users who are looking for a noncompliant retailer (or clerk).

Reducing Availability by Increasing Search-Time Costs

To fully understand the effects of the MLA enforcement on search-time costs, it is first necessary to consider that commercial retailers are only one among a range of sources from which underage users obtain tobacco. As described in Chapter 5, other sources include commercial sellers such as Internet vendors and non-licensed retail sellers (i.e., black market trafficking of untaxed tobacco and single/unpackaged/loose cigarettes) and also social sources. "Social sources" are primarily relatives and peers who give tobacco to underage users or else proxy purchasers (including strangers as well as relatives and peers) who purchase cigarettes on behalf of underage users and are paid a small fee (e.g., a few dollars or a portion of tobacco) for their service. If the law applies only to retailers or is not enforced against noncommercial providers (i.e., social sources), it is likely that any decrease in retail tobacco availability will result in a corresponding increase in access from social sources, although this shift is likely to be incomplete. Nevertheless, if overall tobacco supply to underage users is successfully reduced, it is likely that the overall cost of tobacco will increase to the underage users who purchase tobacco outside the retail market. Together with the increase in "search-time" costs, this increase in monetary cost will make tobacco products more expensive and will likely reduce the demand for the products by underage users, thereby reducing consumption.

One of the most basic and widely documented empirical regularities in economics is the so-called law of demand, which is typically stated as, "All else being equal, when the price of a good goes up, consumers demand less of it." There is ample literature documenting that the law of demand applies to tobacco products (Chaloupka and Warner, 2000), including for adolescents in the United States (Carpenter and Cook, 2008; Ross and Chaloupka, 2003) and abroad (e.g., Kostova et al., 2011; Nikaj and Chaloupka, 2014; Sen and Wirjanto, 2010). Indeed, there is considerable, although not unanimous, evidence that adolescents are more price responsive than are older smokers (e.g., Ding, 2003; Franz, 2008; Harris and Chan, 1999).

Although the law of demand is often stated informally in terms of "price," which would connote the monetary price paid by the customer to the seller, the proper interpretation is broader. The underlying behavioral model is that whenever the total opportunity cost of obtaining the good goes up, then the quantity demanded will go down. This total cost includes the monetary price, of course, but it also includes other costs such as the time and inconvenience of locating the seller and consummating the transaction, which is sometimes referred to as search-time costs.

The modern American economy often offers low search-time costs; the very term "convenience store" derives precisely from the idea that those stores enable customers to obtain their goods quickly and easily. However, search-time costs can dramatically affect market outcomes both in general economic models (e.g., Stahl, 1989) and, specifically, for drugs whose purchase is banned. Indeed, these costs can be important even for illegal drugs, such as heroin, whose monetary price is so high that one might expect it to dominate other considerations because sellers have difficulty advertising directly to banned customers, and parties to a transaction seek to avoid being detected by the authorities (Moore, 1973; Rocheleau and Boyum, 1994).

Penalties for Users

Raising the MLA can be understood as an attempt to raise these non-monetary costs for individuals who were not underage under the previous policy but are underage under the new policy and who are trying to obtain tobacco.[4] The costs are not infinite, so purchase and acquisition by those under the legal age will not go to zero. But it is more convenient simply to walk into a store and purchase what one wants than it is to enlist the assistance of a proxy purchaser, and the counterfeit brands available from the Internet and black markets are not always equivalent in the qualities that smokers value.

Similarly, at least in theory, the demand for illegal drugs could be tempered by increasing the risk that users will be apprehended and punished for possession. There is some debate as to how effective that particular deterrent is, however. Specifically, while some find that decriminalization affects use (e.g., Model, 1993), others have argued that decriminalizing prohibited drugs will not meaningfully increase demand (Bonnie, 1982; Hughes and Stevens, 2010; MacCoun and Reuter, 2001), and still others argue that the term "decriminalization" covers such a wide range of actions that generalizations concerning its effects are suspect (Pacula et al., 2005). Presumably, however large the deterrent effect for illegal drugs, it could well be smaller for underage tobacco use because the sanctions imposed under purchase–use–possession laws tend to be much less severe than the maximum sentences permitted for possession of illegal drugs (see IOM, 2007). Nevertheless, to the extent that PUP provisions exist and are enforced, raising the MLA could also be seen as increasing that aspect of the total cost of underage smokers acquiring cigarettes.

Measures of Availability

To assess the overall effect of MLA laws and their enforcement on use, tobacco availability as a mediating variable can be assessed in two ways. First, it can be assessed as the "observed availability" measured as the num-

[4] In certain circumstances they may also increase the monetary cost (e.g., if only a subset of retail stores are willing to sell to underage customers, and that restriction makes it harder for youth to shop for the best prices, or when a youth enlists a proxy purchaser and the proxy purchase charges a fee for that service).

ber of noncompliant retailers (or rates of violations) within a specified area. Second, it can be measured as "perceived availability," a subjective measure of how easy or difficult it is for underage users to get cigarettes, which is also a reflection of an underage individual's willingness to seek out tobacco products and take up smoking. Presumably, "perceived availability" bears some relationship to the perceived difficulty of accessing tobacco from retail sources, which might be a function of the observed availability; whatever its relationship with observed availability, however, reducing the perceived availability itself may also serve as a mechanism that decreases demand, deterring underage users from purchasing and using tobacco. This includes deterring underage individuals from taking up or escalating smoking as well as increasing likelihood of quitting. In addition to this pathway through perceived availability, there is also likely to be a direct effect of the MLA policy on underage tobacco use through the declarative effect of enacting and enforcing the higher MLA as well as through any effects of enforcement against users. Because social sources are another principal means of accessing tobacco, the impact of restricting retail access on the use of social sources and the corresponding implications for the success of an MLA policy also must be considered. Figure 6-3 illustrates the complete logic model, including pathways through these various measures of availability.

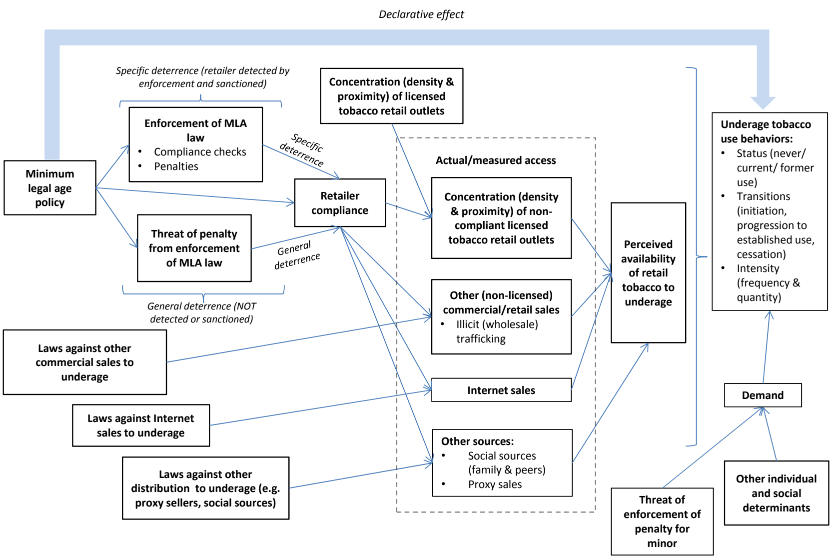


FIGURE 6-3 Complete logic model of the effects of prescribing and enforcing a minimum age of legal access to tobacco products.

The Tobacco Control Context

Youth access restrictions are implemented in the context of other tobacco control programs. However, community-level natural experiments and controlled experiments may not take into account the potential contributions of existing tobacco control programs that may enhance or mitigate the potential effects of increasing the MLA. Thus, this chapter also reviews literature on the effects of an MLA policy and its enforcement in the context of other tobacco control programs aimed at preventing or reducing tobacco use among adolescents and young adults and across the population at large.

EFFECTS OF RETAILER INTERVENTIONS ON ACCESS TO AND USE OF TOBACCO

Within the framework of the logic model, this section reviews the scientific literature bearing on the effects of retailer interventions on underage access to and use of tobacco. The first subsection summarizes studies that assess the impact of enforcement activities on retailer compliance. Even if the number of noncompliant stores (or unsuccessful purchase attempts) is reduced, the question remains whether increased retailer compliance has a discernible impact on the availability of tobacco to underage users and, if so, whether it reduces underage use. The next two subsections summarize studies addressing these two questions. The section closes with methodological observations.

Effect of Retail Enforcement and Other Interventions on Retailer Compliance

In the previous chapter (Chapter 5), the committee reviewed the current status of federal, state, and local youth tobacco access laws in the United States as well as their enforcement under the Synar and the Food and Drug Administration (FDA) inspection contract programs. As discussed, the rates of illegal sales to minors under the Synar program have decreased significantly over the past 20 years. However, these data are challenging to assess because of a number of factors. For one, these data are derived from compliance protocols that can vary significantly by locality in terms of the frequency of inspections, the number of reinspections of a particular retailer, the characteristics of the sales clerk and underage decoy, and the time of day of purchase, among other factors. In addition, a number of other factors aside from inspection protocol, such as the total number of inspections in a region, whether neighboring retailers have been inspected, and whether a retailer has previously been cited for violations, may also influence compliance rates. Variations in each of these factors may influence a state's or locality's compliance rate. As such, it is difficult to compare data collected under different enforcement programs and data collected over time as well as to assess the impact of such compliance data on underage tobacco use. It is also difficult to compare data across geographic regions of both the same and different scales (e.g., across states or from the local to state or state to national levels). These variations are equally a factor in observational studies on the effects of youth access restrictions.

Notwithstanding these limitations, it is possible to draw out several general findings from this body of research regarding the nature and direction of the effects of enforcing youth access restrictions against retailers, if not their magnitude. It is clear, first of all, that restrictions on youth tobacco access are much more seriously and consistently enforced and complied with now than they were two decades ago, when they were first implemented. Early studies (CDC, 1993; Cismoski and Sheridan, 1993; Erickson et al., 1993) examining the effects of enacting an MLA law reported high rates of sales, suggesting that tobacco retailers will not comply with MLA laws absent of active enforcement. Studies of experiences in other countries (Kuendig, 2011; Sanson-Fisher et al., 1992; Sundh and Hagquist, 2004, 2006, 2007) report similar findings. However, both the sales rates reported to Synar and the limited scientific evidence suggest that *active enforcement of youth access restrictions using compliance checks paired with penalties for violations are effective at increasing retailer compliance* with youth access laws. However, evidence bearing on the relationship between the intensity of enforcement and the rate of compliance is inconsistent.

General Deterrence

Most studies evaluating enforcement programs investigate the effect of these programs on the rates of illegal sales by retailers to underage buyers. These studies support the existence of general deterrence stemming from the threat of compliance checks. The studies are typically conducted at the town level and evaluate sales rates before and after the implementation of an active enforcement program. Most of these studies reported some reduction in sales rates following the implementation of enforcement activities, but the reported declines in underage purchases varied, ranging from less than 10 percent to as high as 68 percent (e.g., DiFranza et al., 2001a; Jason et al., 1991, 1996, 1999a; Junck et al., 1997; Ma et al., 2001; Mawkes et al., 1997; Pokorny et al., 2008; Rigotti et al., 1997; Tangirala et al., 2006). In addition to looking at the rates of illegal sales, some studies (e.g., CDC, 1996; Cummings et al., 1998; DiFranza et al., 2001a,b; Schofield et al., 1997) examined the effect of enforcement activities on other measures of retailer compliance (e.g., more frequent and consistent age verification using photographic identification, displaying requisite warning signs, and adherence to other point-of-sale marketing and advertising restrictions) and typically reported that enforcement increased compliance with these other requirements as well. A small number of studies (e.g., Bagott et al., 1998; Cummings et al., 1998; Gemson et al., 1998) compared compliance rates in jurisdictions with active enforcement to those without, and findings were mixed.

Specific Deterrence

Several studies examined the effect of multiple or repeated inspections on the same vendor. Each of these found that prior checks increased future compliance, typically measured by reduced likelihood of future illegal sales (Jason et al., 1996; Pearson et al., 2007; Schensky et al., 1996), while one found increased age verification but no effect on sales (Cummings et al., 1998). Taken together, these studies suggest that active enforcement using compliance inspections may have the specific deterrent effect of increasing compliance among retailers who have been detected and sanctioned for illegally selling tobacco to minors as well as a general deterrent effect of increasing retailers' perceived threat of enforcement.

Retailer Education

Targeted retailer education has also been employed as a strategy to increase retailer compliance with the MLA laws, either in lieu of or in addition to active enforcement. Such education may include direct mailings with information about the MLA law and potential penalties for violations, personal visits delivering education kits and other resources, phone calls presenting information, and letters from senior government officials (e.g., the mayor or police chief). Studies of retailer education are mixed. Many (e.g., Abernathy, 1994; Altman et al., 1989, 1991, 1999; Dovell et al., 1998; Feighery et al., 1991; Gemson et al., 1998; Keay et al., 1993; Naidoo and Platts, 1985; Wildey et al., 1995; Woodruff et al., 1993) have found education effective at increasing compliance as measured by decreases in the rates of illegal sales, although some (e.g., Forster et al., 1992; McDermott et al., 1998; Schofield et al., 1997) have found no effect. Other studies have found that education increases compliance with other requirements—for instance, age verification (Krevor et al., 2011) and warning signs (Skretny et al., 1990). One study that specifically investigated an education intervention alone compared with the education intervention combined with enforcement (Feighery et al., 1991) observed a slight reduction in sales following the education-only intervention and a much larger reduction when enforcement was added. As such, retailer education programs appear to be more effective when reinforced by enforcement activities than when implemented alone.

Comprehensive Youth Sales Interventions

Comprehensive youth sales interventions comprise the active enforcement of MLA laws, retailer and community education programs, and mass media campaigns. For example, Forster and colleagues (1998) conducted the Tobacco Policy Options for Prevention study, a controlled experiment that mobilized treatment communities to introduce, pass, and enforce a youth tobacco access ordinance. This and other studies examining the effect of such comprehensive MLA interventions on illegal tobacco sales to underage users (e.g., Altman et al., 1999; Biglan et al., 1995, 1996; CDC, 1996; Cook et al., 2000; Glanz et al., 2007; Kan and Lau, 2010; Landrine et al., 2000; Tutt et al., 2009; Watson and Grove, 1999) all found that comprehensive interventions are effective at decreasing sales.

Summary

Limited evidence suggests that the active enforcement of MLA laws using random, unannounced compliance checks of tobacco retailers and sanctions for violations tend to reduce underage sales and, as a result, probably reduces the availability of tobacco to underage individuals from commercial tobacco retailers. Furthermore, additional measures such as targeted retailer education about sales laws, community education and mobilization, and mass media campaigns appear to bolster the effect of enforcement activities on increasing retailer compliance. However, evidence on the relationship between the intensity of the enforcement of the tobacco MLA restrictions and retailer compliance is slim.

> *Finding 6-2: Active enforcement of restrictions on the minimum age of legal access to tobacco products, including meaningful penalties for violations, increases retailer compliance, and a reasonable inference can be drawn that enforcement decreases the availability of retail tobacco to underage persons. These effects can be increased by coupling enforcement with retailer and community education programs and media campaigns about the minimum age policy.*

Relationship Between Retail Interventions and Underage Tobacco Use

While the evidence concerning the effects of enforcement of the MLA policies on retailer compliance inferentially supports the effectiveness of the MLA policy, this finding does not directly answer the ultimate question of interest: whether increased retailer compliance is associated with reduced underage use. Three types of studies bear on this question: those investigating whether the intensity of retailer enforcement is related to the levels of underage use; those investigating whether levels of retailer compliance are related to levels of use; and those investigating whether comprehensive youth access programs, including retailer interventions, have an impact on underage use.

Studies attempting to ascertain the effects of retail enforcement on underage tobacco use primarily examine town-level interventions. Woodridge, Illinois, was one of the first jurisdictions to restrict youth access to tobacco from retailers; in 1989 it passed a cigarette ordinance with licensing, enforcement using compliance checks, and possession provisions. An observational study (Jason et al., 1991) assessing the impact of this ordinance on middle school smoking rates found significant reductions in experimental smoking (from 46 percent to 23 percent) and in smoking (from 16 percent to 5 percent) nearly 2 years later. Follow-up studies nearly a decade later (Jason et al., 1999a,b) found that low rates of regular smoking among middle school students had been maintained (5.3 percent in 1997) as well as similarly low rates of experimental (15.4 percent), social (19.5 percent), and regular (8.1 percent) smoking among high schoolers. Moreover, this rate of regular smoking—8.1 percent—in Woodridge, where there was active enforcement, was significantly lower than in towns in the same region that lacked active enforcement (15.5 percent). Similar results were observed elsewhere (e.g., Cook et al., 2000; DiFranza et al., 1992; Levinson and Mickiewicz, 2007), although some studies (e.g., Bagott et al., 1997, 1998) saw no effect. Interestingly, Rigotti and colleagues (1997) found an increase in adolescent smoking in communities that received the enforcement intervention, but not in the control communities, despite increasing retailer compliance.

Studies of retailer compliance are similar to those evaluating active enforcement, but rather than investigating whether any enforcement efforts affect underage tobacco use, studies of retailer compliance typically examine the relationship between tobacco sales rates or retailer compliance rates (as well as changes in those rates) and underage tobacco use. While analyses of town-level interventions have found high retail compliance to be associated with a number of reduced smoking outcomes (Cummings et al., 2003; Dent and Biglan, 2004; DiFranza et al., 2009; Pokorny et al., 2003), a meta-analysis that pooled studies of active enforcement into a single compliance measure (compliance rate) (Fichtenberg and Glantz, 2002) found no relationship between the level of retailer compliance and either 30-day or regular smoking prevalence. While some (e.g., Cummings et al., 2003; Rigotti et al., 1997) have hypothesized that sales restrictions and their enforcement must achieve high rates of compliance before they begin to affect underage tobacco use, findings are mixed (see, e.g., Cummings et al., 2003; Dent and Biglan, 2004; and Fichtenberg and Glantz, 2002).

Finally, findings about the effects of comprehensive interventions incorporating such actions as retailer and community education programs and mass media campaigns on underage smoking are mixed. While two studies (Chen and Forster, 2006; Cook et al., 2000) found that comprehensive programs decreased smoking prevalence, one study (Altman et al., 1999) reported mixed results. A fourth study investigating effects of a comprehensive program on both adolescent and adult smoking (Rohrbach et al., 2002) found that multicomponent exposure was associated with reductions in adult but not adolescent smoking prevalence.

Overestimation of Retail Compliance

Some of the observed discrepancies in the effects of enforcement and compliance on underage tobacco use may be due to methodological errors that result in an inaccurate measurement of the true rate of illegal tobacco sales to minors. Specifically, the standard compliance check protocol requires the use of underage nonsmokers who have no experience purchasing tobacco, whereas underage smokers deploy a wide range of strategies to obtain tobacco from retail stores, including knowing and sharing knowledge of specific stores and clerks that are more likely to sell to underage persons and strategies to appear older (Crawford et al., 2002; DiFranza and Coleman, 2001; Robinson and Amos, 2010). Studies comparing inexperienced nonsmokers following the standard compliance inspection protocol with underage smokers behaving as they normally do (Croghan et al., 2005; DiFranza et al., 2001b) found that more realistic smoker protocols substantially increased the likelihood of sale. These methodological issues suggest that the standardized protocols may be too artificial and may cue retailers that the purchase attempts are not sincere attempts but, in fact, are enforcement inspections. Consequently, the rates of tobacco sales to underage persons reported through Synar and observed in enforcement interventions may underestimate the true rates of sales to minors. Furthermore, if enforcement interventions are unlikely to reduce commercial availability, they are also unlikely to reduce overall tobacco availability to underage individuals or the actual use of tobacco products. Indeed, in a recent review of the literature on interventions to reduce the sale of tobacco to minors, DiFranza (2012) argued that previous reviews of literature on MLA laws and their enforcement may have failed to find an association between the MLA laws and adolescent smoking because they did not distinguish interventions that successfully reduce retail tobacco availability from those that did not. Thus, in his review and analysis, DiFranza (2012) concluded that active enforcement programs that disrupt the sale of tobacco to minors will reduce adolescent smoking.

A Key Variable: Reliance on Social Sources

While it is certainly likely that some of the inconsistencies in the findings are due to measurement errors, some of the inconsistencies may also be genuine. Some critics of youth access policies have suggested that high rates of compliance may not affect use because of the shift to reliance on social sources (e.g., Craig and Boris, 2007; Etter, 2006; Ling et al., 2002). Given that only approximately 50 percent of underage tobacco users report obtaining tobacco from commercial retailers (see Tables 5-2 through 5-8 in Chapter 5), even a complete cut-off of retail tobacco to underage users will contain, but not eliminate, overall tobacco availability to them unless there is a major crackdown on social distribution.

Although the evidence is slim, a handful of studies (Dent and Biglan, 2004; Kim et al., 2013; Levinson and Mickiewicz, 2007; Millett et al., 2011; Rigotti et al., 1997; Rimpela and Rainio, 2004) suggest that the successful restriction of retail tobacco will effectively decrease adolescent purchases of tobacco from retail sources. At the same time, such a restriction is likely to increase reliance on social sources, including both proxy purchases and being given tobacco (DiFranza and Coleman, 2001; Levinson and Mickiewicz, 2007; Millett et al., 2011; Rigotti et al., 1997; Rimpela and Rainio, 2004). Interestingly, a study of Oregon adolescents (Dent and Biglan, 2004) found that increased compliance was associated with an increased reliance on social sources and a decreased use of commercial sources among 11th graders, but that the opposite was true for 8th grade students. It is possible that the younger students' social networks were restricted to underage persons so that increased retail compliance reduced access from these social sources, leading to an increased need for the 8th graders to try to purchase tobacco for themselves. On the other hand, the older students may have been more likely to have social networks that included those who were old enough to buy tobacco products on their behalf.

It seems clear that curtailing retail access will lead to greater use of social sources. Whether the reduction in retail access has an effect on underage use depends on whether the substitution of the social sources for the commercial sources is complete. To the extent that this substitution of social sources for commercial sources is incomplete, the search-time costs for underage users to obtain tobacco will likely increase, and tobacco consumption among underage users will likely decrease. All of the evidence reviewed above is consistent with incomplete substitution.

Relationship Between Retail Interventions and Perceived Availability

Given the mixed findings regarding the relationship between retailer interventions and levels of tobacco use in adolescents, it is instructive to consider whether the intensity of retailer intervention is related to subjective measures of reduced "access" by underage users. Two subjective factors reported by underage youth—the perceived availability of tobacco and self-reported decreases in the use of retail sources—can be considered to be proxy measures of actual underage access. Moreover, as intervening variables, both measures may moderate the effect of an MLA restriction and its enforcement on underage tobacco use.

Perceived Availability

One notable trend in adolescents' access to cigarettes is that the perceived ease of access has declined considerably in recent years. The Monitoring the Future surveys ask 8th and 10th graders how difficult they think it would be for them to get cigarettes, if they wanted to. Among 8th graders in 1996, 77 percent said they could get cigarettes "fairly easily" or "very easily," while in 2013 that figure had declined to 50 percent. Among 10th graders, the corresponding decline was from 90 percent to 70 percent. Thus, although most adolescents still believe they could easily obtain cigarettes, reports of easy access have declined considerably over time (Johnston et al., 2014). This finding is also consistent with reduced retail availability and incomplete substitution by social sources.

Impact of Enforcement on Perceived Availability

The perceived availability of tobacco represents a subjective assessment of an underage person's actual opportunities to obtain tobacco (i.e., supply) and can be assessed either in reference to specific sources or location types (e.g., availability from home, school, or stores) or globally. Findings on the relation between MLA laws and their enforcement and perceived availability are mixed. However, while these studies typically assess perceived tobacco availability globally (e.g., Borland and Amos, 2009; Cummings et al., 2003; Jason et al., 1999a; Rigotti et al., 1997; Rimpela and Rainio, 2004; Staff et al., 1998; Thomson et al., 2004), Forster and colleagues (1997) assessed perceived availability in reference to specific sources and found that the intervention decreased the perceived availability from commercial but not social sources. This suggests that the MLA laws and their enforcement, as expected, may increase the difficulty of obtaining tobacco from commercial sources, but they do not have an impact on social sources. It is likely that the inconsistent findings concerning the impact of the MLA and its enforcement on perceived access may be due to the conflation of sources.

Relationship Between Perceived Availability and Underage Tobacco Use

The evidence on the relationship between perceived availability and underage tobacco use is challenging to interpret because this relationship is dependent on the relative availability of and reliance on tobacco from social sources. For example, Doubeni and colleagues (2008) found that high perceived availability increases the risk for multiple smoking outcomes and that high perceived availability and peer smoking together increased the risk of regular smoking and of smoking progression among initiators more than either variable alone. This is logical given that adolescents with more peers who smoke will likely have greater access to tobacco from these peers and also more positive attitudes toward tobacco use.

Perceived Availability as a Reflection of Social Norms

Perceived tobacco availability may also reflect perceptions of the social environment about tobacco use (e.g., social norms) as well as an underage individual's willingness or intentions to attempt to get tobacco (i.e., demand). By bridging the interface between tobacco supply and demand, perceived availability can be understood as a psychosocial mechanism by which youth tobacco restrictions affect underage tobacco use. Interpreting the impact of perceived availability on consumption is even more challenging precisely because it may reflect changes in both tobacco supply and demand. For example, Gilpin et al. (2004) examined neighboring birth cohorts before and after implementation of a comprehensive, statewide tobacco control program in California and found that adolescents who perceived cigarettes easy to access were more likely to initiate smoking than those who perceived cigarettes hard to obtain, but only in the cohort under higher enforcement conditions. The authors therefore suggest that perceived availability was less a reflection of opportunities to obtain tobacco than of the declarative effect of the tobacco control program changing social norms and thereby decreasing demand to take up tobacco use. Finally, a cross-sectional study (Speizer et al., 2008) examined perceived availability from different sources and found that current and ever smokers were more likely to perceive easy access to cigarettes from all sources (home, school, and stores) than those who never smoked, which suggests that perceived ease of access reflects both a greater demand for tobacco and opportunities to access tobacco.

Summary

Findings about the effects of retail enforcement, retail compliance, and comprehensive interventions on underage tobacco use are difficult to interpret. The difficulty is reflected in the discrepancy between observed commercial availability (as measured by the rates of retail compliance) and perceived tobacco availability, as self-reported by adolescents and young adults. Whereas all states are currently in compliance with Synar and have achieved average compliance rates of 90 percent, 50 to 70 percent of adolescents report fair or very easy access to cigarettes (Johnston et al., 2014). The apparent inconsistency may be partially attributable to an overestimate of compliance rates in compliance checks. In addition, changes in perceived availability may reflect changes not only in opportunities to obtain tobacco but also in social norms and demand for tobacco.

Overall, this body of evidence suggests that the enforcement of MLA laws increases the perceived difficulty of obtaining tobacco from commercial sources. Additionally, MLA laws are likely to change social norms, and thereby indirectly affect perceived ease of access from social sources, especially among younger adolescents. Insofar as the substitution of non-retail sources for commercial retail sources is incomplete, the total tobacco available to underage individuals is probably reduced. However, reduced access does not have a robust and easily measurable impact on use because of the youths' increased reliance on social and other non-retail sources, especially by older adolescents and youth who are already daily smokers.

Finding 6-3: While increasing retailer compliance reduces the availability of retail tobacco to underage persons, the magnitude of this effect and its impact on underage consumption are highly uncertain due to the continued availability of tobacco from noncommercial sources. However, the level of substitution by social sources is likely to be lowest for the youngest underage users.

UNDERAGE ACCESS RESTRICTIONS IN THE CONTEXT OF OTHER TOBACCO CONTROL POLICIES

It is unlikely that any revised MLA laws will be aggressively enforced in isolation, so examining the MLA laws and their enforcement in the context of other tobacco control policies can help elucidate their likely effects in circumstances that more closely resemble the likely real world scenarios in which an MLA increase would be implemented. In particular, investigating the effect of the MLA laws in this way may help explain some of the observed variations in community-level natural experiments. Studies in these small localities may not account for the contributions of other concurrent tobacco control programs at the state and national levels (e.g., smoke-free policies, excise taxes and price, mass media campaigns), and they also may be subject to spillover effects from neighboring jurisdictions, in particular, smuggling.[5] The following section reviews the evidence on MLA retailer interventions in the context of other youth access restrictions, followed by other, general tobacco control programs.

Multiple Statewide Retailer Interventions and Underage Tobacco Consumption

In addition to MLA laws and their enforcement, youth access policies also include licensing requirements (i.e., requiring a license to sell tobacco products), signage requirements at the point of sale (i.e., posting warning signs about the MLA), vending machine restrictions, inspection requirements, clerk intervention policies (i.e., retailer and clerk education), penalties for retailers found to be in violation (especially graduated penalties), identification requirements, packaging restrictions (e.g., minimum pack size, labeling standards), restrictions on free distribution (i.e., bans on free samples), and establishing or designating a statewide enforcement authority. These policies are typically examined at the state level and can be examined both individually and in an aggregate measure of overall "extensiveness." When examined in the aggregate, having more policies constitutes a higher score and is considered to be more extensive. In this context, it is imperative to control for the impact of other policies in order to isolate the independent effect of MLA on underage tobacco use and also to identify possible interactions.

Of the studies that examined multiple youth access policies, including an MLA and its enforcement, Chaloupka and Pacula (1998), Luke et al. (2000), and Powell et al. (2003), found that more extensive policies were associated with decreased teen current smoking prevalence. Further, Chaloupka and Pacula (1998) also showed that, when measured individually, the use of compliance inspections versus only observing retailers and the use of statewide sampling to measure compliance versus local or no sampling were both associated with significantly lower adolescent smoking prevalence. On the other hand, Thomson and colleagues (2004) examined six types of youth access ordinances (licensing, fines for merchants who

[5] Indeed, adolescents achieve increasing mobility as they begin to drive, and implementation at the town or county level may have a smaller effect than state- or national-level implementation due to the potential smuggling of tobacco from neighboring jurisdictions where tobacco availability is higher. Lessons from the alcohol experience suggest precisely this: Lovenheim and Slemrod (2010) and Dejong and Blanchette (2014) examined the effect of a minimum legal drinking age on fatal traffic accidents when states were implementing an MLDA of 21 in a patchwork while the national MLDA remained 18. Their analysis of county-level data found no reduction in fatal traffic crashes involving youth in counties with an MLDA of 21 that were within 25 miles of a state with a lower minimum drinking age, but significant reductions in fatal traffic crashes involving youth in counties further from the state borders.

sell to minors, vending machine restrictions, self-service bans, bans of the sale of single cigarettes, and bans on distributing free samples) in several Massachusetts towns and statewide and found that none of the youth access ordinances were associated with any measure of adolescent smoking. One study examined how state youth access policies in effect when study participants were age 17 affected their smoking after they became adults (Grucza et al., 2013). The researchers examined the effects of the policies both individually and in multi-policy models and found that multiple youth access policies together were associated with significant reductions in prevalence of both ever and current smokers among females (although not among males) despite the individual policies having only small effects in isolation. These findings suggest that individual youth access policies alone may have small, additive effects that contribute to more substantial impacts when implemented together.

Comprehensive Tobacco Control Policies and Underage Tobacco Consumption

Other policies that have an effect on tobacco use in addition to youth access initiatives are smoke-free laws, state-level expenditures, excise taxes, and minimum cigarette prices. As with studies of multiple youth access policies, studies of multiple tobacco control policies can examine the policies individually or in aggregate.

Of the studies attempting to isolate the independent effects of MLA laws in the context of other tobacco control policies, two (Botello-Harbaum et al., 2009; Farrelly et al., 2013) found no association between youth access policies and any adolescent smoking outcome after controlling for the other policies. However, Ross and Chaloupka (2001) found that the decision to smoke and smoking intensity were each negatively associated with retailer compliance in models that both included all policies together and controlled for the effects from the other tobacco control measures. Tworek et al. (2010) examined the effects of tobacco control policies, including an index of the strength of youth tobacco sales restrictions on adolescent smoking cessation, and found that youth access restrictions slightly increased the odds of non-continuation of smoking, but they were not associated with any other cessation measure.

Other studies have investigated the effects of comprehensive tobacco control programs; these can be considered to be studies of multiple tobacco control policies in aggregate. The multi-pronged tobacco-control approaches integrate educational, clinical, regulatory, economic, and social strategies to prevent or reduce tobacco use and to reduce tobacco-related diseases (CDC, 2014b; HHS, 2000). For example, Helakorpi et al. (2008) investigated the effects of the 1976 Tobacco Control Act in Sweden, which prohibited smoking in public places, including public transit; prohibited tobacco sales to those under 16; required health warnings on cigarette packs; and established a tobacco tax whose revenue was earmarked for health education and tobacco-related research on adult smoking by gender and socioeconomic status. Among men, the researchers found that after the passage of the act, the prevalence of ever-daily smoking declined beyond secular trends for all SES groups, with the strongest declines observed among the higher SES group (white-collar employees). Among women, there was an increasing secular trend for all SES groups prior to the legislation, but after the act women's ever-daily smoking prevalence reversed in all groups. A comprehensive tobacco control program in New Zealand was similarly effective at reducing tobacco use in adolescents and adults and also reducing tobacco-related death and disease (Laugesen and Swinburn, 2000).

Comprehensive programs in the United States have been shown to effectively reduce tobacco use among adolescents and adults (e.g., Farrelly et al., 2008, 2013, 2014; Kuiper et al., 2005; Pierce et al., 2009; Stillman et al., 2003; Tauras et al., 2005; Wakefield and Chaloupka, 2000; Zaza et al., 2005) as well as to reduce tobacco-related death and disease (e.g., Jemal et al., 2003; Kuiper et al., 2005). However, they frequently do not specify the inclusion of youth access policies (e.g, because comprehensive tobacco control efforts are frequently measured using state-level expenditures). Despite the lack of explicitly identified youth access program components, it is reasonable to assume that studies of state-level comprehensive tobacco control programs within the past two decades would have included youth access restrictions conducted in compliance with Synar. Moreover, the inclusion of youth access restrictions in comprehensive approaches is considered best practice, and stronger state-level tobacco control programs are likely to include extensive youth access measures (CDC, 2014b). Thus, it is likely that these comprehensive approaches to tobacco control that have proved effective at reducing tobacco use and tobacco-related morbidity and mortality include some youth access provisions.

Summary

Evidence on the independent effect of youth access policies in the context of other tobacco control policies is mixed. However, studies of multiple statewide retailer interventions that include active enforcement of the MLA restrictions suggest that these interventions are effective in reducing underage use. Moreover, there is some evidence that comprehensive tobacco programs that include youth access restrictions are effective at reducing underage tobacco use, although it is difficult to isolate the relative contributions of youth access restrictions in these comprehensive programs.

Finding 6-4: Underage tobacco use is most substantially reduced when the jurisdiction adopts a strong array of tobacco control measures, including strongly enforced youth access restrictions.

TOBACCO PURCHASE, USE, AND POSSESSION LAWS

Although the focus of this analysis is on sales restrictions, it is also important to consider the effects of supplementing bans on distribution and sales with laws targeting underage tobacco PUP. As noted in Chapter 5, the laws of 44 states and the District of Columbia penalize underage individuals for purchasing, using, or possessing tobacco products, typically by civil fines or community service. Proponents of the laws argue that PUP laws are another effective strategy for deterring underage tobacco use (e.g., Jason et al., 2009b; Lazovich et al., 2007; Livingood et al., 2001), while critics argue that PUP laws shift blame from retailers and tobacco industry marketing and advertising practices toward adolescents and young adults and, furthermore, that PUP laws may actually increase the desirability of tobacco as an aspirational, adult product, further enticing adolescents to use tobacco (e.g., Wakefield and Giovino, 2003). Opponents of PUP laws also suggest that enforcement would be difficult, expensive, and therefore realistically infeasible (Tworek et al., 2011). The IOM's report *Growing Up Tobacco Free* (1994) elaborated on this, arguing that PUP laws lacking enforcement would only serve as a symbolic deterrent, which would be unlikely to deter tobacco use any more than laws punishing sellers, while also undermining respect for the law.

There is currently no systematic surveillance of PUP laws, and thus there is little information about either the extent to which they are enforced or their efficacy. The only available data on statewide enforcement that the committee was able to locate (Rogers et al., 2008) come from California, an aggressive tobacco control state, and the data show that, in 2007, 76 percent of youth access enforcement agencies across the state indicated that they did not "often" or "very often" issue citations to minors for PUP violations. Additionally, the average number of citations issued in the past 12 months across all 249 enforcement agencies statewide was 24.1 citations, or an average of two per agency per month. Similarly, qualitative studies also suggest that PUP laws are seldom enforced. Two studies using key informant interviews with individuals responsible for enforcing PUP laws (e.g., mayors, police officers, and school officials) found that PUP laws are poorly enforced and that only a small number of citations are issued (Hrywna et al., 2004); they also found that there was little knowledge about PUP enforcement, that active enforcement of PUP laws was not a priority, and that even when they were enforced, the enforcement was inconsistent (Hahn et al., 2007). Indeed, any widely violated and under-enforced prohibition is likely to be plagued by selective enforcement, and PUP laws are no exception. For example, Gottlieb et al. (2004) found differential enforcement of PUP laws, such that African-American and Hispanic students had a significantly greater probability of receiving a citation than white students.

Despite lax enforcement efforts, limited empirical data suggest that active enforcement of PUP laws in addition to active enforcement of youth tobacco sales restrictions may be effective at reducing tobacco sales to underage persons and, ultimately, at reducing underage tobacco consumption. Most of these findings come from a series of studies conducted by Jason and colleagues in a convenience sample of small, suburban towns in Illinois, which may not be representative of the rest of the state or the country as a whole. They found that active enforcement of PUP laws in addition to sales restrictions is associated with reduced tobacco sales to underage users (Jason et al., 2003); decreased observed and perceived adolescent tobacco use (Jason et al., 2009a); slower increases in the rate of smoking compared to enforcing sales restrictions alone (Jason et al., 2008); reduced smoking, both among whites only (Jason et al., 2003) and, alternately, among all groups (Jason et al., 2007c); lowered rates of heavy smoking (Jason et al., 2009b); reduced use of other drugs (Jason et al., 2010), and reduced crime rates (Jason et al., 2000). They also found that underage individuals who were fined for PUP violations were more likely to reduce tobacco use or quit than those who participated in tobacco prevention education programs (Jason et al., 2007b). Additionally, fines had a bigger effect than education on changing parental and adolescent attitudes toward tobacco use (Jason et al., 2007b). Finally, Jason and colleagues also found that the presence of PUP laws facilitated the uptake of smoke-free policies (Jason et al., 2007a). Studies by other researchers have further supported these findings, including studies demonstrating that actively enforcing PUP laws may be effective at reducing underage tobacco use (Gottlieb et al., 2004; Lazovich et al., 2007; Livingood et al., 2001) and increasing adolescent smoking cessation (Langer and Warheit, 2000). Moreover, Gottlieb et al. (2004) found that the threat of driver's license suspension as a penalty for PUP violations reduced smoking intentions among adolescent ever-daily smokers (but not ever or experimental smokers), suggesting a general deterrent effect. At the same time, having received a citation was associated with reduced smoking intentions in only some of the schools sampled, thus showing mixed findings with respect to specific deterrence.

On the other hand, two analyses also examined PUP laws in the context of other youth access restrictions, and neither found that they decreased adolescent smoking. Ross and Chaloupka (2001) found that punishing minors for the use or possession of cigarettes increased the number of cigarettes adolescents smoked, while Tworek and colleagues (2010) found no association between PUP laws and any measure of adolescent smoking cessation.

In sum, there continues to be some controversy about the relative advantages and disadvantages of implementing PUP laws for tobacco. Although a small number of observational studies of PUP interventions suggest that they can contribute to the reduction of underage tobacco use if enforced, there is scant evidence of enforcement. Moreover, the few existing studies also suggest that, when enforced, the laws are selectively applied and that minority populations may carry a disproportionate burden of PUP violations.

> *Finding 6-5: Enforcement of purchase–use–possession laws is a controversial strategy for reducing underage tobacco use. Although a small number of studies suggest that enforcing these laws, in combination with strategies that limit retail tobacco sales, can reduce use, they also raise concerns about fair enforcement.*

SUMMARY

This chapter reviewed the existing evidence on the effects of raising the minimum legal age to purchase tobacco products, in particular the effect on underage tobacco use. No published evidence is yet available on the effects of raising the MLA to 21 in any of the localities in the United States that have done so. Limited international evidence suggests that raising the MLA from 16 to 18 in countries that already had an actively enforced MLA can be implemented successfully to reduce the availability of retail tobacco to newly underage persons and thereby reduce underage tobacco use. Experience with raising the minimum legal drinking age for alcohol in the United States from 18 to 21 is instructive for tobacco control, in that it has led to reductions in the use of alcohol and concomitant harms, such as motor vehicle accidents in the underage population, although it also demonstrates that the prevalence of underage drinking remains high.

In light of the dearth of direct evidence on the effects of raising the MLA for tobacco, the committee focused its attention on the substantial body of literature on the effects of enforcing the MLA restrictions that have already existed in the United States for more than two decades. This literature suggests that the MLA policies that are actively enforced and supported by other retailer interventions will likely increase retailer compliance and thereby reduce retail tobacco availability to underage individuals. Furthermore, although increased retailer compliance is predictably accompanied by a corresponding increase in the use of social sources to obtain tobacco, this substitution of sources is likely to be incomplete, leading to decreased use, especially if the youth access policy is implemented in a robust comprehensive tobacco control context.

REFERENCES

Abernathy, T. J. 1994. Compliance for kids: A community-based tobacco prevention project. *Canadian Journal of Public Health* 85(2):82–84.

Altman, D. G., V. Foster, L. Rasenick-Douss, and J. B. Tye. 1989. Reducing the illegal sale of cigarettes to minors. *JAMA* 261(1):80–83.

Altman, D. G., L. Rasenick-Douss, V. Foster, and J. B. Tye. 1991. Sustained effects of an educational program to reduce sales of cigarettes to minors. *American Journal of Public Health* 81(7):891–893.

Altman, D. G., A. Y. Wheelis, M. McFarlane, H. Lee, and S. P. Fortmann. 1999. The relationship between tobacco access and use among adolescents: A four community study. *Social Science and Medicine* 48(6):759–775.

Bagott, M., C. Jordan, C. Wright, and S. Jarvis. 1997. Test sales do not have impact on prevalence of smoking by children. *BMJ* 315(7106):491.

———.1998. How easy is it for young people to obtain cigarettes, and do test sales by trading standards have any effect? A survey of two schools in Gateshead. *Child: Care, Health and Development* 24(3):207–216.

Biglan, A., J. Henderson, D. Humphrey, M. Yasui, R. Whisman, C. Black, and L. James. 1995. Mobilising positive reinforcement to reduce youth access to tobacco. *Tobacco Control* 4(1):42–48.

Biglan, A., D. Ary, V. Koehn, D. Levings, S. Smith, Z. Wright, L. James, and J. Henderson. 1996. Mobilizing positive reinforcement in communities to reduce youth access to tobacco. *American Journal of Community Psychology* 24(5):625–638.

Birckmayer, J., and D. Hemenway. 1999. Minimum-age drinking laws and youth suicide, 1970–1990. *American Journal of Public Health* 89(9):1365–1368.

Bonnie, R. 1982. Discouraging the use of alcohol, tobacco and other drugs: The effects of legal controls and restrictions. In N. K. Mello, ed., *Advances in substance abuse research, Volume II* (pp. 145–184). Greenwich, CT: JAI Press.

Borland, T., and A. Amos. 2009. An exploratory study of the perceived impact of raising the age of cigarette purchase on young smokers in Scotland. *Public Health* 123(10):673–679.

Botello-Harbaum, M. T., D. L. Haynie, R. J. Iannotti, J. Wang, L. Gase, and B. Simons-Morton. 2009. Tobacco control policy and adolescent cigarette smoking status in the United States. *Nicotine & Tobacco Research* 11(7):875–885.

Carpenter, C., and P. J. Cook. 2008. Cigarette taxes and youth smoking: New evidence from national, state, and local youth risk behavior surveys. *Journal of Health Economics* 27(2):287–299.

Carpenter, C., and C. Dobkin. 2011. The minimum legal drinking age and public health. *Journal of Economic Perspectives* 25(2):133–156.

CDC (Centers for Disease Control and Prevention). 1993. Minors' access to tobacco—Missouri, 1992, and Texas, 1993. *Morbidity & Mortality Weekly Report* 42(7):125–128.

———. 1996. Estimates of retailers willing to sell tobacco to minors—California, August–September 1995 and June–July 1996. *Morbidity & Mortality Weekly Report* 45(50):1095–1099. [Erratum appears in *Morbidity and Mortality Weekly Report* 45(51–52):1129.]

———. 2014a. Smoking and tobacco use: Economic facts about U.S. tobacco production and use. http://www.cdc.gov/tobacco/data_statistics/fact_sheets/economics/econ_facts (accessed January 21, 2015).

———. 2014b. *Best practices for comprehensive tobacco control programs—2014*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

Chaloupka, F. J., and R. L. Pacula. 1998. Limiting youth access to tobacco: The early impact of the Synar Amendment on youth smoking. Paper presented at Biennial Pacific Rim Allied Economic Organizations Conference, 1997, Bangkok, Thailand. http://tigger.uic.edu/~fjc/Presentations/Papers/Synar94b1.pdf (accessed February 25, 2015).

Chaloupka, F. J., and K. E. Warner. 2000. The economics of smoking. *Handbook of Health Economics* 1(B):1539–1627.

Chen, V., and J. L. Forster. 2006. The long-term effect of local policies to restrict retail sale of tobacco to youth. *Nicotine & Tobacco Research* 8(3):371–377.

Cismoski, J., and M. Sheridan. 1993. Availability of cigarettes to under-age youth in Fond du Lac, Wisconsin. *Wisconsin Medical Journal* 92(11):626–630.

Conover, E., and D. Scrimgeour. 2013. Health consequences of easier access to alcohol: New Zealand evidence. *Journal of Health Economics* 32(3):570–585.

Cook, D., C. Edwards, L. Bauer, and D. Tutt. 2000. Reducing adolescent smoking rates. Maintaining high retail compliance results in substantial improvements. *Health Promotion Journal of Australia* 10(1):20–24.

Craig, M. J., and N. W. Boris. 2007. Youth tobacco access restrictions: Time to shift resources to other interventions? *Health Promotion Practice* 8(1):22–27.

Crawford, M., G. Balch, and R. Mermelstein. 2002. Responses to tobacco control policies among youth. *Tobacco Control* 11(1):14–19.

Croghan, E., P. Aveyard, and C. Johnson. 2005. Is it as easy as young people claim for them to buy cigarettes? Comparing the results of realistic test purchases with those from trading standards test purchases. *Health Education* 105(2):103–108.

Cummings, K. M., A. Hyland, T. Saunders-Martin, J. Perla, P. R. Coppola, and T. F. Pechacek. 1998. Evaluation of an enforcement program to reduce tobacco sales to minors. *American Journal of Public Health* 88(6):932–936.

Cummings, K. M., A. Hyland, J. Perla, and G. A. Giovino. 2003. Is the prevalence of youth smoking affected by efforts to increase retailer compliance with a minors' access law? *Nicotine & Tobacco Research* 5(4):465–471.

DeJong, W., and J. Blanchette. 2014. Case closed: Research evidence on the positive public health impact of the age 21 minimum legal drinking age in the United States. *Journal of Studies on Alcohol and Drugs* 75(Suppl 17):108–115.

Dent, C., and A. Biglan. 2004. Relation between access to tobacco and adolescent smoking. *Tobacco Control* 13(4):334–338.

DiFranza, J. R. 2012. Which interventions against the sale of tobacco to minors can be expected to reduce smoking? *Tobacco Control* 21(4):436–442.

DiFranza, J. R., and M. Coleman. 2001. Sources of tobacco for youths in communities with strong enforcement of youth access laws. *Tobacco Control* 10(4):323–328.

DiFranza, J. R., R. P. Carlson, and R. E. Caisse. 1992. Reducing youth access to tobacco. *Tobacco Control* 1(1):58.

DiFranza, J. R., C. C. Celebucki, and P. D. Mowery. 2001a. Measuring statewide merchant compliance with tobacco minimum age laws: The Massachusetts experience. *American Journal of Public Health* 91(7):1124–1125.

DiFranza, J. R., J. A. Savageau, and J. Bouchard. 2001b. Is the standard compliance check protocol a valid measure of the accessibility of tobacco to underage smokers? *Tobacco Control* 10(3):227–232.

DiFranza, J. R., J. A. Savageau, and K. E. Fletcher. 2009. Enforcement of underage sales laws as a predictor of daily smoking among adolescents—A national study. *BMC Public Health* 9:107.

Ding, A. 2003. Youth are more sensitive to price changes in cigarettes than adults. *Yale Journal of Biology and Medicine* 76(3):115–124.

Doubeni, C. A., W. Li, H. Rouayzi, and J. R. DiFranza. 2008. Perceived accessibility as a predictor of youth smoking. *Annals of Family Medicine* 6(4):323–330.

Dovell, R. A., D. L. Mowat, J. Dorland, and M. Lam. 1998. Tobacco access to youth: Beliefs and attitudes of retailers. *Canadian Journal of Public Health.* 89(1):17–21.

EDC (Education Development Center). 2010a. *Highlights from the Metrowest Adolescent Health Survey: Needham High School report.* Newton, MA: MetroWest Community Health Care Foundation.

———. 2010b. *Highlights from the Metrowest Adolescent Health Survey: Needham Middle School report.* Newton, MA: MetroWest Community Health Care Foundation.

Erickson, A. D., S. I. Woodruff, M. B. Wildey, and E. Kenney. 1993. A baseline assessment of cigarette sales to minors in San Diego, California. *Journal of Community Health* 18(4):213–224.

Etter, J. F. 2006. Laws prohibiting the sale of tobacco to minors: Impact and adverse consequences. *American Journal of Preventive Medicine* 31(1):47–51.

Farrelly, M. C., T. F. Pechacek, K. Y. Thomas, and D. Nelson. 2008. The impact of tobacco control programs on adult smoking. *American Journal of Public Health* 98(2):304–309.

Farrelly, M. C., B. R. Loomis, B. Han, J. Gfroerer, N. Kuiper, G. L. Couzens, S. Dube, and R. S. Caraballo. 2013. A comprehensive examination of the influence of state tobacco control programs and policies on youth smoking. *American Journal of Public Health* 103(3):549–555.

Farrelly, M. C., B. R. Loomis, N. Kuiper, B. Han, J. Gfroerer, R. S. Caraballo, T. F. Pechacek, and G. L. Couzens. 2014. Are tobacco control policies effective in reducing young adult smoking? *Journal of Adolescent Health* 54(4):481–486.

Feighery, E., D. G. Altman, and G. Shaffer. 1991. The effects of combining education and enforcement to reduce tobacco sales to minors. A study of four Northern California communities. *JAMA* 266(22):3168–3171.

Fichtenberg, C. M., and S. A. Glantz. 2002. Youth access interventions do not affect youth smoking. *Pediatrics* 109(6):1088–1092.

Fidler, J. A., and R. West. 2010. Changes in smoking prevalence in 16–17-year-old versus older adults following a rise in legal age of sale: Findings from an English population study. *Addiction* 105(11):1984–1988.

Forster, J. L., M. Hourigan, and P. McGovern. 1992. Availability of cigarettes to underage youth in three communities. *Preventive Medicine* 21(3):320–328.

Forster, J. L., M. Wolfson, D. M. Murray, A. C. Wagenaar, and A. J. Claxton. 1997. Perceived and measured availability of tobacco to youths in 14 Minnesota communities: The TPOP Study. *American Journal of Preventive Medicine* 13(3):167–174.

Forster, J. L., D. M. Murray, M. Wolfson, T. M. Blaine, A. C. Wagenaar, and D. J. Hennrikus. 1998. The effects of community policies to reduce youth access to tobacco. *American Journal of Public Health* 88(8):1193–1198.

Franz, G. A. 2008. Price effects on the smoking behaviour of adult age groups. *Public Health* 122(12):1343–1348.

Gemson, D. H., H. L. Moats, B. X. Watkins, M. L. Ganz, S. Robinson, and E. Healton. 1998. Laying down the law: Reducing illegal tobacco sales to minors in central Harlem. *American Journal of Public Health* 88(6):936–939.

Gilpin, E. A., L. Lee, and J. P. Pierce. 2004. Does adolescent perception of difficulty in getting cigarettes deter experimentation? *Preventive Medicine* 38(4):485–491.

Glanz, K., A. D. Jarrette, E. A. Wilson, D. L. O'Riordan, and K. R. Jacob Arriola. 2007. Reducing minors' access to tobacco: Eight years' experience in Hawaii. *Preventive Medicine* 44(1):55–58.

Gottlieb, N., A. Loukas, M. Corrao, A. McAlister, C. Snell, and P. Huang. 2004. Minors' tobacco possession law violations and intentions to smoke: Implications for tobacco control. *Tobacco Control* 13(3):237–243.

Grucza, R. A., A. D. Plunk, P. R. Hipp, P. Cavazos-Rehg, M. J. Krauss, R. C. Brownson, and L. J. Bierut. 2013. Long-term effects of laws governing youth access to tobacco. *American Journal of Public Health* 103(8):1493–1499.

Hahn, E. J., C. Riker, K. M. Butler, S. Cavendish, P. Lewis, L. W. Greathouse Maggio, and V. Nunley. 2007. Enforcement of tobacco purchase, use, and possession laws in four Kentucky communities. *Policy, Politics, & Nursing Practice* 8(2):140–147.

Harris, J. E., and S. W. Chan. 1999. The continuum-of-addiction: Cigarette smoking in relation to price among Americans aged 15–29. *Health Economics* 8(1):81–86.

Helakorpi, S., T. Martelin, J. Torppa, E. Vartiainen, A. Uutela, and K. Patja. 2008. Impact of the 1976 tobacco control act in Finland on the proportion of ever daily smokers by socioeconomic status. *Preventive Medicine* 46(4):340–345.

HHS (Department of Health and Human Services). 2000. *Reducing tobacco use: A report of the Surgeon General.* Atlanta, GA: U.S. Department of Health and Human Services; Centers for Disease Control and Prevention; National Center for Chronic Disease Prevention and Health Promotion; Office on Smoking and Health.

Hrywna, M., R. K. Adler, C. D. Delnevo, and J. D. Slade. 2004. Content analysis and key informant interviews to examine community response to the purchase, possession, and/or use of tobacco by minors. *Journal of Community Health* 29(3):209–216.

Huckle, T., and K. Parker. 2014. Long-term impact on alcohol-involved crashes of lowering the minimum purchase age in New Zealand. *American Journal of Public Health* 104(6):1087–1091.

Hughes, C. E., and A. Stevens. 2010. What can we learn from the Portuguese decriminalization of illicit drugs? *British Journal of Criminology* 50(6):999–1022.

IOM (Institute of Medicine). 1994. *Growing up tobacco free: Preventing nicotine addiction in children and youths*. Edited by B. S. Lynch and R. J. Bonnie. Washington, DC: National Academy Press.

———. 2007. *Ending the tobacco problem: A blueprint for the nation*. Edited by R. J. Bonnie. Washington, DC: The National Academies Press.

IOM and NRC (Institute of Medicine and National Research Council). 2004. *Reducing underage drinking: A collective responsibility*. Edited by R. J. Bonnie. Washington, DC: The National Academies Press.

Jason, L. A., P. Y. Ji, M. D. Anes, and S. H. Birkhead. 1991. Active enforcement of cigarette control laws in the prevention of cigarette sales to minors. *JAMA* 266(22):3159–3161.

Jason, L., W. Billows, D. Schnopp-Wyatt, and C. King. 1996. Reducing the illegal sales of cigarettes to minors: Analysis of alternative enforcement schedules. *Journal of Applied Behavior Analysis* 29(3):333–344.

Jason, L. A., M. Berk, D. L. Schnopp-Wyatt, and B. Talbot. 1999a. Effects of enforcement of youth access laws on smoking prevalence. *American Journal of Community Psychology* 27(2):143–160.

Jason, L. A., R. Katz, J. Vavra, D. L. Schnopp-Wyatt, and B. Talbot. 1999b. Long-term follow-up of youth access to tobacco laws' impact on smoking prevalence. *Journal of Human Behavior in the Social Environment* 2(3):1–13.

Jason, L. A., R. Katz, S. B. Pokorny, M. Engstrom, G. Tegart, and C. Curie. 2000. The relationship between youth tobacco control enforcement and crime rates in a Midwestern county. *American Journal of Health Promotion* 14(4):229–231.

Jason, L. A., S. B. Pokorny, and M. E. Schoeny. 2003. Evaluating the effects of enforcements and fines on youth smoking. *Critical Public Health* 13(1):33–45.

Jason, L. A., Y. M. Hunt, M. L. Adams, S. B. Pokorny, and P. B. Gadiraju. 2007a. Strengthening communities' youth access policies may facilitate clean indoor air action. *Preventing Chronic Disease* 4(4):A113.

Jason, L. A., S. B. Pokorny, M. Adams, Y. Hunt, P. Gadiraju, T. Morello, M. Schoeny, and C. Dinwiddie. 2007b. Youth caught in violation of tobacco purchase, use, and possession laws: Education versus fines. *Behavior Modification* 31(6):713–731.

Jason, L. A., S. B. Pokorny, M. Adams, Y. Hunt, P. Gadiraju, and M. Schoeny. 2007c. Do fines for violating possession–use–purchase laws reduce youth tobacco use? *Journal of Drug Education* 37(4):393–400.

Jason, L. A., S. B. Pokorny, and M. Adams. 2008. A randomized trial evaluating tobacco possession–use–purchase laws in the USA. *Social Science and Medicine* 67(11):1700–1707.

Jason, L. A., S. B. Pokorny, M. Adams, A. Topliff, C. Harris, and Y. Hunt. 2009a. Youth tobacco access and possession policy interventions: Effects on observed and perceived tobacco use. *American Journal on Addictions* 18(5):367–374.

———. 2009b. Effects of youth tobacco access and possession policy interventions on heavy adolescent smokers. *International Journal of Environmental Research and Public Health* 6(1):1–9.

Jason, L. A., S. B. Pokorny, M. Adams, A. Nihls, H. Y. Kim, and Y. Hunt. 2010. Cracking down on youth tobacco may influence drug use. *Journal of Community Psychology* 38(1):1–15.

Jemal, A., V. E. Cokkinides, O. Shafey, and M. J. Thun. 2003. Lung cancer trends in young adults: An early indicator of progress in tobacco control (United States). *Cancer Causes and Control* 14(6):579–585.

Johnston, L. D., P. M. O'Malley, J. G. Bachman, J. E. Schulenberg, and R. A. Miech. 2014. *Monitoring the Future: National survey results on drug use, 1975–2013. Volume 1: Secondary school students*. Ann Arbor, MI: Institute for Social Research, The University of Michigan.

Junck, E., J. Humphries, and C. Rissel. 1997. Reducing tobacco sales to minors in Manly: 10 months follow-up. *Health Promotion Journal of Australia* 7(1):29–34.

Kan, M. Y., and M. Lau. 2010. Minor access control of Hong Kong under the Framework Convention on Tobacco Control. *Health Policy* 95(2–3):204–210.

Keay, D., S. I. Woodruff, M. B. Wildey, and E. M. Kenney. 1993. Effect of a retailer intervention on cigarette sales to minors in San Diego County, California. *Tobacco Control* 2(2):145–151.

Kim, A. E., B. R. Loomis, A. H. Busey, M. C. Farrelly, J. G. Willett, and H. R. Juster. 2013. Influence of retail cigarette advertising, price promotions, and retailer compliance on youth smoking-related attitudes and behaviors. *Journal of Public Health Management and Practice* 19(6):E1–E9.

Kostova, D., H. Ross, E. Blecher, and S. Markowitz. 2011. Is youth smoking responsive to cigarette prices? Evidence from low- and middle-income countries. *Tobacco Control* 20(6):419–424.

Krevor, B. S., W. R. Ponicki, J. W. Grube, and W. DeJong. 2011. The effect of mystery shopper reports on age verification for tobacco purchases. *Journal of Health Communications* 16(8):820–830.

Kuendig, H. 2011. Enforcement of regional bans on tobacco sales to minors in Switzerland—Example of missed opportunity? *European Journal of Public Health* 21(6):750–752.

Kuiper, N. M., D. E. Nelson, and M. Schooley. 2005. *Evidence of effectiveness: A summary of state tobacco control program evaluation literature*. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

Kypri, K., R. B. Voas, J. D. Langley, S. C. R. Stephenson, D. J. Begg, A. S. Tippetts, and G. S. Davie. 2006. Minimum purchasing age for alcohol and traffic crash injuries among 15- to 19-year-olds in New Zealand. *American Journal of Public Health* 96(5):126–131.

Landrine, H., E. A. Klonoff, and A. Reina-Patton. 2000. Minors' access to tobacco before and after the California STAKE Act. *Tobacco Control* 9(Suppl 2):II15–II17.

Langer, L. M., and G. J. Warheit. 2000. Teen tobacco court: A determination of the short-term outcomes of judicial processes with teens engaging in tobacco possession. *Adolescent & Family Health* 1(1):5–10.

Laugesen, M., and B. Swinburn. 2000. New Zealand's tobacco control programme, 1985–1998. *Tobacco Control* 9(2):155–162.

Lazovich, D., J. Forster, R. Widome, and P. VanCoevering. 2007. Tobacco possession, use, and purchase laws and penalties in Minnesota: Enforcement, tobacco diversion programs, and youth awareness. *Nicotine & Tobacco Research* 9(Suppl 1):S57–S64.

Levinson, A. H., and T. Mickiewicz. 2007. Reducing underage cigarette sales in an isolated community: The effect on adolescent cigarette supplies. *Preventive Medicine* 45(6):447–453.

Ling, P. M., A. Landman, and S. A. Glantz. 2002. It is time to abandon youth access tobacco programmes. *Tobacco Control* 11(1):3–6.

Livingood, W. C., C. D. Woodhouse, J. J. Sayre, and P. Wludyka. 2001. Impact study of tobacco possession law enforcement in Florida. *Health Education and Behavior* 28(6):733–748.

Lovenheim, M. F., and J. Slemrod. 2010. The fatal toll of driving to drink: The effect of minimum legal drinking age evasion on traffic fatalities. *Journal of Health Economics* 29(1):62–77.

Luke, D. A., K. A. Stamatakis, and R. C. Brownson. 2000. State youth-access tobacco control policies and youth smoking behavior in the United States. *American Journal of Preventive Medicine* 19(3):180–187.

Ma, G. X., S. Shive, and M. Tracy. 2001. The effects of licensing and inspection enforcement to reduce tobacco sales to minors in greater Philadelphia, 1994–1998. *Addictive Behaviors* 26(5):677–687.

MacCoun, R., and P. Reuter. 2001. Evaluating alternative cannabis regimes. *British Journal of Psychiatry* 178:123–128.

Mawkes, L., M. Swanson, L. Wood, P. Markham, N. De Klerk, and N. Walker. 1997. Choking the supply: Restricting the sale of cigarettes to children in western Australia. *Health Promotion Journal of Australia* 7(1):22–28.

McCartt, A. T., L. A. Hellinga, and B. B. Kirley. 2010. The effects of minimum legal drinking age 21 laws on alcohol-related driving in the United States. *Journal of Safety Research* 41(2):173–181.

McDermott, S. R., K. L. Scott, and M. P. Frintner. 1998. Accessibility of cigarettes to minors in suburban Cook County, Illinois. *Journal of Community Health* 23(2):153–160.

Millett, C., J. T. Lee, D. C. Gibbons, and S. A. Glantz. 2011. Increasing the age for the legal purchase of tobacco in England: Impacts on socio-economic disparities in youth smoking. *Thorax* 66(10):862–865.

Model, K. E. 1993. The effect of marijuana decriminalization on hospital emergency room drug episodes, 1975–1978. *Journal of the American Statistical Association* 88(423):737–747.

Moore, M. H. 1973. Policies to achieve discrimination on the effective price of heroin. *American Economic Review* 63(2):270–277.

Naidoo, J., and C. Platts. 1985. Smoking prevention in Bristol: Getting maximum results using minimum resources. *Health Education Journal* 44(1):39–42.

Nikaj, S., and F. J. Chaloupka. 2014. The effect of prices on cigarette use among youths in the Global Youth Tobacco Survey. *Nicotine & Tobacco Research* 16(Suppl 1):S16–S23.

Norberg, K. E., L. J. Bierut, and R. A. Grucza. 2009. Long-term effects of minimum drinking age laws on past-year alcohol and drug use disorders. *Alcoholism: Clinical and Experimental Research* 33(12):2180–2190.

NPHD (Needham Public Health Department). 2008. Thirteen years of tobacco efforts in Needham. http://www.needhamma.gov/DocumentCenter/Home/View/1868 (accessed November 20, 2014).

———. 2012. Metrowest adolescent health survey—Highlights from Needham High School, 2012. http://www.needhamma.gov/documentcenter/view/8554 (accessed January 17, 2014).

O'Malley, P. M., and A. C. Wagenaar. 1991. Effects of minimum drinking age laws on alcohol use, related behaviors and traffic crash involvement among American youth: 1976–1987. *Journal of Studies on Alcohol and Drugs* 52(5):478–491.

Pacula, R. L., R. MacCoun, P. Reuter, J. Chriqui, B. Kilmer, K. Harris, L. Paoli, and C. Schafer. 2005. What does it mean to decriminalize marijuana? A cross-national empirical examination. *Advances in Health Economics and Health Services Research* 16:347–369.

Pearson, D. C., L. Song, R. B. Valdez, and A. S. Angulo. 2007. Youth tobacco sales in a metropolitan county: Factors associated with compliance. *American Journal of Preventive Medicine* 33(2):91–97.

Pierce, J. P., M. M. White, and K. Messer. 2009. Changing age-specific patterns of cigarette consumption in the United States, 1992–2002: Association with smoke-free homes and state-level tobacco control activity. *Nicotine & Tobacco Research* 11(2):171–177.

Plunk, A. D., P. Cavazaos-Rehg, L. J. Bierut, and R. A. Grucza. 2013. The persistent effects of minimum legal drinking age laws on drinking patterns later in life. *Alcoholism: Clinical and Experimental Research* 37(3):463–469.

Pokorny, S. B., L. A. Jason, and M. E. Schoeny. 2003. The relation of retail tobacco availability to initiation and continued smoking. *Journal of Clinical Child and Adolescent Psychology* 32(2):193–204.

Pokorny, S. B., S. Corbin, M. Driscoll, and L. A. Jason. 2008. The effect of enforcement history and ordinance provisions on merchant compliance with tobacco-control laws. *Journal of Social Work Practice in the Addictions* 8(2):228–243.

Powell, L. M., J. A. Tauras, and H. Ross. 2003. *Peer effects, tobacco control policies, and youth smoking behavior.* Chicago, IL: ImpacTeen.

Rigotti, N. A., J. R. DiFranza, Y. Chang, T. Tisdale, B. Kemp, and D. E. Singer. 1997. The effect of enforcing tobacco-sales laws on adolescents' access to tobacco and smoking behavior. *New England Journal of Medicine* 337(15):1044–1051.

Rimpela, A. H., and S. U. Rainio. 2004. The effectiveness of tobacco sales ban to minors: The case of Finland. *Tobacco Control* 13(2):167–174.

Robinson, J., and A. Amos. 2010. A qualitative study of young people's sources of cigarettes and attempts to circumvent underage sales laws. *Addiction* 105(10):1835–1843.

Rocheleau, A. M., and D. Boyum. 1994. *Measuring heroin availability in three cities.* Washington, DC: Executive Office of the President, Office of National Drug Control Policy.

Rogers, T., E. C. Feighery, and H. H. Haladijan. 2008. *Current practices in enforcement of California laws regarding youth access to tobacco products and exposure to secondhand smoke.* Sacramento, CA: California Department of Public Health, California Tobacco Control Program.

Rohrbach, L. A., B. Howard-Pitney, J. B. Unger, C. W. Dent, K. A. Howard, T. B. Cruz, K. M. Ribisl, G. J. Norman, H. Fishbein, and C. A. Johnson. 2002. Independent evaluation of the California Tobacco Control Program: Relationships between program exposure and outcomes, 1996–1998. *American Journal of Public Health* 92(6):975–983.

Ross, H., and F. J. Chaloupka. 2001. *The effect of public policies and prices on youth smoking*. Chicago, IL: ImpacTeen.

———. 2003. The effect of cigarette prices on youth smoking. *Health Economics* 12(3):217–230.

SAMHSA (Substance Abuse and Mental Health Services Administration). 2009. *The NSDUH report: Alcohol use before and after the 21st birthday.* Rockville, MD: Office of Applied Studies.

Sanson-Fisher, R. W., M. J. Schofield, and M. See. 1992. Availability of cigarettes to minors. *Australian Journal of Public Health* 16(4):354–359.

Schensky, A. E., S. S. Smith, D. L. Icenogle, and M. C. Fiore. 1996. Youth tobacco sale compliance checks: Impact on vendor practices and community policy. *Wisconsin Medical Journal* 95(11):775–778.

Schofield, M. J., R. W. Sanson-Fisher, and S. Gulliver. 1997. Interventions with retailers to reduce cigarette sales to minors: A randomised controlled trial. *Australian and New Zealand Journal of Public Health* 21(6):590–596.

Sen, A., and T. Wirjanto. 2010. Estimating the impacts of cigarette taxes on youth smoking participation, initiation, and persistence: Empirical evidence from Canada. *Health Economics* 19(11):1264–1280.

Shults, R. A., R. W. Elder, D. A. Sleet, J. L. Nichols, M. O. Alao, V. G. Carande-Kulis, S. Zaza, D. M. Sosin, and R. S. Thompson. 2001. Reviews of evidence regarding interventions to reduce alcohol-impaired driving. *American Journal of Preventive Medicine* 21(4):66–88.

Skretny, M. T., K. M. Cummings, R. Sciandra, and J. Marshall. 1990. An intervention to reduce the sale of cigarettes to minors. *New York State Journal of Medicine* 90(2):54–55.

Speizer, I. S., M. K. Bean, C. P. Obando, and E. Fries. 2008. Middle school students' perceived access to cigarettes in Virginia. *American Journal of Health Behavior* 32(4):399–410.

Staff, M., L. March, A. Brnabic, K. Hort, J. Alcock, S. Coles, and R. Baxter. 1998. Can nonprosecutory enforcement of public health legislation reduce smoking among high school students? *Australian and New Zealand Journal of Public Health* 22(3 Suppl):332–335.

Stahl, D. O. 1989. Oligopolistic pricing with sequential consumer search. *American Economic Review* 79(4):700–712.

Stillman, F. A., A. M. Hartman, B. I. Graubard, E. A. Gilpin, D. M. Murray, and J. T. Gibson. 2003. Evaluation of the American Stop Smoking Intervention Study (ASSIST): A report of outcomes. *CancerSpectrum Knowledge Environment* 95(22):1681–1691.

Sundh, M., and C. Hagquist. 2004. The importance of a minimum age law for the possibility of purchase of tobacco by adolescents: A study based on Swedish experiences. *Scandinavian Journal of Public Health* 32(1):68–74.

———. 2006. Compliance with a minimum-age law of 18 for the purchase of tobacco—The case of Sweden. *Health Education Research* 21(3):378–385.

———. 2007. Does a minimum-age law for purchasing tobacco make any difference? Swedish experiences over eight years. *European Journal of Public Health* 17(2):171–177.

Tangirala, M. K., E. L. J. McKyer, D. D. Goetze, and J. McCarthy–Jean. 2006. Use of tobacco retailer inspections to reduce tobacco sales to youth: Do inspections increase retailer compliance? *International Journal of Consumer Studies* 30(3):278–283.

Tauras, J. A., S. Markowitz, and J. Cawley. 2005. Tobacco control policies and youth smoking: Evidence from a new era. *Advances in Health Economics and Health Services Research* 16:277–291.

Thomson, C. C., M. Gokhale, L. Biener, M. B. Siegel, and N. A. Rigotti. 2004. Statewide evaluation of youth access ordinances in practice: Effects of the implementation of community-level regulations in Massachusetts. *Journal of Public Health Management and Practice* 10(6):481–489.

Tutt, D., L. Bauer, and J. Difranza. 2009. Restricting the retail supply of tobacco to minors. *Journal of Public Health Policy* 30(1):68–82.

Tworek, C., R. Yamaguchi, D. D. Kloska, S. Emery, D. C. Barker, G. A. Giovino, P. M. O'Malley, and F. J. Chaloupka. 2010. State-level tobacco control policies and youth smoking cessation measures. *Health Policy* 97(2–3):136–144.

Tworek, C., G. A. Giovino, K. M. Cummings, A. Hyland, and F. Chaloupka. 2011. *Youth access tobacco possession, use and purchase laws: Measures of state and local enforcement*. Chicago, IL: ImpacTeen.

Wagenaar, A. C., and T. L. Toomey. 2002. Effects of minimum drinking age laws: Review and analyses of the literature from 1960 to 2000. *Journal of Studies on Alcohol and Drugs* (Suppl 14):206–225.

Wakefield, M., and F. Chaloupka. 2000. Effectiveness of comprehensive tobacco control programmes in reducing teenage smoking in the USA. *Tobacco Control* 9(2):177–186.

Wakefield, M., and G. Giovino. 2003. Teen penalties for tobacco possession, use, and purchase: Evidence and issues. *Tobacco Control* 12(Suppl 1):i6–i13.

Watson, A., and N. Grove. 1999. Larimer County Tobacco and Youth Project. *American Journal of Public Health* 89(4):597–598.

Wildey, M. B., S. I. Woodruff, A. Agro, K. D. Keay, E. Kenney, and T. L. Conway. 1995. Sustained effects of educating retailers to reduce cigarette sales to minors. *Public Health Reports* 110(5):625–629.

Woodruff, S. I., A. D. Erickson, M. B. Wildey, and E. M. Kenney. 1993. Changing retailer knowledge, attitudes, and behaviors related to cigarette sales to minors. *Journal of Community Psychology* 21(3):234–245.

Zaza, S., P. A. Briss, and K. W. Harris. 2005. *The guide to community preventive services: What works to promote health*. New York: Task Force on Community Preventive Services.

7

The Effect on Tobacco Use of Raising the Minimum Age of Legal Access to Tobacco Products

The charge to the committee, as discussed in Chapter 1, was to assess the public health implications of raising the minimum age of legal access to tobacco products (MLA) through a review of the literature on tobacco initiation, modeling, and other approaches, as appropriate. This chapter provides the rationale for the committee's consensus conclusions about the likely effects of raising the MLA on tobacco initiation. The committee's conclusions serve as inputs to the two commissioned models, which provide quantification of the likely effects of increases in the MLA on smoking prevalence in the United States. The two simulation models used for the findings presented in both this chapter and the next (the Cancer Intervention and Surveillance Modeling Network [CISNET] and SimSmoke models) are well established approaches for estimating the likely impact of changes in tobacco control policies on population-level smoking initiation and prevalence, and on population health outcomes. The next chapter (Chapter 8) uses the results presented in this chapter (i.e., the estimates of the effects of different MLA policies on smoking initiation) as inputs for modeling several important public health outcomes, smoking-related morbidity and mortality. Chapter 8 concludes with a discussion of the likely effect of a change in the MLA on the many tobacco-related health effects not modeled.

METHODS

The committee followed a principled and evidence-based process to arrive at its estimates of the potential impact of a change in the MLA on tobacco initiation behavior. First, the committee conducted a review of relevant literature and synthesized the background evidence relevant to understanding age-related effects of tobacco use. This review included attention to the effects of MLA enforcement and the sources through which underage adolescents and young adults get tobacco as well as the development of an understanding of the biological, psychological, social, and environmental influences on tobacco use during adolescence and young adulthood.

Second, through an iterative and consensus-driven process, the committee considered how these age-related effects would translate into potential changes in rates of initiation across different age segments in adolescence and young adulthood. The committee considered the likely magnitude of changes in initiation effects that each of the three policy options under consideration (raising the MLA to 19, 21, or 25 years of age) would have on the different age segments and arrived at ordered, categorical estimates labeled as "small," "medium," or "large."

Third, once consensus about the magnitude of the effect at each age segment and policy option combination was reached, the committee attached numeric ranges to each of the magnitude estimate descriptors. These ranges were developed through consideration of reasonable and conservative estimates of effects from a variety of public health interventions, including prior tobacco-related policy changes and data from the experience of changing the minimum age for alcohol purchase and use. These estimates were well vetted over a series of discussions in the committee. The committee selected ranges that showed increasing relationships with the ordered categories and which ranged in increments of 5 percent (to avoid implying an unrealistic precision in the estimates) from 5 to 30 percent for potential changes in initiation.

Finally, the committee discussed how to deal with the fact that there is scant direct evidence about how raising the MLA would affect tobacco use at different ages and thus that there is necessarily less confidence about some effects than others. The committee has most confidence about the estimates for the effects of raising the MLA to 19 and 21, and it is much less confident in estimates for an MLA of 25 because of the greater degree of extrapolation needed for estimating change. Thus, the inputs of estimates for the simulation models in Chapters 7 and 8 also include a range of potential values, with a broader range for the MLA of 25.

In assessing the possible impact of raising the MLA, the committee made a number of assumptions that affect the conclusions about the magnitude of the estimates and the inputs into the simulation models. Some of these assumptions are discussed in this chapter; others are discussed in Chapter 9. These assumptions include

- While policies implemented in the past will continue to have effects in the future, existing tobacco policies will remain in effect at their current rates and no new policies will be implemented. This assumption was made to isolate the effects of the new MLA.
- Levels of enforcement and of retailers' compliance with age-based laws will remain at levels similar to those that currently exist.
- Noncommercial or social sources (e.g., through social networks of peers, families, and coworkers) of tobacco products will remain essentially as they are now, and no new efforts will be made to enforce the MLA restrictions against noncommercial or social sources who provide tobacco products to underage users.
- Sanctions will be directed as they are now, primarily toward retailers and not toward individual users.
- The new MLA will be applied to all tobacco products. However, the estimates of the magnitudes of effects are based on decades of research on cigarette use and not on other products. The committee acknowledges that the tobacco use landscape is changing rapidly with the introduction of a variety of tobacco products, including electronic nicotine delivery systems (ENDS; e.g., "e-cigarettes"). How these products may change existing patterns of cigarette use is not yet known, however, and thus these potential sources of influence could not be reasonably considered in arriving at estimates.
- The estimate of effects will be constant over time.
- Subpopulation differences in tobacco use that currently exist and that go into current initiation and prevalence rates will continue into the future. The committee did not consider whether there would be differential effects in subpopulations over future years.
- Rates of use of alcohol and other illicit drugs will not change in response to a change in the MLA for tobacco.

RATIONALE FOR EXPECTED IMPACT OF RAISING THE MINIMUM AGE OF LEGAL ACCESS ON INITIATION OF TOBACCO USE

Estimating changes in the prevalence of tobacco use following a change in the MLA requires consideration of how each of the dynamic and interacting biological, psychosocial, and environmental factors contributing to use may vary by age. At any age, prevalence is a function of the rates of initiation (defined here as reaching a minimum of 100 cigarettes/lifetime) and the rates of cessation (defined in models as no use for 2 years after achieving the threshold for initiation). Both initiation and cessation are strongly related to age: Initiation decreases dramatically after young adulthood, and cessation rates start to increase during that same period. Thus, changes in the MLA will have their strongest impact on rates of initiation.

The committee based its estimates on an understanding of factors that are most relevant to achieving the threshold of 100 cigarettes for initiation, the data about which come from the National Health Interview Survey and are used in the simulation models in Chapter 8. The committee considered factors that operate both directly on tobacco use, such as access to tobacco products, and factors that operate more indirectly or distally, such as changes in biological vulnerability to the effects of nicotine with age or changes in social norms that indirectly affect motives for use. Smoking at least 100 cigarettes in one's lifetime goes beyond occasionally trying cigarettes or "experimentation." To achieve the benchmark of 100 cigarettes, an individual must have access to cigarettes over a period of time and is also likely to have developed symptoms of dependence and stronger motives for use beyond any perceived peer or social group pressure (Dierker and Mermelstein, 2010). Thus, the factors that influence vulnerabilities to developing dependence are more central to achieving the initiation threshold than factors related to the vulnerabilities to trying just one cigarette.

A critical component in the development of dependence and in continued tobacco use is the reinforcing effects of nicotine. As reviewed in Chapter 3, adolescents are at a heightened sensitivity to the rewarding effects of nicotine, and this sensitivity diminishes with age (Adriani et al., 2006; Jamner et al., 2003). Thus, the probability of use escalating to dependence after the first few trials is likely to decrease as one moves further away from adolescence. In addition, better developed executive functions provide young adults with increased decision-making capacity compared to younger adolescents, especially during times of emotional arousal (Steinberg, 2007), and, as a consequence, young adults may be less susceptible to cues to use tobacco than adolescents. These changes in biological vulnerabilities with age provide good support for suggesting that initiation rates and overall prevalence will decline with each increase in the MLA.

However, changes in the prevalence of tobacco use may not necessarily be linear with increases in the MLA or equal for all segments of underage individuals. Consider, for example, the declarative effect of raising the MLA. Changing the MLA has an indirect effect of helping to change norms about the acceptability of tobacco use, but this effect may take time to build. In addition, norms about the acceptability of tobacco use are also likely to vary by age, with a more stringent perceived unacceptability the farther away one is in age from the MLA. For example, if the MLA increases to 21, the social unacceptability of smoking is greater for a 16-year-old than it is for a 20-year-old.

Given this assumption that changes in the MLA will have different effects on adolescents at different ages, the committee considered possible changes in initiation rates for three age divisions: (1) children and adolescents under age 15, (2) adolescents between 15 and 17, and (3) individuals at age 18 (for estimates of MLA of 19) or individuals at ages 18–20 or 21–24, for an MLA change to either 21 or 25. These age groupings reflect not just differences in years from the MLA but several important life developmental transitions that play a role in tobacco use as well. These developmental transitions include the increased mobility that comes with driving privileges, changes in social networks as adolescents enter and leave high school or transition to higher education, changes in employment levels and venues, leaving home, and potential changes in relationship status (e.g., marriage) and parenthood (Arnett, 2000, 2004; IOM and NRC, 2014; Settersten and Ray, 2010). Each of these life transitions and markers changes both potential sources of access to tobacco as well as motives for use (Bachman et al., 2002).

Adolescents Less Than 15 Years of Age

A substantial percentage of adolescents under age 15 are not yet in high school and, importantly, not yet of driving age. Adolescents under 15 are less likely to have peer networks that include individuals who are over the MLA (and the distance increases as the MLA increases), and these adolescents are also unlikely to be working in established work environments where they have coworkers who are over the MLA. Thus, social network sources and mobility are most restricted for adolescents under age 15. Social sources are the greatest access point for tobacco for underage youth (see Tables 5-2 and 5-3 in Chapter 5), and changes to the MLA affect the relative ease of availability of tobacco through social sources. For adolescents under 15 years of age, raising the MLA from 18 to 19 may have only a modest impact on reducing social sources, given the closeness in age. If adolescents already have networks with 18-year-olds, then these networks may also include 19-year-olds who have access to tobacco. Increasing the MLA to 21, however, provides a greater distancing of social sources. Although 19-year-olds may still be in high schools and thus potentially influence those under 15, it is far less likely that 21-year-olds are in the same social networks. Increasing the MLA from 21 to 25, however, is not likely to achieve any additional notable reductions in social sources for those under 15 than what is achieved with the 21-year-old MLA policy.

Although social sources play a central role in establishing adolescent tobacco use patterns, other factors that contribute to early adolescent tobacco use (for those who initiate before age 15) may place a limit on the reductions that would be achieved with increases in the MLA. Adolescents who reach a level of 100 cigarettes prior to age 15 may be those who are most susceptible to the reinforcing effects of nicotine, given their neurodevelopmental stage and the brain's increased sensitivity to nicotine during those prime adolescent years (Jamner et al., 2003; Slotkin, 2002; Spear, 2000). These adolescents are also likely to be ones who have higher levels of psychological or substance use comorbidities, and ones for whom tobacco use has critical mood management properties (Kassel et al., 2003). These adolescents are the ones most likely to have a combination of problem behaviors, of which tobacco use is one manifestation (Ellickson et al., 2001; Silk et al., 2003). Their early use may be accelerated by these reinforcing and functional properties of nicotine, and these benefits of tobacco use may outweigh perceived consequences (Baker et al., 2004). These more vulnerable adolescents may also have social networks within which tobacco and other substances are more readily available, regardless of age, or they may have more contact with older individuals (Kobus, 2003). Thus, the committee expects that there may be a limit to the effect that changes in the MLA have on this subset of adolescents who initiate prior to age 15 and that changes in the MLA will not totally eliminate initiation at this young age. Thus, considering the balance of these factors, the committee estimates that, for adolescents under age 15, reductions in initiation will be small for an MLA of 19 and medium for MLAs of 21 and 25.

Adolescents 15 to 17 Years of Age

The committee expects that the greatest gains in reducing tobacco use will be achieved for adolescents between the ages of 15 and 17. This is a critical period in which to intervene to prevent not only an initial trial of tobacco use but also escalation to reach a threshold for initiation. A substantial proportion of adolescents try tobacco during these high school years, but most of these adolescents do not escalate beyond initial "experimentation," and continued access to tobacco products is a major factor in this progression of use (Widome et al., 2007). Initial trials are often motivated by opportunity, social influences, as well as in-the-moment image enhancement, curiosity, and emotional arousals (both positive and negative) (Sarason et al., 1992). For this age group, negative consequences for tobacco use, through parental or school controls, are still relevant (IOM and NRC, 2011), and changes in the MLA are likely to increase these negative consequences as social norms adjust. Yet access to tobacco will still exist. Adolescents in this age group are still most likely to get tobacco through social sources (CDC, 2014; Johnston et al., 2014b). Between the ages of 15 and 17, youth mobility increases with the arrival driving privileges. Adolescents' social networks and potential social sources of tobacco start to grow as some take on formal, part-time jobs with coworkers who may be over the MLA. Changing the MLA for tobacco to 19 may not change social sources substantially for these adolescents, but the committee expects that raising the MLA to 21 will have a substantial impact in reducing the prevalence of tobacco use. Raising the MLA further to 25 may provide only an additional modest reduction in prevalence over that achieved with an MLA of 21, given that the resulting changes to social network sources may not be substantially different. However, boosting the MLA to 25 does have the additional benefit of social norm change.

Balancing these factors, the committee estimates that, for all the policy options considered, the reduction in initiation in the 15- to 17-year-old age group will likely be greater than the reduction in initiation among adolescents less than 15 years of age. Furthermore, the committee estimates that the higher the MLA is raised, the greater the effect on initiation rates is likely to be.

Young Adults 18 to 20 Years of Age

By age 18, many adolescents graduate from high school and have numerous transitions, including entering higher education, being exposed to more adults in the workforce, leaving home, and often experiencing significant changes in social networks (Arnett, 2000, 2004; Bachman et al., 2002; IOM and NRC, 2014; Settersten and Ray, 2010). To date, patterns of initiation have shown a tailing off in initiation by age 18 (see Table 2-8 in Chapter 2). The committee considered an estimate for this age group specifically only in the case of a raise in the MLA to 19, when individuals at age 18 are most directly affected by this policy change. Given that the social networks of 18-year-olds overlap more with the 19-year-olds, the committee expected a small reduction in initiation for 18-year-olds under an MLA of 19. The expected effect on initiation rates is higher for an MLA of 21 and higher still for an MLA of 25. The committee expects the effects of increasing the MLA to 21 or 25 on the initiation rates of 19- and 20-year-olds will be similar to the effects on 18-year-olds. This expectation of increased effect is due primarily to the increased social distancing expected when the MLA is raised to 21 or 25, but it also takes into account the benefits of the additional maturing of executive functions, the decreased sensitivity to the rewarding properties of nicotine, the additional social norms proscribing tobacco use, and the decreased social value of tobacco and motives for its use as individuals enter the workforce or parenthood.

Young Adults 21 to 24 Years of Age

Changes in initiation rates for young adults in the 21–24 age group were considered only for the case of raising the MLA to 25. The probability of initiation at these ages is substantially less than at earlier ages, given the developmental changes in life settings and milestones which are likely to reduce the various motives for smoking (Bachman et al., 2002). In addition, young adults who have not yet begun smoking have likely developed coping strategies other than smoking for dealing with mood management and life stressors. Thus, the overall probability of new initiation is substantially lower. However, current patterns of tobacco marketing suggest that young adults are increasingly being targeted in tobacco promotions (Ling and Glantz, 2002), and tobacco promotions are frequently linked with bar settings and alcohol consumption, which may also keep this age group susceptible to initiation (Ling and Glantz, 2002). In addition, the committee considered that there may be more lax enforcement for an MLA of 25. Considering the balance of factors, the committee anticipates that some reduction in initiation would still occur with a raise in the MLA to 25 but that this reduction will be small.

Rebound

Changes in the MLA for tobacco may also create some rebound effects—that is, delaying initiation to a later age. Rebound will result in increases in initiation over what has been seen historically in a given age group. The committee anticipates that most of the potential rebound from delayed initiation will occur in the first year after the new MLA and that this effect is likely to be modest. The changes in the MLA are likely to have an effect of further moving social norms and attitudes toward discouraging tobacco use and making it less appealing. These social normative changes may help to reduce rebound effects. Rebound may be most likely at the lower end of young adulthood (18–21) and very unlikely after age 25, when decision making has matured, individuals have established other coping strategies, and normative developmental life changes often further push individuals away from tobacco use.

Intensity

The models commissioned by the committee considered only changes in initiation and not changes in intensity of smoking. Intensity is important to consider both because of its strong association with nicotine dependence (Fagerstrom et al., 1990; Prokhorov et al., 1996), and thus difficulties in quitting tobacco use and also because of the strong dose–response relationship between smoking intensity and morbidity (Hu et al., 2006). It is reasonable to expect that changes in the MLA for tobacco will also change the intensity of smoking for underage individuals, given the likely resulting changes in the ease of access to tobacco. At the same time, though, there is a background of ongoing historical changes, with overall consumption and intensity both decreasing among smokers, as there are more environmental restrictions on tobacco use and increasing prices (HHS, 2014). Thus, it is difficult to estimate the independent gains in reducing intensity that will result from changes in the MLA, although the committee expects that these additional gains may be modest. Given this level of uncertainty and the lack of data about potential reductions in intensity, changes in intensity are not included in the modeling. For that reason the overall model estimates may ultimately underrepresent the potential health gains of changes in the MLA for tobacco.

Summary of Committee Estimates and Conclusions of the Likely Effects of Raising the MLA on Tobacco Use Initiation

Table 7-1 summarizes the committee's ordered, categorical estimates of the effects that changes in the MLA will have in reducing initiation for the different age groups. The committee has more confidence in its estimates pertaining to the raising of the MLA to 19 or 21 than it does for raising the MLA to 25 because of the greater level of extrapolation needed for estimating change and other factors with increasing age. There are a variety of reasons for the uncertainty in these estimates. One is the lack of empirical evidence directly linking changes in the MLA and levels of MLA enforcement with changes in tobacco use. Another is the changing array of available tobacco products and uncertainty about how these new products may change patterns of tobacco use. The estimates being used as inputs for the simulation models include a range of potential values, with a broader range for the MLA of 25.

Conclusion 7-1: Increasing the minimum age of legal access to tobacco products will likely prevent or delay initiation of tobacco use by adolescents and young adults.

Conclusion 7-2: Although changes in the minimum age of legal access to tobacco products will directly pertain to individuals who are age 18 or older, the largest proportionate reduction in the initiation of tobacco use will likely occur among adolescents 15 to 17 years old.

Conclusion 7-3: The impact on initiation of tobacco use of raising the minimum age of legal access to tobacco products (MLA) to 21 will likely be substantially higher than raising it to 19, but the added effect of raising the MLA beyond age 21 to age 25 will likely be considerably smaller.

The previous section outlined, in qualitative terms, the expected effects of raising the MLA on initiation of tobacco use. The modeling exercise

TABLE 7-1 Committee Estimates Regarding Effects on Initiation

Reduction in Initiation by Age Group	MLA 19	MLA 21	MLA 25
Reduction in initiation for adolescents under age 15	small	medium	medium
Reduction in initiation for adolescents ages 15–17	small	large	large
Reduction in initiation for young adults age 18	small	medium	medium
Reduction in initiation for young adults ages 19–20	n/a	medium	medium
Reduction in initiation for young adults ages 21–24	n/a	n/a	small

Characteristics of the Age Group That Might Influence Responsiveness to an MLA Increase	Factors Related to Effects on This Age Group as the MLA Increase Is Larger
The youngest adolescents who have access to tobacco products and who persist in using tobacco beyond the first experimentation with them are ones who may be most susceptible to the reinforcing effects of nicotine or who have higher levels of psychological or substance use comorbidities, placing them at greater risk for escalation beyond 100 cigarettes and into established initiation and smoking. These youth may be less affected by increases in the MLA than even slightly older youth.	Younger adolescents are less likely to be in social groups with older adolescents or young adults. Their mobility is most restricted, depending on parents and other adults for transportation, thus reducing ease of access. Social sources remain the greatest access point for tobacco products, so the characteristics of social networks and the problem behaviors in those networks matter. Thus, the effect of MLA 19 will be less than that of MLA 21 or MLA 25.
Changes in the MLA will increase the negative social consequences of tobacco use; adolescents at this age are most likely to get tobacco from social sources, including from coworkers above the MLA.	MLA 21 will begin to change access to tobacco products from social sources, much more so than MLA 19. MLA 25 will have only modest additional changes to social network, but includes benefits of social norm change.
Most graduate from high school and experience life transitions. However, some 18-year-olds are in high school with, or are friends with, 19-year-olds who could purchase tobacco products.	Networks of 18-year-olds overlap with 19-year-olds but less so with those 21 or over.
Young adults benefit from increased executive functioning, as well as decreased sensitivity to rewarding properties of nicotine and decreased social value of tobacco and motives for use as individuals enter workforce or parenthood.	19- and 20-year-olds are often in college or the workforce, and their network of friends includes those age 21 and older. MLA 25 will have only modest additional changes to their social network, but includes benefits of social norm change.
The probability of initiation among young adults ages 21 to 24 is substantially less than at earlier ages. Developmental changes in life setting and milestones are likely to reduce motives for smoking. Young adults in this age group have likely developed coping strategies other than smoking.	There could be more lax enforcement of MLA 25 in this age group. The tobacco industry engages in extensive marketing in bars to which this age group will have legal access; many young adults link smoking and drinking behaviors.

undertaken by the committee required quantification of these effects; the next section details the process by which the committee translated the qualitative terms into specific quantitative estimates of effects on the rate of initiation of smoking for various age segments. The SimSmoke and CISNET models used those committee-estimated initiation rates to project the effects of a change in the MLA on smoking prevalence. Chapter 8 then translates those quantitative estimates of effects on initiation and prevalence into quantitative estimates of effects on smoking-related premature mortality, lung cancer mortality, and maternal and child health outcomes using the simulation models that track lifetime trajectories of smoking behavior post-initiation. Chapter 8 also includes a discussion of the likely effect of changes in tobacco use on the many important adverse health effects not encompassed by the modeling exercises.

ESTIMATED INITIATION EFFECT SIZES

As described above, the committee used a consensus process to arrive at estimates for changes in initiation rates. As shown above in Table 7-1, the committee decided on three qualitative descriptors, labeled small, medium, and large. The committee attached numeric ranges to each of these magnitude descriptors. The ranges increase in increments of 5 percent (to avoid implying an unrealistic precision in the estimates) from 5 to 30 percent for potential changes in initiation. Small effects were considered to be 5 and 10 percent; medium effects were 15 and 20 percent; and large effects were 25 and 30 percent.

These estimates can be compared to effect sizes from a variety of tobacco control policies. The committee provides this brief summary not to make direct comparisons between other researchers' findings and the committee's estimates but to illustrate that the committee's informed judgment about the likely effects of raising the MLA falls within the range of relevant effect sizes identified by or considered reasonable by other tobacco control researchers.

For example, tobacco control policy modules incorporated into the SimSmoke model used estimates from an expert judgment process to project the effects of a variety of interventions on adolescent, young adult, and adult smoking behaviors. As shown in Table D-1, these effects range from 1 percent to 50 percent. Of note, the effect size of the youth access restriction module in SimSmoke range from 2.5 percent to 30 percent. A modeling exercise assessing the cost-effectiveness of raising the legal smoking age in California, an effort not dissimilar from that in this report, used a range of 10 to 50 percent decrease in initiation for the projected effect on those under age 21 (Ahmad, 2005).

Flay (2007) summarized the effects of school-based prevention programs using a relative risk reduction calculation and estimated that the potential medium-term (2–4 years) effects of a national program of well-implemented, school-based smoking prevention programs of proven effectiveness would be approximately 28 percent, rising to a potential 31 percent if the programming included a mass media component as well. A recent review of the effectiveness of increases in tobacco product excise taxes and fees on initiation of tobacco use in young people reports –0.43 as the median estimate of the elasticity of adolescent initiation with respect to price, meaning that a 10 percent increase in price would result in a 4.30 percent decrease in initiation (CPSTF, 2012).

Table 7-2 summarizes the committee's estimates for percent reductions in initiation rates and potential rebound effects for the different age groupings assuming a change in the MLA to 19, 21, or 25 years of age, referred to as MLA 19, MLA 21, or MLA 25, respectively. The effect sizes used in the modeling reflect the committee's judgment about the effect of an increase in the MLA on the entire United States. Some regions or subpopulations might experience larger effects, some smaller. The largest effect size used in other modeling exercises identified by the committee is 50 percent. The committee thinks that is overly optimistic and chose to use more conservative estimates in the modeling, although upper estimates are provided.

In addition, the committee recognized that although there is limited direct evidence about how raising the MLA might affect tobacco use at different ages, there is less confidence about some effects than others. The committee is the most confident about the estimates related to an MLA of 19 and 21 and is much less confident regarding estimates related to an MLA of 25 because of the greater level of extrapolation needed for estimating changes. To address this uncertainty, the committee includes ranges (upper and lower estimates) around each mid-estimate that vary according to the degree of the committee's uncertainty. Thus, the estimates for the MLA of 25 used the broader range. The effect ranges do not represent bounds or a measure of uncertainty in the classical statistical sense. Rather these values reflect ranges that the committee deemed plausible (see Table 7-3). As will be discussed, the models simulate national cigarette smoking patterns and, in Chapter 8, their consequences. However, the committee's effect sizes are percentage decreases from the status quo and thus would apply to any jurisdiction of any size assuming the jurisdiction roughly mirrors the United States as a whole. Absolute numbers of people affected would vary with the size of the population. The implications of this are discussed in Chapter 9.

MODELING

For this report, the committee used the CISNET smoking population model (hereafter referred to simply as the CISNET model) calibrated to data from 36 National Health Interview Surveys covering the years 1965–

TABLE 7-2 Committee Estimates Regarding Effects on Initiation with Qualitative Descriptors and Numeric Estimates

	MLA 19		MLA 21		MLA 25	
Reduction in Initiation by Age Group	Qualitative Descriptor	Numeric Estimate	Qualitative Descriptor	Numeric Estimate	Qualitative Descriptor	Numeric Estimate
Reduction in initiation for adolescents under age 15	small	5%	medium	15%	medium	15%
Reduction in initiation for adolescents ages 15–17	small	10%	large	25%	large	30%
Reduction in initiation for young adults age 18	small	10%	medium	15%	medium	20%
Reduction in initiation for young adults ages 19–20	n/a	n/a	medium	15%	medium	20%
Reduction in initiation for young adults ages 21–24	n/a	n/a	n/a	n/a	small	5%

TABLE 7-3 Committee Inputs to the Model for Each MLA Policy Option with Qualitative Descriptors, Numeric Estimates, and Upper and Lower Range Estimates

	MLA 19		MLA 21		MLA 25	
Change in Initiation	Qualitative Descriptor and Numeric Estimate	Upper and Lower Estimates[a]	Qualitative Descriptor and Numeric Estimate	Upper and Lower Estimates[a]	Qualitative Descriptor and Numeric Estimate	Upper and Lower Estimates[a]
Reduction in initiation for adolescents under age 15	small (5%)	(4.2%, 6%)	medium (15%)	(12.5%, 18%)	medium (15%)	(10.7%, 21%)
Reduction in initiation for adolescents ages 15–17	small (10%)	(8.3%, 12%)	large (25%)	(20.8%, 30%)	large (30%)	(21.4%, 42%)
Reduction in initiation for young adults age 18	small (10%)	(8.3%, 12%)	medium (15%)	(12.5%, 18%)	medium (20%)	(14.3%, 28%)
Reduction in initiation for young adults ages 19–20	n/a	n/a	medium (15%)	(12.5%, 18%)	medium (20%)	(14.3%, 28%)
Reduction in initiation for young adults ages 21–24	n/a	n/a	n/a	n/a	small (5%)	(3.6%, 7%)
Rebound	small (5%)	(4.2%, 6%)	small (5%)	(4.2%, 6%)	none (0%)	n/a
Duration of rebound (in number of years)	2	n/a	2	n/a	0	n/a

[a] Upper and lower estimates reflect the uncertainty ranges, with a smaller range (1.2) for MLA 19 and MLA 21, and a larger range (1.4) for MLA 25. The mid-estimate is treated as a geometric mean, not an arithmetic mean, thus, upper estimates are calculated as 1.2(x) and lower estimates as x/1.2 for MLA 19 and MLA 21 and as 1.4(x) and x/1.4 for MLA 25, resulting in slightly nonsymmetric ranges around the mid-estimates. These ranges do not represent bounds or a measure of uncertainty in a classical statistical sense. Rather, these values reflect ranges that the committee deemed plausible as described in the text.

2012 (Holford et al., 2014) to simulate age-specific smoking prevalence and mortality outcomes for birth cohorts projected through 2100. Using the smoking initiation estimates developed by the committee as inputs, the model was used to assess the potential effects of raising the MLA on U.S. smoking patterns by birth cohort and calendar year and the corresponding smoking-attributable mortality, life expectancy, and lung cancer deaths, using lung cancer projections from the CISNET Yale Lung Cancer Model (Holford et al., 2012).This report also used a recently updated version of the SimSmoke model that assumes the same smoking-rate inputs used by the CISNET model based on NHIS (Holford et al., 2014) and beginning in 1965. SimSmoke is able to reproduce the population smoking patterns by gender and by age in the United States from 1965 through 2012 (Levy, under review; Levy et al., under review), and it predicts the impact of current and future policies from 2015 through 2100. The initiation rates from 2015 forward reflect the effect of past policies under the assumption that policies other than raising the MLA will remain at 2014 levels into the future. As such, the initiation rates remain constant in future years under the status quo policy option. More details about the models can be found in Appendix D.

The models focused on characterizing the potential effects of raising the MLA on future rates of smoking initiation rates by age (the probability of becoming an established smoker at a given age, conditional on not having started before), considering both the prevention of smoking initiation for individuals younger than the new MLA (*prevented initiation*) and the delay of smoking initiation for some individuals who will start at an older age because of the policy (*delayed initiation*). The modeled policy effects varied by age, with assumed reductions in smoking initiation rates among individuals younger than the new MLA, while allowing for a potential increase (*rebound*) in the smoking initiation rates for individuals of or above the MLA (*delayed smoking initiation*).

Effects of Raising the MLA on Smoking Initiation

Figure 7-1 shows the initiation rates for the baseline (the current MLA) for both CISNET and SimSmoke and the corresponding mid-estimate for the smoking initiation inputs for the MLA 21. The SimSmoke baseline initiation rates are generally higher than those of the CISNET model. The specific initiation rates used in both models can be accessed on the CISNET webpage.[1] Applying the CISNET initiation rates directly to a hypothetical birth cohort of 100,000 individuals would result roughly in 30,000 ever smokers by age 40. Applying the reductions in the mid MLA 21 scenario

[1] See https://resources.cisnet.cancer.gov/projects/#shg/iomr.

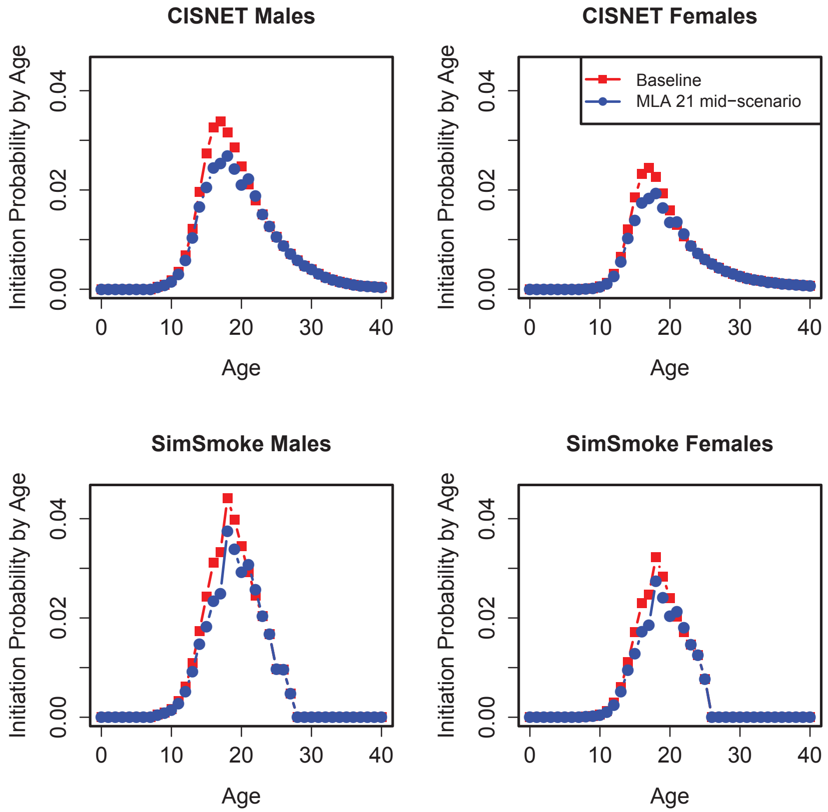


FIGURE 7-1 Initiation rates by age under baseline and middle scenarios for the effects of raising the MLA to 21.

would translate into 10 percent fewer smokers, with approximately 3,000 individuals never initiating plus another 600 individuals delaying smoking initiation until an older age (data not shown).

Smoking Prevalence

The models estimate the impact of reduced and delayed initiation on future annual U.S. smoking prevalence (described below) and smoking-related health outcomes (shown in Chapter 8), assuming that the MLA would change in 2015 and go into full effect immediately (with progressive staggered implementation evaluated in sensitivity analyses). Although raising the MLA could also affect future rates of cessation and smoking intensity, the models did not incorporate effects on these rates because of uncertainty about the potential impacts. Thus, this represents a conservative assumption (one that underestimates the health benefits of the MLA policy), considering the substantial evidence linking delayed initiation with higher smoking cessation and lower smoking consumption rates.

Status Quo Projections

Any projections into the future imply some uncertainty because one cannot observe future outcomes before they occur. However, models provide an opportunity to explore the potential outcomes associated with various policy options and compare with the status quo, assuming all else remains unchanged. Both of the models employed by the committee begin with the creation of a baseline projection that assumes no change in the MLA; this serves as the status quo projection. The models are then run assuming the altered initiation rates provided by the committee (see Table 7-2) beginning after 2015. To characterize the incremental impacts of policy changes that are predicted by the model, the committee subtracted the outcome result for the baseline or status quo policy from the outcome result for the new MLA policy and then divided by the baseline outcome result, thus expressing the change as a percentage.

Both models project the baseline smoking prevalence in the United States from 2015 to 2100 assuming that smoking initiation and cessation rates will remain the same in all future years, but they do so in different ways and at different levels. CISNET projects that the age-specific initiation and cessation rates by gender estimated *for the 1980 birth cohort* will apply to all future birth cohorts. By contrast, SimSmoke assumes that the estimated age-specific initiation and cessation rates by gender observed *for the year 2014* will persist throughout the modeled horizon (effectively assuming that tobacco control policies will remain at current levels). Although the differences may seem relatively minor, they lead to different projected smoking rates at the baseline for the two models. To facilitate comparison of the projected policy consequences associated with raising the MLA, the focus here will be on the relative effects of the MLA policy (i.e., the percentage reductions in smoking, mortality, and other health outcomes) while noting uncertainty about the absolute magnitude of the status quo.

Effects of Changing the MLA on Smoking Prevalence

Figure 7-2 shows projected smoking prevalence in the United States from 2014 to 2100 by gender as estimated by the CISNET model for the status quo and the three MLAs considered. The figure shows that even under the status quo, the CISNET model predicts a decrease in adult smok-

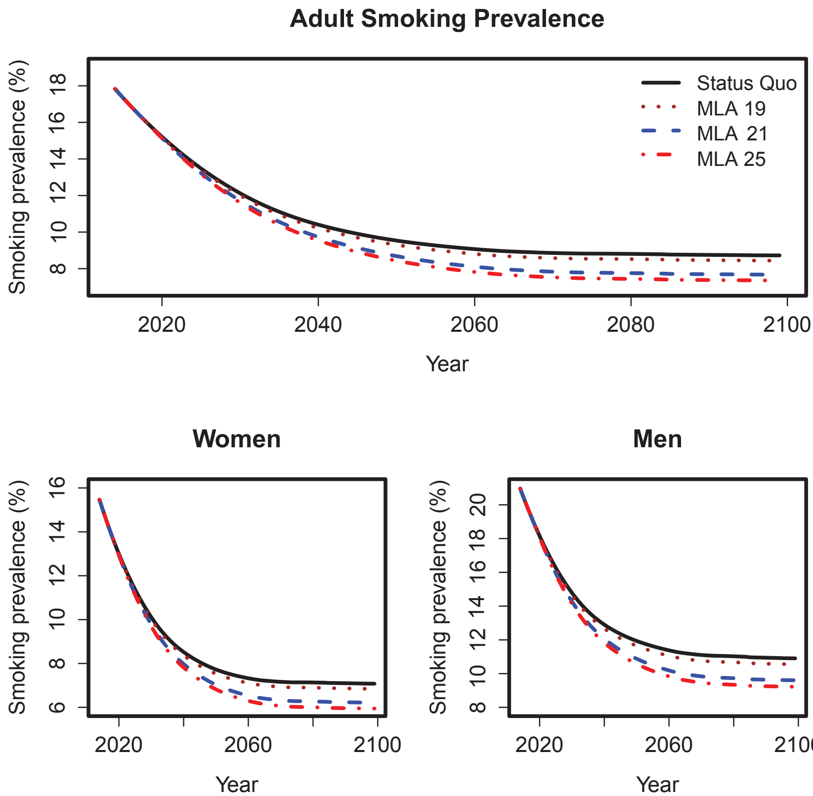


FIGURE 7-2 CISNET model-projected smoking prevalence for the three mid-MLA scenarios for adults (18+), adult women, and adult men in the United States for 2014–2100.

ing prevalence from 18 percent in 2014 to 9 percent in 2100 (15 percent in 2014 to 7 percent in 2100 for females and 21 percent in 2014 to 11 percent in 2100 for males).

The figure also suggests that the MLA 21 and MLA 25 options lead to considerable further reductions in smoking prevalence relative to MLA 19. Switching to a progressive staggered implementation of the policy (i.e., for an MLA greater than 19, increasing the MLA by 1 year each calendar year until reaching the desired MLA) did not significantly change the results (not shown).

Figure 7-3 shows the corresponding projection from the SimSmoke model. As can be seen, the SimSmoke model also projects a significant

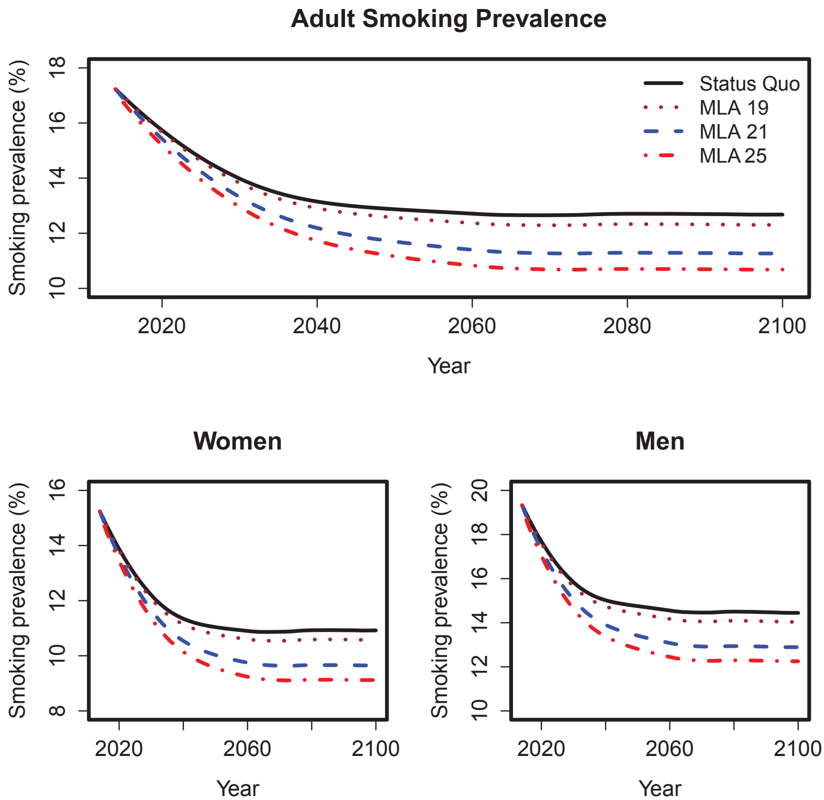


FIGURE 7-3 Projected smoking prevalence predicted by the SimSmoke model for adults (18+), adult women, and adult men in the United States for 2014–2100.

reduction in adult smoking prevalence—from 17 percent in 2014 to 13 percent in 2100 (15 percent in 2014 to 11 percent in 2100 for females and 19 percent in 2014 to 14 percent in 2100 for males)—to occur in the following decades. As shown in these figures, the SimSmoke model projects smaller decreases in prevalence than does the CISNET model because of the underlying lower baseline smoking initiation and higher (not shown) cessation rates in the CISNET model. Both models project that MLA 21 and MLA 25 would lead to larger reductions in smoking prevalence compared to MLA 19.

Table 7-4 shows a comparison between the two models of the projected adult smoking prevalence and the absolute percentage reductions in prevalence versus the status quo for selected years. The ranges in percentage

TABLE 7-4 Adult (18+) Smoking Prevalence (%) and Percentage (%) Reduction for Selected Years for the Mid-Estimates of Initiation Inputs from Table 7-3 (lower and upper estimate results shown in parentheses)

MLA/Outcome	2020	2040	2060	2080	2100
SQ (status quo)					
SimSmoke prevalence	15.7	13.1	12.7	12.7	12.7
CISNET prevalence	15.2	10.4	9.1	8.8	8.7
MLA 19					
SimSmoke prevalence	15.7	12.9	12.4	12.3	12.3
reduction versus SQ	0.4%	1.8%	2.7%	3.0%	**3.0%**
	(0.2, 0.6)	(1.3, 2.4)	(1.9, 3.5)	(2.1, 3.9)	(2.1, 3.9)
CISNET prevalence	15.2	10.2	8.8	8.5	8.4
reduction versus SQ	0.2%	1.8%	2.9%	3.3%	**3.3%**
	(0.14, 0.21)	(1.5, 2.3)	(2.4, 3.8)	(2.7, 4.3)	(2.7, 4.3)
MLA 21					
SimSmoke prevalence	15.4	12.2	11.4	11.3	11.2
reduction versus SQ	2.0%	8.3%	10.3%	11.2%	**11.2%**
	(1.5, 2.4)	(5.8, 8.9)	(8.3, 12.7)	(9.0, 13.7)	(9.0, 13.7)
CISNET prevalence	15.1	9.7	8.1	7.8	7.7
reduction versus SQ	0.4%	6.4%	10.6%	11.9%	**12.0%**
	(0.37, 0.53)	(5.4, 8.8)	(8.8, 12.9)	(9.9, 14.5)	(10.0, 14.7)
MLA 25					
SimSmoke prevalence	15.2	11.7	10.8	10.7	10.7
reduction versus SQ	3.4%	10.8%	14.8%	15.8%	**15.8%**
	(2.9, 4.8)	(9.2, 15.2)	(12.6, 20.9)	(13.4, 22.3)	(13.4, 22.3)
CISNET prevalence	15.1	9.5	7.8	7.4	7.3
reduction versus SQ	0.5%	8.3%	13.8%	15.6%	**15.7%**
	(0.36, 0.71)	(5.9, 11.7)	(9.8, 19.4)	(11.1, 21.9)	(11.2, 22.1)

reduction represent the results from the lower and upper estimate scenarios (see Table 7-3) for effects on initiation for each MLA option. The results in Table 7-4 demonstrate that although the absolute prevalence predictions differ between the models, the two models predict similar percentage reductions in smoking for each MLA relative to the status quo. Specifically, both models estimate a roughly 3 percent decrease in the 2100 prevalence for the mid-MLA 19, an 11–12 percent decrease for the mid-MLA 21 scenario, and a 15.7 percent decrease for the mid-MLA 25 scenario.

Summary of Smoking Prevalence Projections

The modeling analysis suggests that raising the MLA for tobacco products could lead to considerable reductions in smoking prevalence. Both models suggest that it would take about a decade for the reductions in population-wide smoking prevalence to become meaningful; the delay can be attributed to the nature of the policy, which primarily affects children, adolescents, and young adults, so the effects become apparent only after those individuals affected by the policy have aged. Still, the projections show that with time the potential reductions and delays in smoking initiation would accumulate and lead to considerable decreases in prevalence.

Both models suggest that there is a considerable difference between the results of MLA 19 and MLA 21. Increasing the MLA from 21 to 25 leads to additional reductions, but they are smaller than the changes seen increasing the MLA from 19 to 21. This reflects the uncertainty in the assumed smoking initiation reductions for each MLA and the overlapping ranges for MLA 21 and MLA 25 (wider effect ranges for MLA 25).

Finding 7-1: Two policy simulation models project significant reductions in smoking prevalence from 2015 to 2100 in the United States in a status quo policy that captures the benefits from prior tobacco control policies.

Finding 7-2: The models predict that raising the minimum age of legal access to tobacco products would lead to additional reductions beyond the status quo in smoking prevalence based on reasonably conservative assumptions about the potential reductions in smoking initiation rates.

Finding 7-3: Raising the minimum age of legal access to tobacco products to 21 or 25 years would lead to larger reductions in smoking prevalence than the status quo or an increase of the MLA to 19.

Conclusion 7-4: Based on the modeling, raising the minimum age of legal access to tobacco products, particularly to age 21 or 25, will likely lead to substantial reductions in smoking prevalence.

As discussed in Chapter 2, tobacco use is far from uniform among various subpopulations and varies, for example, by race and ethnicity, social and economic status, geography, incarceration status, and the presence of mental illness (Bachman et al., 2011; Cropsey et al., 2004, 2008; Goodman and Capitman, 2000; Green et al., 2007; HHS, 2012; Johnson et al., 2000; Johnston et al., 2014a; Kann et al., 2014; Melnick et al., 2001; Peek et al., in preparation; SAMHSA, 2012; Welte et al., 2011; Ziedonis et al., 2008). Tobacco control advocates interested in decreasing tobacco use are particularly concerned about closing the "equity gap" by reducing tobacco use among the highest-risk populations. An important consideration for the committee is whether a change in the MLA would differentially affect high-risk populations with initiation rates that vary significantly from the national averages considered in this report, including the rates contained in the modeling. One possibility is that groups with higher-than-average initiation rates would remain relatively resistant to tobacco control interventions and the effect would be smaller in those populations, widening the equity gap. The equity gap could be narrowed if groups with lower-than-average initiation rates respond less to an increase in the MLA. The third possibility is that the effects will not vary significantly between groups.

The literature provides little evidence to clarify this issue. Two recent systematic reviews of the effects of population-level tobacco control interventions on adolescents and young adults found no clear evidence of a differential impact by social factors. One review found "little evidence of policies that have the potential to increase inequalities" (Thomas et al., 2008, p. 235). The second review identified price as the only intervention with a consistent effect that would decrease the inequalities in smoking initiation (Brown et al., 2014). Given the extremely limited data available and the fact that the models are not equipped to analyze according to high-risk populations, the committee did not produce separate analyses of the effect of raising the MLA by subpopulation. The committee's conclusions also do not anticipate the changing landscape of tobacco products—in particular, the burgeoning popularity of electronic nicotine delivery systems (ENDS) (e.g., "e-cigarettes"). This new pattern of tobacco use creates various unknowns. The committee has no basis on which to conclude that the effect of a change in the MLA would have more or less effect on initiation with ENDS than with other tobacco products. Both of these limitations are discussed further in Chapter 9.

REFERENCES

Adriani, W., V. Deroche-Gamonet, M. Le Moal, G. Laviola, and P. V. Piazza. 2006. Pre-exposure during or following adolescence differently affects nicotine-rewarding properties in adult rats. *Psychopharmacology* 184(3–4):382–390.

Ahmad, S. 2005. Closing the youth access gap: The projected health benefits and cost savings of a national policy to raise the legal smoking age to 21 in the United States. *Health Policy* 75(1):74–84.

Arnett, J. J. 2000. Emerging adulthood: A theory of development from the late teens through the twenties. *American Psychologist* 55(5):469–480.

———. 2004. *Emerging adulthood: The winding road from the late teens through the twenties.* New York: Oxford University Press.

Bachman, J. G., P. M. O'Malley, J. E. Schulenberg, L. D. Johnston, A. L. Bryant, and A. C. Merline. 2002. *The decline of substance use in young adulthood changes in social activities, roles, and beliefs*. Mahwah, NJ: Lawrence Erlbaum Associates.

Bachman, J. G., P. M. O'Malley, L. D. Johnston, J. E. Schulenberg, and J. M. Wallace, Jr. 2011. Racial/ethnic differences in the relationship between parental education and substance use among U.S. 8th-, 10th-, and 12th-grade students: Findings from the Monitoring the Future project. *Journal of Studies on Alcohol and Drugs* 72(2):279–285.

Baker, T. B., T. H. Brandon, and L. Chassin. 2004. Motivational influences on cigarette smoking. *Annual Review of Psychology* 55:463–491.

Brown, T., S. Platt, and A. Amos. 2014. Equity impact of interventions and policies to reduce smoking in youth: Systematic review. *Tobacco Control* 23(e2):e98–e105.

CDC (Centers for Disease Control and Prevention). 2014. National Youth Tobacco Survey. http://www.cdc.gov/tobacco/data_statistics/surveys/nyts (accessed February 8, 2015).

CPSTF (Community Preventive Services Task Force). 2012. Reducing tobacco use and secondhand smoke exposure: Interventions to increase the unit price for tobacco products. http://www.thecommunityguide.org/tobacco/RRincreasingunitprice.html (accessed January 20, 2015).

Cropsey, K., G. D. Eldridge, and T. Ladner. 2004. Smoking among female prisoners: An ignored public health epidemic. *Addictive Behaviors* 29(2):425–431.

Cropsey, K. L., J. A. Linker, and D. E. Waite. 2008. An analysis of racial and sex differences for smoking among adolescents in a juvenile correctional center. *Drug and Alcohol Dependence* 92(1–3):156–163.

Dierker, L., and R. Mermelstein. 2010. Early emerging nicotine-dependence symptoms: A signal of propensity for chronic smoking behavior in adolescents. *Journal of Pediatrics* 156(5):818–822.

Ellickson, P. L., J. S. Tucker, and D. J. Klein. 2001. High-risk behaviors associated with early smoking: Results from a 5-year follow-up. *Journal of Adolescent Health* 28(6):465–473.

Fagerstrom, K. O., T. F. Heatherton, and L. Kozlowski. 1990. Nicotine addiction and its assessment. *Ear, Nose, and Throat Journal* 69(11):763–765.

Flay, B. R. 2007. *The long-term promise of effective school-based smoking prevention programs*. Paper commmissioned by the Committee on Reducing Tobacco Use: Strategies, Barriers, and Consequences, Institute of Medicine. In *Ending the tobacco problem* (see Appendix D). Edited by R. J. Bonnie. Washington, DC: The National Academies Press.

Goodman, E., and J. Capitman. 2000. Depressive symptoms and cigarette smoking among teens. *Pediatrics* 106(4):748–755.

Green, M. P., K. L. McCausland, H. Xiao, J. C. Duke, D. M. Vallone, and C. G. Healton. 2007. A closer look at smoking among young adults: Where tobacco control should focus its attention. *American Journal of Public Health* 97(8):1427–1433.

HHS (Department of Health and Human Services). 2012. *Preventing tobacco use among youth and young adults: A report of the Surgeon General*. Atlanta GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

———. 2014. *The health consequences of smoking—50 years of progress: A report of the Surgeon General*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

Holford, T. R., K. Ebisu, L. McKay, C. Oh, and T. Zheng. 2012. Chapter 12: Yale lung cancer model. *Risk Analysis* 32(Suppl 1):S151–S165.

Holford, T. R., D. T. Levy, L. A. McKay, L. Clarke, B. Racine, R. Meza, S. Land, J. Jeon, and E. J. Feuer. 2014. Patterns of birth cohort-specific smoking histories, 1965–2009. *American Journal of Preventive Medicine* 46(2):e31–e37.

Hu, M. C., M. Davies, and D. B. Kandel. 2006. Epidemiology and correlates of daily smoking and nicotine dependence among young adults in the United States. *American Journal of Public Health* 96(2):299–308.

IOM and NRC (Institute of Medicine and National Research Council). 2011. *The science of adolescent risk-taking: Workshop report*. Washington, DC: The National Academies Press.

———. 2014. *Investing in the health and well-being of young adults*. Edited by R. J. Bonnie, C. Stroud, and H. Breiner. Washington, DC: The National Academies Press.

Jamner, L. D., C. K. Whalen, S. E. Loughlin, R. Mermelstein, J. Audrain-McGovern, S. Krishnan-Sarin, J. K. Worden, and F. M. Leslie. 2003. Tobacco use across the formative years: A road map to developmental vulnerabilities. *Nicotine & Tobacco Research* 5(Suppl 1):S71–S87.

Johnson, J. G., P. Cohen, D. S. Pine, D. F. Klein, S. Kasen, and J. S. Brook. 2000. Association between cigarette smoking and anxiety disorders during adolescence and early adulthood. *JAMA* 284(18):2348–2351.

Johnston, L. D., P. M. O'Malley, J. G. Bachman, J. E. Schulenberg, and R. A. Miech. 2014a. *Monitoring the Future: National survey results on drug use, 1975–2013. Volume 1: Secondary school students*. Ann Arbor, MI: Institute for Social Research, University of Michigan.

Johnston, L. D., P. M. O'Malley, R. A. Miech, J. G. Bachman, and J. E. Schulenberg. 2014b. *Monitoring the Future: National survey results on drug use, 1975–2013: Overview, key findings on adolescent drug use*. Ann Arbor, MI: Institute for Social Research, University of Michigan.

Kann, L., S. Kinchen, S. L. Shanklin, K. H. Flint, J. Hawkins, W. A. Harris, R. Lowry, E. O'Malley Olsen, T. McManus, D. Chyen, L. Whittle, E. Taylor, Z. Demissie, N. Brener, J. Thornton, J. Moore, and S. Zaza. 2014. Youth risk behavior surveillance—United States, 2013. *Morbidity and Mortality Weekly Report* 63(4):1–168.

Kassel, J. D., L. R. Stroud, and C. A. Paronis. 2003. Smoking, stress, and negative affect: Correlation, causation, and context across stages of smoking. *Psychological Bulletin* 129(2):270–304.

Kobus, K. 2003. Peers and adolescent smoking. *Addiction* 98(Suppl 1):37–55.

Levy, D. T. Under review. The use of SimSmoke to investigate maternal child health outcomes with exposure to cigarette smoke in the United States.

Levy, D. T., R. Meza, Y. Zhang, and T. R. Holford. Under review. The role of tobacco control policies in reducing US smoking prevalence from 1965-2012: Results from the SimSmoke Tobacco Policy Simulation Model.

Ling, P. M., and S. A. Glantz. 2002. Why and how the tobacco industry sells cigarettes to young adults: Evidence from industry documents. *American Journal of Public Health* 92(6):908–916.

Melnick, M. J., K. E. Miller, D. F. Sabo, M. P. Farrell, and G. M. Barnes. 2001. Tobacco use among high school athletes and nonathletes: Results of the 1997 Youth Risk Behavior Survey. *Adolescence* 36(144):727–747.

Peek, K. J., J. Kusel, S. L. Eyre, C. L. Auerswald, and B. L. Halpern-Felsher. In preparation. Understanding smokeless tobacco initiation and use among rural youth: An unexplored population.

Prokhorov, A. V., U. E. Pallonen, J. L. Fava, L. Ding, and R. Niaura. 1996. Measuring nicotine dependence among high-risk adolescent smokers. *Addictive Behaviors* 21(1):117–127.

SAMHSA (Substance Abuse and Mental Health Services Administration). 2012. *National Survey on Drug Use and Health: Comparison of 2002–2003 and 2010–2011 model-based prevalence estimates (50 states and the District of Columbia)*. Rockville, MD: Substance Abuse and Mental Health Services Administration, Center for Behavioral Statistics and Quality, Department of Population Surveys.

Sarason, I. G., E. S. Mankowski, A. V. Peterson, Jr., and K. T. Dinh. 1992. Adolescents' reasons for smoking. *Journal of School Health* 62(5):185–190.

Settersten, R., and B. E. Ray. 2010. *Not quite adults*. New York: Bantam Books.

Silk, J. S., L. Steinberg, and A. S. Morris. 2003. Adolescents' emotion regulation in daily life: Links to depressive symptoms and problem behavior. *Child Development* 74(6):1869–1880.

Slotkin, T. A. 2002. Nicotine and the adolescent brain: Insights from an animal model. *Neurotoxicology and Teratology* 24(3):369–384.

Spear, L. P. 2000. The adolescent brain and age-related behavioral manifestations. *Neuroscience and Biobehavioral Reviews* 24(4):417–463.

Steinberg, L. 2007. Risk taking in adolescence: New perspectives from brain and behavioral science. *Current Directions in Psychological Science* 16(2):55–59.

Thomas, S., D. Fayter, K. Misso, D. Ogilvie, M. Petticrew, A. Sowden, M. Whitehead, and G. Worthy. 2008. Population tobacco control interventions and their effects on social inequalities in smoking: Systematic review. *Tobacco Control* 17(4):230–237.

Welte, J. W., G. M. Barnes, M.-C. O. Tidwell, and J. H. Hoffman. 2011. Tobacco use, heavy use, and dependence among adolescents and young adults in the United States. *Substance Use and Misuse* 46(9):1090–1098.

Widome, R., J. L. Forster, P. J. Hannan, and C. L. Perry. 2007. Longitudinal patterns of youth access to cigarettes and smoking progression: Minnesota Adolescent Community Cohort (MACC) study (2000–2003). *Preventive Medicine* 45(6):442–446.

Ziedonis, D., B. Hitsman, J. C. Beckham, M. Zvolensky, L. E. Adler, J. Audrain-McGovern, N. Breslau, R. A. Brown, T. P. George, and J. Williams. 2008. Tobacco use and cessation in psychiatric disorders: National Institute of Mental Health report. *Nicotine & Tobacco Research* 10(12):1691–1715.

8

Health Benefits of Raising the Minimum Age of Legal Access to Tobacco Products

The preceding chapter describes the committee's conclusions regarding the likely effects of raising the minimum age of legal access to tobacco products (MLA) on initiation of tobacco use by adolescents and young adults under each of the three policy options: MLA 19, MLA 21, or MLA 25. The committee uses SimSmoke and Cancer Intervention and Surveillance Modeling Network (CISNET) simulation modeling to project numerical estimates of how, through to the year 2100, these effects on initiation would affect cigarette smoking prevalence, as the cohorts affected by an MLA increase age into adulthood and, in fact, through middle and older ages. This chapter uses those changes in initiation and prevalence to model the likely effects on morbidity and mortality. Projections from CISNET and SimSmoke include some measures of mortality (premature deaths, years of life lost [YLL], and lung cancer deaths) and of morbidity (low birth weight, pre-term birth, and sudden infant death syndrome, or SIDS). The chapter concludes with the committee's findings and conclusions on the likely effects of raising the MLA on the many other important health outcomes not included in the modeling exercise. See Appendix D for a detailed discussion of the models.

PREMATURE DEATHS PREVENTED

The CISNET model provided estimates of the smoking-attributable mortality by birth cohort (generation) for each policy option for raising the minimum age of legal access to tobacco products.[1] The mortality predictions by birth cohort summarize in a single statistic the cumulative effects of raising the MLA on the mortality experienced by new generations throughout their lifetime.

Table 8-1 presents the CISNET model projections of lifetime deaths prevented by birth cohort (i.e., for the hypothetical population of U.S. individuals born in 2000–2019, 2020–2039, . . ., and 2080–2099) for the status quo as well as the premature deaths[2] prevented by the mid-scenario of the three MLA policy options for initiation, along with the percentage mortality reduction. The projections show that for each MLA the percentage reduction in premature deaths appears to be consistent across birth cohorts; this makes sense because all the cohorts would reach adulthood after—sometimes substantially after—implementation of the law. Nonetheless, the number of deaths prevented for each birth cohort varies because of differences in the projected size of these different cohorts, with more lives saved in a larger cohort than in a smaller cohort even with the same proportionate reductions. The results show that MLA 19 could reduce the lifetime smoking-attributable deaths versus the status quo by approximately 3 percent, with reductions of 11 percent for MLA 21 and 15 percent for MLA 25. Hence, the projected reductions in smoking-related deaths track the long-run projected declines in smoking prevalence. The results show similar patterns for the upper and lower estimates[3] of smoking initiation (see Appendix D).

Figure 8-1 shows the CISNET model estimates of the cumulative numbers of premature deaths prevented from 2014 to 2099 for each MLA; these cumulative numbers aggregate over all individuals in the birth cohorts alive during the time period. The lines represent the mid-estimate, and the shaded regions correspond to the upper and lower (see Table 8-2). The figure shows the considerable gains achieved by both MLA 21 and MLA 25

[1] Modeling results are presented as cohort effects or period effects. Cohort effects are patterns that differentiate individuals born in the same epoch or generation. Period effects are patterns that characterize individuals who happened to be alive at a certain point in time, independent of their age or generation.

[2] Premature deaths are the difference between the effective mortality rate versus the mortality rate of never smokers multiplied by the corresponding age-specific population (see Appendix D).

[3] As described in Chapter 7, the simulation models include a range of potential values, resulting in upper and lower estimates around the mid-estimate that vary according to the degree of the committee's uncertainty, with a broader range for the MLA of 25. The effect ranges do not represent bounds or a measure of uncertainty in the classical statistical sense. Rather, these values reflect ranges that the committee deemed plausible. The mid-estimate is treated as a geometric mean rather than an arithmetic mean; thus, upper estimates are calculated as 1.2(x) and lower estimates as x/1.2 for MLA 19 and MLA 21 and as 1.4(x) and x/1.4 for MLA 25, resulting in slightly nonsymmetric ranges around the mid-estimates.

TABLE 8-1 Lifetime Premature Deaths by Birth Cohort—CISNET Model

	Status Quo	Deaths Averted Under MLA 19 Mid-Scenario	MLA 19 % Reduction	Deaths Averted Under MLA 21 Mid-Scenario	MLA 21 % Reduction	Deaths Averted Under MLA 25 Mid-Scenario	MLA 25 % Reduction
2000–2019	2,160,000	59,000	2.7%	223,000	10.3%	296,000	13.7%
2020–2039	1,996,000	58,000	2.9%	218,000	10.9%	289,000	14.5%
2040–2059	2,024,000	58,000	2.9%	222,000	10.9%	293,000	14.5%
2060–2079	2,097,000	60,000	2.9%	229,000	10.9%	304,000	14.5%
2080–2099	2,171,000	63,000	2.9%	238,000	10.9%	315,000	14.5%

NOTE: Although the table carries many significant figures to aid in reproducibility, precision is limited to one or two digits.

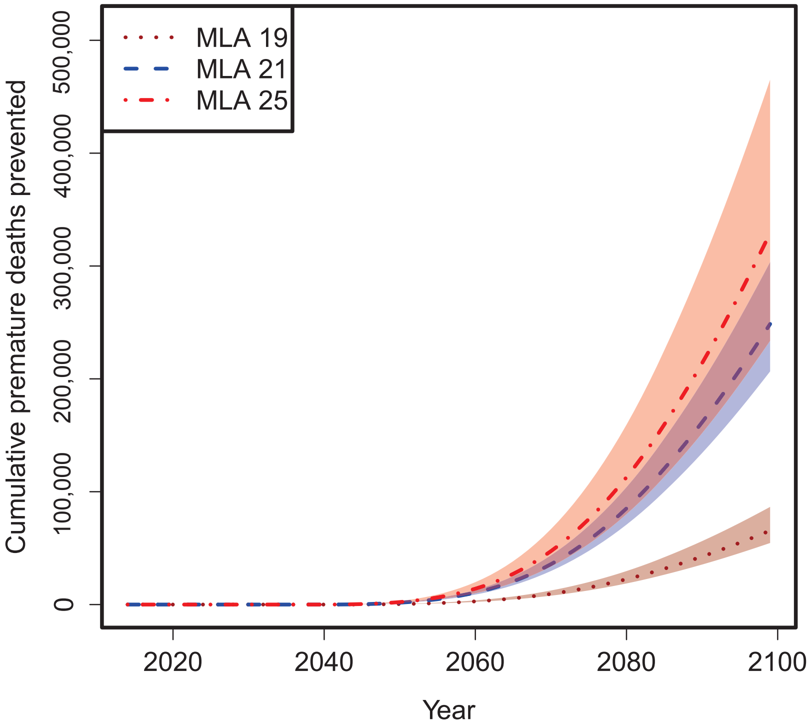


FIGURE 8-1 Predicted number of premature deaths prevented (lives saved) for the three MLA policies using the CISNET model. Lines correspond to the mid-scenario for each MLA. Shaded regions represent the area between the upper and lower scenarios for each MLA.

in comparison with MLA 19, with the mortality benefits beginning many years after implementation of the policy, because smoking-attributed mortality becomes more significant after age 40 and the policy primarily affects adolescent and young adult initiation. The figure shows the preservation of the general patterns across the mid, upper, and lower initiation scenarios.

Table 8-2 shows the predicted number of premature deaths due to smoking for selected periods as well as the corresponding number of deaths prevented and the percentage reduction for each of the MLA mid-estimate scenarios. According to the CISNET model, raising the MLA to 19, 21, or 25 would save approximately 66,000, 250,000, or 330,000 lives, respectively, by 2100. Of those lives saved, 23,000 (MLA 19), 90,000 (MLA 21), and 120,000 (MLA 25) would be premature deaths avoided among people

TABLE 8-2 Cumulative Premature Deaths Expected and Prevented by Period—CISNET

MLA/Outcome	2020–2039	2040–2059	2060–2079	2080–2099	2015–2099
Status Quo					
Premature deaths expected	6,782,000	4,568,000	2,927,000	1,996,000	18,978,000
MLA 19					
Deaths prevented	—	3,000	20,000	43,000	66,000
Percentage reduction	0.0%	0.1%	0.7%	2.2%	0.0%
Deaths prevented (ages <65)	—	3,000	11,000	9,000	23,000
MLA 21					
Deaths prevented	—	11,000	75,000	163,000	249,000
Percentage reduction	0.0%	0.2%	2.6%	8.2%	0.3%
Deaths prevented (ages <65)	—	11,000	43,000	36,000	90,000
MLA 25					
Deaths prevented	—	14,000	99,000	216,000	329,000
Percentage reduction	0.0%	0.3%	3.4%	10.8%	1.3%
Deaths prevented (ages <65)	—	14,000	57,000	47,000	118,000

NOTE: This assumes the use of mid-scenarios and that the policy is implemented in 2015. Although the table carries many significant figures to aid in reproducibility, precision is limited to one or two digits.

younger than 65 years. The table shows that the percentage of premature deaths prevented would increase progressively with time, going from approximately 0.1 percent, 0.2 percent, and 0.3 percent in 2040–2059 to 2.2 percent, 8.2 percent, and 10.8 percent in 2080–2099 for MLA 19, MLA 21, and MLA 25, respectively, all based on the mid-estimate scenarios.

Figure 8-2 shows the SimSmoke model estimates of the number of smoking-related deaths that would be prevented from 2014 to 2100 for each MLA. The model projects more prevented deaths than the CISNET model primarily because of the higher future smoking prevalence predicted by the SimSmoke model and the model differences in assumed mortality rates for current smokers. The CISNET model also allows for differential age-specific mortality by smoking intensity, which is particularly relevant due to the significant decreases in smoking intensity levels projected by the CISNET model under the status quo (see Appendix D).

The relative proportion of deaths prevented between the three MLAs appears consistent across the two models, with MLA 21 and MLA 25 lead-

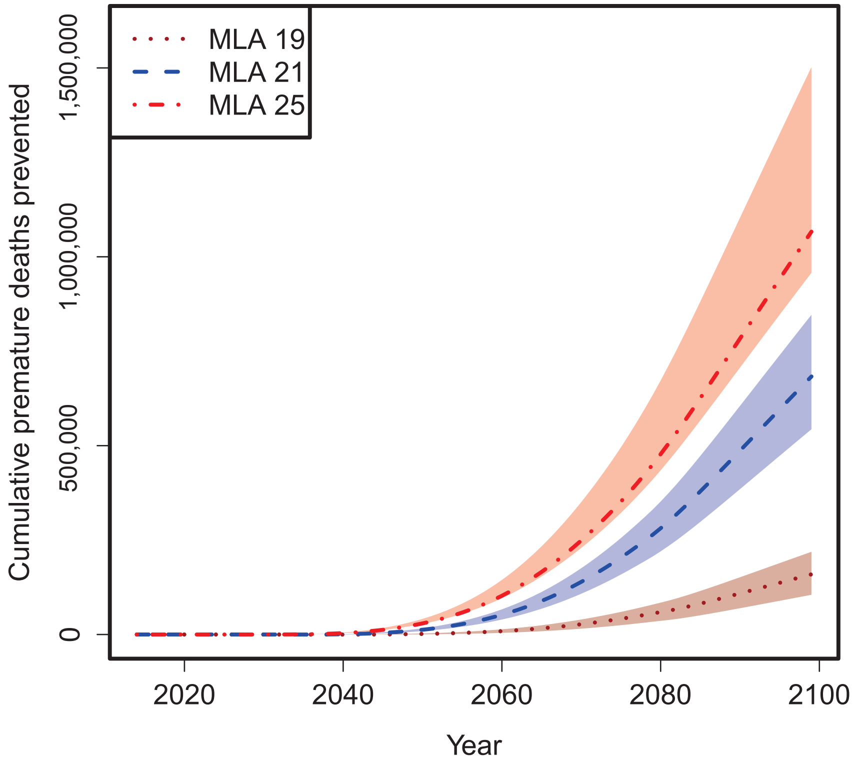


FIGURE 8-2 Number of premature deaths prevented (lives saved) for the three MLA policies estimated using the SimSmoke model. Lines correspond to the mid-input scenario for each MLA. Shaded regions represent the area between the upper and lower scenarios for each MLA.

ing to significantly greater proportions of lives saved than with MLA 19. In contrast with the SimSmoke model, the CISNET model's projections of premature deaths prevented for the upper MLA 21 scenario and the lower MLA 25 scenarios overlap, although they still lead to significantly larger gains compared to MLA 19, just as in SimSmoke. Table 8-3 shows the SimSmoke model's projected number of premature deaths due to smoking for selected periods as well as the corresponding number of deaths prevented and the percentage reduction for each of the MLA mid-scenarios. The table shows that the SimSmoke model estimates that the percentage reduction in smoking-attributed mortality increases progressively with time, from approximately 0.1 percent, 0.8 percent, and 1.5 percent in 2040–2059 to 2.5 percent, 9.9 percent, and 14.5 percent in 2080–2100 for MLA 19, MLA 21, and MLA 25, respectively. Thus, although the absolute numbers

TABLE 8-3 Cumulative Premature Deaths Expected and Prevented by Period—SimSmoke

MLA/Outcome	2020–2039	2040–2059	2060–2079	2080–2100	2015–2100
Status Quo					
Premature deaths expected	8,108,000	6,393,000	4,963,000	4,277,000	26,840,000
MLA 19					
Deaths prevented	—	9,000	50,000	106,000	165,000
Percentage reduction	0.0%	0.1%	1.0%	2.5%	0.6%
Deaths prevented (ages <65)	—	9,000	28,000	23,000	60,000
MLA 21					
Deaths prevented	1,000	51,000	229,000	423,000	705,000
Percentage reduction	0.0%	0.8%	4.6%	9.9%	2.6%
Deaths prevented (ages <65)	700	51,000	108,000	89,000	249,000
MLA 25					
Deaths prevented	4,000	99,000	375,000	620,000	1,098,000
Percentage reduction	0.0%	1.5%	8.6%	14.5%	4.1%
Deaths prevented (ages <65)	4,000	94,000	156,000	129,000	383,000

NOTE: Assumes the use of mid-scenarios and that the policy is implemented in 2015. Although the table carries many significant figures to aid in reproducibility, precision is limited to one or two digits.

of deaths prevented differ considerably between the models, the percentage reductions in smoking-attributable deaths appear relatively consistent, especially for later years.

Tables 8-4 and 8-5 show estimates of the number of YLL in the United States for each of the MLA scenarios by calendar-year (period) and birth cohort, respectively. The calendar-year results (see Table 8-4) suggest the gains in years of life would begin several decades after implementation of the policy. Nonetheless, the birth cohort results (see Table 8-5) show large reductions in the lifetime YLL (>10 percent) achieved by MLA 21 or MLA 25 for new generations, starting with those born in 2000–2019, with similar patterns observed for the upper and lower smoking initiation input values (see Appendix D).

Finding 8-1: Model results suggest that reductions in smoking-related mortality will not be observed for at least 30 years following the increase in the minimum age of legal access to tobacco products.

TABLE 8-4 Years of Life Lost (YLL) by Period—CISNET Model

	Status Quo	YLL Under MLA 19 Mid-Scenario	MLA 19 % Reduction	YLL Under MLA 21 Mid-Scenario	MLA 21 % Reduction	YLL Under MLA 25 Mid-Scenario	MLA 25 % Reduction
2000–2019	134,823,000	—	0.0%	—	0.0%	—	0.0%
2020–2039	106,126,000	—	0.0%	—	0.0%	—	0.0%
2040–2059	68,217,000	100,000	0.1%	352,000	0.5%	469,000	0.7%
2060–2079	46,490,000	561,000	1.2%	1,979,000	4.3%	2,641,000	5.7%
2080–2099	36,688,000	964,000	2.6%	3,401,000	9.3%	4,542,000	12.4%

NOTE: Although the table carries many significant figures to aid in reproducibility, precision is limited to one or two digits.

TABLE 8-5 Lifetime Years of Life Lost (YLL) by Cohort—CISNET Model

	Status Quo	YLL Under MLA 19 Mid-Scenario	MLA 19 % Reduction	YLL Under MLA 21 Mid-Scenario	MLA 21 % Reduction	YLL Under MLA 25 Mid-Scenario	MLA 25 % Reduction
2000–2019	40,116,000	1,180,000	2.9%	4,163,000	10.4%	5,560,000	13.9%
2020–2039	36,447,000	1,134,000	3.1%	4,000,000	11.0%	5,343,000	14.7%
2040–2059	36,084,000	1,123,000	3.1%	3,962,000	11.0%	5,291,000	14.7%
2060–2079	37,412,000	1,164,000	3.1%	4,108,000	11.0%	5,486,000	14.7%
2080–2099	38,874,000	1,210,000	3.1%	4,268,000	11.0%	5,700,000	14.7%

NOTE: Although the table carries many significant figures to aid in reproducibility, precision is limited to one or two digits.

LUNG CANCER DEATHS

The CISNET Yale Lung Cancer Model, in combination with the CISNET smoking population model, provides estimates of lung cancer deaths prevented (Holford et al., 2012; Moolgavkar et al., 2012). The model uses a multistage lung carcinogenesis model to translate the population patterns of smoking projected by the CISNET smoking population model into predictions of lung cancer deaths (Hazelton et al., 2012; Meza et al., 2008). More details are provided in Appendix D. Figure 8-3 shows the projected number of annual lung cancer deaths prevented for each of the MLA mid-scenarios. Figure 8-4 shows the corresponding cumulative number of lung cancer deaths prevented. The figures show that the reductions in lung cancer mortality would not become observable until the late 2040s because of the time delay between smoking exposure and lung cancer risk. As in the case with

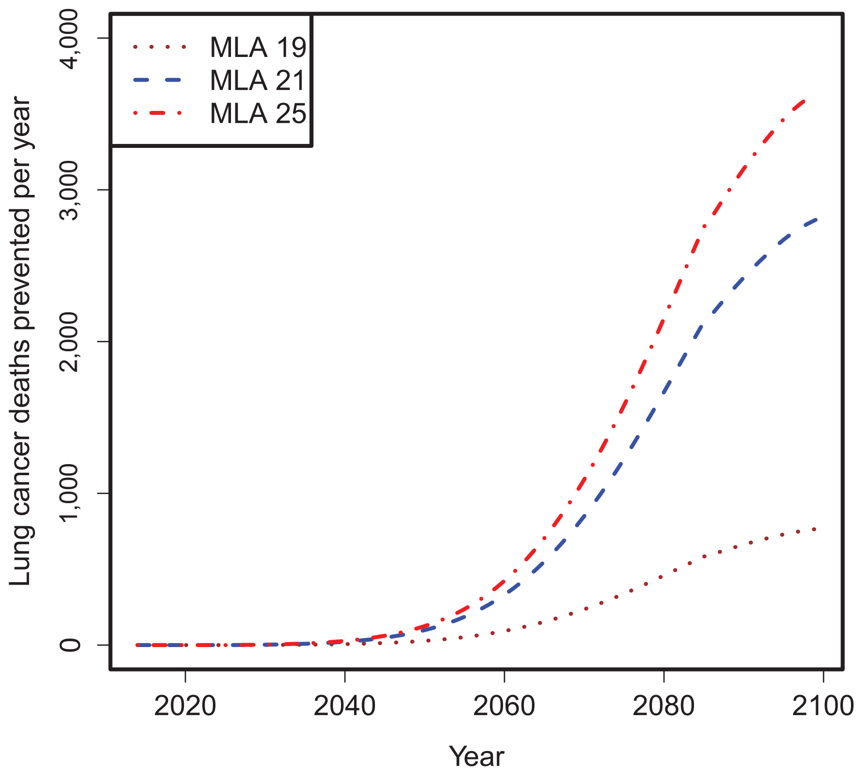


FIGURE 8-3 CISNET model estimates of the number of lung cancer deaths prevented per year for the three MLAs (mid-scenario).

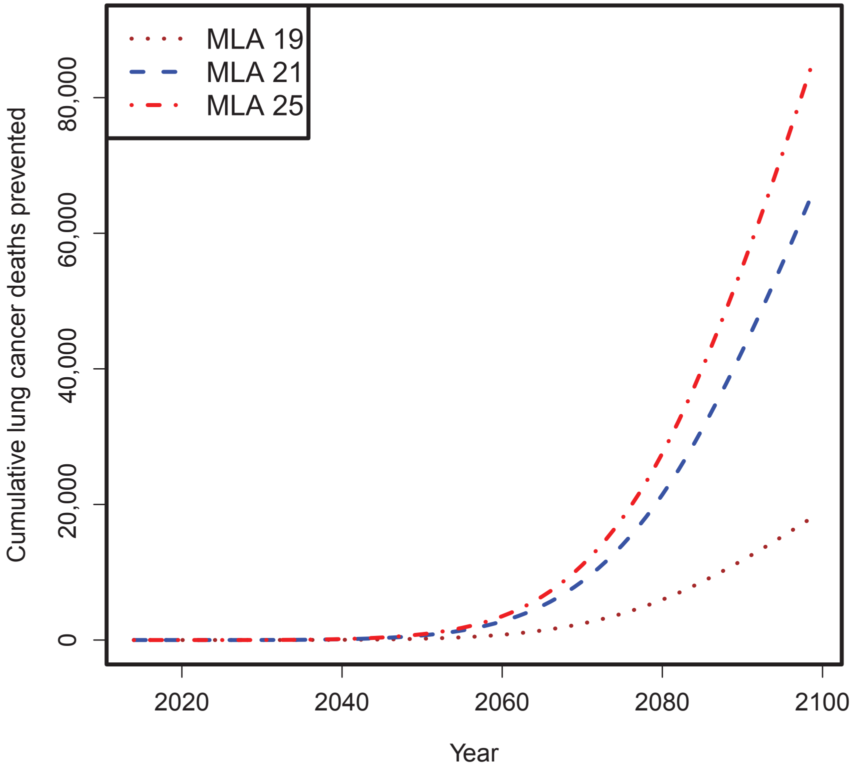


FIGURE 8-4 CISNET model estimates of the number of cumulative lung cancer deaths prevented per year for the three MLAs (mid-scenario).

overall mortality, the model predicts that raising the MLA to 21 or 25 would lead to a considerably higher number of lung cancer deaths prevented than if the MLA was raised only to 19. Table 8-6 shows the projected number of lung cancer deaths and deaths prevented for selected periods for each MLA (mid-scenario). The table shows the progressive increase in the percentage of lung cancer deaths prevented, going from 0.1 percent, 0.3 percent, and 0.4 percent in 2040–2059 to 2.9 percent, 10.5 percent, and 13.6 percent in 2080–2099 for MLA 19, MLA 21, and MLA 25, respectively.

> *Finding 8-2: Raising the minimum age of legal access to tobacco products to 21 or 25 years would lead to larger reductions in smoking-attributable mortality than keeping the status quo or raising the MLA to 19 years.*

TABLE 8-6 Lung Cancer Deaths and Prevented Deaths by Period Under Each MLA (CISNET)

	2020–2039	2040–2059	2060–2079	2080–2099
Status Quo	1,388,000	771,000	510,000	431,000
MLA 19	0	1,000	5,000	12,000
averted percentage reduction	0.0%	0.1%	1.0%	2.8%
MLA 21	0	3,000	19,000	45,000
averted percentage reduction	0.0%	0.4%	3.7%	10.4%
MLA 25	0	3,000	24,000	59,000
averted percentage reduction	0.0%	0.4%	4.7%	13.7%

NOTE: Although the table carries many significant figures to aid in reproducibility, precision is limited to one or two digits.

Finding 8-3: Modeling mortality outcomes by birth cohort estimates that large reductions in lifetime smoking-attributable deaths and years of life lost would be achieved by raising the minimum age of legal access to tobacco products to age 21 or 25 for new generations starting with the cohort born in 2000. It also projects the prevention of a large number of lung cancer deaths under such scenarios, with most of these prevented deaths realized after 2050.

MATERNAL AND CHILD HEALTH OUTCOMES

The fetal and early infancy periods in life are particularly critical periods for future development, and, as such, adverse exposures are especially harmful during these periods (HHS, 2004). Cigarette smoke exposure has potent adverse effects that negatively affect the likelihood of conception, degrade the health of pregnant women and the developing fetus, increase the risk of pregnancy complications, and reduce the likelihood of infant survival (HHS, 2004). An increase in the MLA would therefore have a robust and immediate impact in improving maternal/fetal and infant outcomes by reducing the likelihood of maternal/paternal smoking. Benefits would be expected to occur immediately with a change in the MLA, and they would at first be concentrated within the younger ages of the reproductive years because of the short-term policy impact that would quickly appear by reducing smoking prevalence in this age range. The impact of a raise in the MLA would then increase over time as the early birth cohorts affected by the MLA increase aged into the reproductive ages. The magnitude of the benefit would be directly associated with the magnitude of the decrease in smoking prevalence.

The SimSmoke model projected the effects of raising the MLA on the incidence of pre-term births (PTBs), low birth weight (LBW), and SIDS. The focus on maternal health outcomes required modification of the model to distinguish the number of smoking women who become pregnant and the number of children born to smoking women. The model calculated the number of cases of smoking-attributable birth outcomes using standard attribution formulas based on relative risks and projected smoking prevalence (HHS, 2010; Levin, 1953; Lilienfeld and Lilienfeld, 1980) (see Appendix D).

Tables 8-7, 8-8, and 8-9 show the predicted cumulative numbers of LBW, PTB, and SIDS, respectively, for each MLA for the mid-scenario and the corresponding number of averted cases versus the status quo for selected years. For mothers ages 15 to 49, the SimSmoke model predicts that about 124,000 LBW cases, 82,000 PTBs, and 1,100 SIDS deaths would be averted between 2015 and 2100 for MLA 19. These increase to 438,000 LBW cases, 286,000 PTBs, and 4,000 SIDS deaths averted under MLA 21 and to 597,000 LBW cases, 388,000 PTBs, and 5,400 SIDS deaths averted under MLA 25. Thus, about three times more cases could be avoided under MLA 21 than under MLA 19, while only about 1.35 times more cases could be prevented under MLA 25 than under MLA 21.

TABLE 8-7 Smoking Attributable LBW Cases and Averted Cases by Period Under Each Policy Option (Mothers Ages 15–49) (SimSmoke)

	2015–2019	2020–2039	2040–2059	2060–2079	2080–2099
Status Quo	242,000	727,000	854,000	964,000	1,064,000
MLA 19	2,000	22,000	30,000	34,000	37,000
averted percentage reduction	0.8%	3.0%	3.5%	3.5%	3.5%
MLA 21	10,000	78,000	104,000	117,000	129,000
averted percentage reduction	4.1%	10.7%	12.2%	12.1%	12.1%
MLA 25	16,000	109,000	140,000	158,000	174,000
averted percentage reduction	6.6%	15.0%	16.4%	16.4%	16.4%

NOTE: Although the table carries many significant figures to aid in reproducibility, precision is limited to one or two digits.

TABLE 8-8 Smoking Attributable PTB Cases and Averted Cases by Period Under Each Policy Option (Mothers Ages 15–49) (SimSmoke)

	2015–2019	2020–2049	2040–2059	2060–2079	2080–2099
Status Quo	148,000	442,000	520,000	587,000	648,000
MLA 19	1,000	14,000	20,000	22,000	24,000
averted percentage reduction	0.9%	3.2%	3.8%	3.8%	3.8%
MLA 21	6,000	51,000	68,000	76,000	84,000
averted percentage reduction	4.3%	11.6%	13.0%	13.0%	13.0%
MLA 25	11,000	71,000	91,000	103,000	113,000
averted percentage reduction	8.2%	16.0%	18.5%	18.5%	18.5%

NOTE: Although the table carries many significant figures to aid in reproducibility, precision is limited to one or two digits.

TABLE 8-9 Smoking Attributable SIDS Cases and Averted Cases by Period Under Each Policy Option (Mothers Ages 15–49) (SimSmoke)

	2015–2019	2020–2049	2040–2059	2060–2079	2080–2099
Status Quo	2,280	6,850	8,060	9,090	10,020
MLA 19	20	200	270	300	340
averted percentage reduction	0.8%	3.0%	3.4%	3.4%	3.4%
MLA 21	100	730	950	1,070	1,180
averted percentage reduction	4.2%	10.7%	11.7%	11.7%	11.7%
MLA 25	160	1,010	1,270	1,430	1,580
averted percentage reduction	8.0%	14.7%	15.8%	15.7%	15.7%

NOTE: Although the table carries many significant figures to aid in reproducibility, precision is limited to one or two digits.

Finding 8-4: Modeling estimates that immediate reductions in cases of low birth weight, pre-term birth, and sudden infant death syndrome will occur with changes in the minimum age of legal access to tobacco products.

TABLE 8-10 Reduction (percentage) in Smoking Prevalence for MLA 21 by Year

	2020	2040	2060	2080	2100
Smoking prevalence—SimSmoke	2.0%	8.3%	10.3%	11.2%	11.20%
Smoking prevalence—CISNET	0.4%	6.4%	10.6%	11.9%	12.00%

TABLE 8-11 Reduction (percentage) in Health Outcomes for MLA 21 by Period

	2020–2039	2040–2059	2060–2079	2080–2099
Deaths prevented—SimSmoke	0.0%	0.8%	4.6%	9.9%
Deaths prevented—CISNET	0.0%	0.2%	2.6%	8.2%
Years of life lost—CISNET	0.0%	0.5%	4.3%	9.3%
Lung cancer deaths prevented	0.0%	0.3%	3.7%	10.5%
Low birth weight cases	10.8%	12.2%	12.2%	12.2%
Pre-term birth cases	11.6%	13.0%	13.0%	13.0%
Sudden infant death syndrome cases	16.0%	18.5%	18.5%	18.5%

TIME TO ACCRUE BENEFITS

Tables 8-10 and 8-11 summarize the reductions in smoking prevalence for selected years and health outcomes by 20-year periods for MLA 21, showing the relative timing at which different benefits occur. The results illustrate the longer times required for chronic outcomes compared to short-term outcomes.

OTHER HEALTH EFFECTS

The previous section laid out the results of the simulation modeling regarding the likely effects of raising the MLA on cigarette-related mortality and select health outcomes, limited to the capacity of the commissioned models. However, such results can only begin to estimate the magnitude of the effects of reduced tobacco use on individual and population health in the United States. As the cohorts of adolescents and young adults affected by a raise in the MLA age, the benefits accrue and grow over time. The adverse health effects of tobacco use are well documented and described in Chapter 4. Here, the committee describes qualitatively the wide spectrum of likely benefits to health throughout the life span from decreased tobacco initiation in adolescents and young adults and the resulting lowered prevalence rates in adulthood. It should be stressed that most of the data about adverse health effects of tobacco come from studies of cigarette smoking.

Immediate Health Effects

Cigarette smoking causes the immediate adverse health effects of increased oxidative stress; depletion of selected bioavailable antioxidant micronutrients; increased inflammation; impaired immune status; altered lipid profiles; poorer self-rated health status; respiratory symptoms such as coughing, phlegm, wheezing, and dyspnea; and nicotine addiction (HHS, 2004). As summarized above, increasing the MLA would be expected to reduce the initiation of tobacco use by adolescents and young adults, which would naturally lead to a decrease in the prevalence of tobacco use. Reducing the prevalence of smoking by any amount will automatically lead to immediate population health benefits that are directly proportional to the size of the reduction. Each one of the immediate adverse health effects caused by cigarette smoking itself compromises the health status of smokers, and when combined, this constellation of immediate adverse health effects leaves the smoker with a health status that is significantly impaired and subpar compared to nonsmokers. For example, smokers are less able to fend off acute infectious diseases and more likely to exhibit respiratory symptoms (HHS, 2014). The cumulative toll leaves the smoker generally feeling worse off about his or her health status soon after starting to smoke (HHS, 2004, 2014). Nicotine addiction makes the smoker more likely to keep smoking over the long term, which in turn makes the smoker more and more prone to the immediate and long-term health effects as the lifetime extent of smoking grows.

The immediate adverse health effects of smoking affect people of all ages, but the immediate impact upon adolescents who initiate smoking is the most disconcerting from a population health perspective because these adverse consequences occur during such a critical developmental period of life. The immediate health effects result in adolescents and young adults who smoke having compromised educational achievement, diminished athletic performance, reduced proficiency in performing occupational duties, and, for those enlisted in the armed forces, having compromised military performance (HHS, 2004). In fact, each of these populations of students, workers, and military personnel can be viewed as having a subpopulation of smokers that is physiologically disadvantaged compared to the nonsmoker portion of the population. Thus, a reduction in smoking prevalence by any amount is a step toward reducing a population health disparity that is created by cigarette smoking even in the ostensibly healthy population of adolescents and young adults. The larger the reduction in smoking prevalence created by raising the MLA, the larger the commensurate reduction will be in these smoking-caused health disparities. Reducing the prevalence of these immediate adverse health effects would not only benefit population health but also have downstream benefits on population educational achievement, workforce productivity, and military performance. The higher the MLA, the greater the public health benefit will be in terms of reducing the size of the population of smokers and hence decreasing the number who experience the corresponding health deficits.

Further public health benefits will occur from the delays in the age of starting to smoke that would result from raising the MLA for tobacco. Within the age range where the delays occur, the delayed age of initiation would postpone the immediate adverse health effects until the individuals are older. The child and adolescent population would directly benefit, with a smaller percentage of the adolescent population smoking and a larger percentage maintaining a more optimal health status. Delaying smoking in adolescents until they are older would help protect the tissues and organ systems that are still in the growth and maturation phase during adolescence and hence are particularly vulnerable to the detrimental effects of the toxicants in smoke (HHS, 2004). As with the prevention of smoking, the extent to which smoking initiation will be delayed will be directly related to how high the MLA is set.

Intermediate Health Effects

Cigarette smoking causes the intermediate adverse health effects of increased absence from school and work, increased use of medical services, subclinical atherosclerosis, impaired lung development and function, increased risk of lung infections, diabetes, periodontitis, exacerbation of asthma, subclinical organ injury, and adverse surgical outcomes (HHS, 2004). The reductions in smoking prevalence caused by increasing the MLA will reduce the entire burden that these intermediate adverse health effects pose to population health. The estimated amount of reduction in this burden will be larger with a higher MLA and will grow in magnitude over time as the policy impact matures.

Reducing the prevalence of smoking will lead to population health benefits in the near term by reducing the burden of the intermediate adverse health effects of cigarette smoking. Each of the intermediate adverse health effects caused by cigarette smoking compromises an individual smoker's health status; in total, they combine to exact a severe toll on individuals and on population health in general. They further widen the health status differential between smokers and nonsmokers, which commences with the immediate adverse health effects. The intermediate health effects leave the smoker not only with subclinical diminished health status but also with clinically apparent morbidities across multiple organ systems (HHS, 2004). In turn, the diminished health status and clinical morbidities have a detrimental influence on the national economy both by limiting workforce productivity via absences and also by increasing health care costs (HHS, 2004). The morbidities experienced by smokers during this intermediate period are outward manifestations of the subclinical effects that begin immediately after smoking initiation, a fact that reinforces the observation that the health status of smokers is diminished throughout the life span compared to nonsmokers, even before the impact of clinically apparent morbidities and then mortality make this difference in health status obvious.

These intermediate adverse health effects affect the entire age continuum, generating clear smoker–nonsmoker health disparities during early life (HHS, 2004, 2014). As with the immediate health effects, as smoking persists into adulthood the divergence in markers of health status between smokers and nonsmokers widens. Cigarette smokers constitute a sub-population that is physiologically disadvantaged compared with the nonsmoker population, and a reduction in smoking prevalence resulting from an increase in the MLA is a step toward achieving a reduction in smoking-caused population health disparities.

The public health benefits from delayed initiation would not simply be seen in a decrease in the immediate adverse health effects, but would continue to have a ripple effect over time, benefiting people at all ages and stages of life. For example, the fact that delayed initiation reduces the dose of cigarette toxins ingested by smokers would help to offset the population burden of intermediate health effects, and because an older age of initiation is associated with increased likelihood of cessation, this would further benefit population health by leading to further reductions in cigarette smoking prevalence during those stages of life affected by the intermediate adverse health effects of cigarette smoking.

Long-Term Health Effects

Cigarette smoking is causally associated with a long list of long-term health effects that includes 12 different types of cancer, vascular and heart disease outcomes, respiratory disease, eye disease, rheumatoid arthritis, and bone health (HHS, 2004, 2014). The immediate, intermediate, and long-term adverse health effects of cigarette smoking are related as several of these long-term outcomes are mechanistically linked to the immediate and intermediate adverse health effects summarized above. Cancer, cardiovascular disease, and chronic obstructive pulmonary disease are caused by smoking and are also the major causes of death in the United States (HHS, 2014); thus, these specific outcomes are also included indirectly in the statistical modeling of all-cause mortality. On the other hand, although such long-term adverse health effects as eye disease, rheumatoid arthritis, and adverse effects on bone health are not direct causes of death, they do pose a major burden of disability and impaired quality of life in the U.S. population (HHS, 2004, 2014). Furthermore, regardless of the ultimate prognosis, cancer, cardiovascular disease, and chronic obstructive pulmonary disease all contribute to the burden of disability and impaired quality of life.

Unlike the case with the immediate and intermediate adverse health effects caused by cigarette smoking, the impact of increasing the MLA on long-term adverse health effects caused by cigarette smoking would not become apparent until decades after the policy change occurred because raising the MLA will primarily affect the initiation and delay of smoking among children, adolescents, and young adults. Therefore, the impact of raising the MLA on the long-term adverse health effects would not occur until the initial birth cohorts affected by an MLA increase were old enough to be in the older age groups where these chronic diseases typically occur. The degree of morbidity reduction in these cohorts would be expected to be directly correlated with the decrease in smoking prevalence and delayed initiation that the older MLA generated. The population health impact would be profound even for modest decreases in smoking prevalence because of the broad spectrum of the long-term health effects caused by smoking and the population health burden caused by each of these diseases. Delays in initiating cigarette smoking would result in further reductions in the long-term adverse health effects caused by smoking because of reductions in the population-level exposure to tobacco toxins; these reductions would occur because a later age of initiation leads to individuals smoking fewer cigarettes per day, on average, and also for fewer years because individuals who start smoking later are more likely to eventually quit.

The focus here has been specifically on the public health effects of reducing the prevalence of, and delaying initiation of, cigarette smoking. Raising the MLA will also reduce the prevalence of smoking combustible tobacco products other than cigarettes, such as pipes and cigars. As reviewed in Chapter 4, although less thoroughly studied than cigarette smoking, smoking other tobacco products also causes significant adverse health effects that will be prevented with a reduction in prevalence. Furthermore, raising the MLA will lead to reductions in smokeless tobacco use and hence a reduction in the adverse health effects caused by smokeless tobacco use.

By reducing the prevalence of smoking of all tobacco products in the population, raising the MLA will also lead to a reduction in the population exposure to secondhand smoke (SHS). A reduction in the prevalence of exposure to SHS will benefit public health by reducing the spectrum of adverse health effects, reviewed in Chapter 4, that have been causally associated with SHS exposure.

IMPLICATIONS OF RAISING THE MINIMUM AGE OF LEGAL ACCESS TO TOBACCO PRODUCTS ON HEALTH

The modeling analysis suggests that raising the MLA could lead to considerable reductions in smoking-attributed mortality and morbidity over time, mirroring the reductions in smoking discussed earlier. Both models suggest a time delay of a few decades for the overall mortality benefits to accrue at the population level because of the lag time between smoking exposure and major health outcomes and because the policy primarily affects adolescents and young adults. Nonetheless, more immediate effects would be observed for maternal and child outcomes as well as other acute outcomes. Moreover, the analysis shows that new generations, starting with those born between 2000 and 2019, could see significant reductions in mortality and years of life lost accumulated throughout their lifetimes.

Both models suggest that significant mortality gains occur when going from MLA 19 to MLA 21. Increasing the MLA from 21 to 25 leads to additional benefits, but the magnitude of these benefits is less than achieved when going from MLA 19 to MLA 21, based on conservative assumptions that reflect uncertainty about extrapolation to MLA 25.

The CISNET model predicts about one-third as many premature deaths prevented as the SimSmoke model. This occurs largely because of the lower smoking prevalence projected by the CISNET model for all cases and the concomitant lower baseline smoking-attributable deaths. Furthermore, the CISNET model allows for differential mortality by smoking intensity. Thus, the large reductions in smoking intensity levels projected by this model translate into fewer estimated smoking-attributable mortality in all cases than in the SimSmoke model. Nonetheless, the estimated percentage mortality reductions of the different MLAs appear consistent between the two models, particularly for later years.

Raising the MLA would significantly reduce lung cancer mortality in the long term, with most of the benefits realized after 2050. Similarly, as with the overall mortality projections, the models predict considerably larger reductions when raising the MLA to 21 or 25 versus 19. Raising the MLA to 19, 21, and 25 will reduce LBW, PTB, and SIDS outcomes, with these benefits occurring relatively earlier in time.

All models come with limitations because their results depend on the model structure and assumptions. In this case, uncertainty also arises from the assumptions about the effects of various MLA policies on smoking initiation scenarios. The committee used an evidence-driven process to create the inputs regarding potential ranges for the assumed effects of the MLA policies. While these inputs are assumptions, they are well reasoned based on the existing evidence regarding adolescent and young adult smoking behavior and tobacco control policy responses, as explained in Chapter 7.

The use of two established tobacco control simulation models with differences in the underlying assumptions related to future baseline initiation and cessation rates led to different estimates of the absolute decrease in smoking prevalence and different status quo estimates. However, the two distinct models predict similar results for the percentage reductions associated with the various MLA options considered. Similarly, although the models differ in their predicted absolute numbers of deaths prevented, they agree in their estimated relative reductions and relative effects among the different MLAs. This provides some confidence about these overall findings. Sensitivity analyses (see Appendix D) showed that the conclusions about the relative effects of the different MLAs appear robust to alternative assumptions on the initiation effects (upper and lower scenarios).

The projections provide somewhat conservative estimates, given that the models did not account for the possible synergistic effects of reduced and delayed initiation with increased cessation, and the committee estimates accounted for greater uncertainty about projection to an MLA 25 policy. Moreover, the models only considered smoking, ignoring the potential additional health benefits from reductions in the consumption of other tobacco products. The models also ignored the potential additional health benefits from reductions in the consumption of other tobacco products and the likely synergistic effects of increased cessation on disease risk. The models also ignore benefits that might accrue because nonsmokers engage in a variety of healthy behaviors compared to smokers. Overall, the results from both models are consistent with the conclusions from the literature review and show that raising the MLA would lead to significant health benefits. Some, such as maternal and child health outcomes, will occur immediately, while others, such as overall mortality benefits, will take time to accrue.

Conclusion 8-1: Based on the modeling, raising the minimum age of legal access to tobacco products will likely lead to substantial reductions in smoking-related mortality.

As described above and in Chapter 4, cigarette smoking causes numerous adverse health effects, and these can be categorized as immediate, intermediate, or long term. In assessing the potential public health impact of raising the MLA, it is worth keeping in mind that this lengthy catalogue of well-established consequences of cigarette smoking and SHS exposure will grow as more definitive evidence coalesces for additional health outcomes. There are many additional adverse health effects currently suspected of being causally associated with both cigarette smoking and SHS exposure, but the evidence currently falls short of being definitive; thus, the scope of adverse health effects will grow over time.

Considering the causes of the health effects of cigarette smoking throughout the entire life course more accurately characterizes the full extent of the public health burden imposed by cigarette smoking. It is important to emphasize that because the spectrum of adverse health effects caused by cigarette smoking is so extensive in both the near term and the long term, even small reductions in smoking prevalence will benefit public health substantially. The magnitude of the public health impact will be larger for greater reductions in smoking prevalence; thus, the public health impact will be greatest for an MLA of 25 years and least for an MLA of 19 years.

Conclusion 8-2: Based on a review of the literature, raising the minimum age of legal access to tobacco products (MLA) will likely immediately improve the health of adolescents and young adults by reducing the number of those with smoking-caused diminished health status. As the initial birth cohorts affected by the policy change age into adulthood, the benefits of the reductions of the intermediate and long-term adverse health effects will also begin to manifest. Raising the MLA will also likely reduce the prevalence of other tobacco products and exposure to secondhand smoke, further reducing tobacco-caused adverse health effects, both immediately and over time.

Conclusion 8-3: Based on a review of the literature and on the modeling, an increase in the minimum age of legal access to tobacco products will likely improve maternal, fetal, and infant outcomes by reducing the likelihood of maternal and paternal smoking.

As discussed in Chapter 7 with regard to effects of an increase in the MLA on tobacco initiation, it is an open question whether raising the MLA will have a greater or lesser impact on the health of population subgroups with a higher prevalence of cigarette smoking than on the general population. If the reduction in smoking prevalence was proportionally larger in the subgroups of the population with the highest smoking prevalence, then the public health impact of raising the MLA might be even greater than anticipated. If the converse were true, however, and these population subgroups were more resistant to the influence of the policy with respect to reducing smoking prevalence and delayed initiation, then the end result would be to widen the existing disparities.

REFERENCES

Hazelton, W. D., J. Jeon, R. Meza, and S. H. Moolgavkar. 2012. Chapter 8: The FHCRC lung cancer model. *Risk Analysis* 32(Suppl 1):S99–S116.

HHS (Department of Health and Human Services). 2004. *The health consequences of smoking: A report of the Surgeon General.* Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

———. 2010. Smoking-attributable mortality, morbidity, and economic costs (SAMMEC). https://apps.nccd.cdc.gov/sammec/mch_mort_comp.asp?cdc=706 (accessed January 29, 2015).

———. 2014. *The health consequences of smoking—50 years of progress: A report of the Surgeon General.* Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

Holford, T. R., K. Ebisu, L. McKay, C. Oh, and T. Zheng. 2012. Chapter 12: Yale Lung Cancer Model. *Risk Analysis* 32(Suppl 1):S151–S165.

Levin, M. 1953. The occurrence of lung cancer in man. *Acta Unio Internationalis Contra Cancrum* 9:531–541.

Lilienfeld, A., and D. Lilienfeld. 1980. *Foundations of epidemiology*. New York: Oxford University Press.

Meza, R., W. D. Hazelton, G. A. Colditz, and S. H. Moolgavkar. 2008. Analysis of lung cancer incidence in the Nurses' Health and the Health Professionals' Follow-Up Studies using a multistage carcinogenesis model. *Cancer Causes and Control* 19(3):317–328.

Moolgavkar, S. H., T. R. Holford, D. T. Levy, C. Y. Kong, M. Foy, L. Clarke, J. Jeon, W. D. Hazelton, R. Meza, F. Schultz, W. McCarthy, R. Boer, O. Gorlova, G. S. Gazelle, M. Kimmel, P. M. McMahon, H. J. de Koning, and E. J. Feuer. 2012. Impact of reduced tobacco smoking on lung cancer mortality in the United States during 1975–2000. *Journal of the National Cancer Institute* 104(7):541–548.

9

Other Considerations for Policy Makers

The objective of this report is to predict what the health consequences would be of raising the minimum age of legal access to tobacco products (MLA) to 19, 21, or 25. As discussed in Chapter 5, few jurisdictions, states, or localities in this country have undertaken such changes, and no other country has done so. None of the state and local initiatives has been followed by a rigorous evaluation published in the peer-reviewed literature. Because a review and synthesis of existing empirical literature cannot answer the question at hand, the committee drew on a comprehensive review of the relevant scientific literature, on its collective expertise, and on models of population-level smoking behavior to predict changes in adolescent and young adult initiation attributable to raising the MLA and to project the impact of these changes on the prevalence of use and on health outcomes.

Using conservative assumptions about the enforcement of the MLA increases, the committee concluded that raising the MLA will likely decrease initiation of tobacco use by adolescents and young adults and thereby, over time, reduce adult prevalence, leading to longer and healthier lives for those who would have otherwise used tobacco. More specifically, the modeling analysis concluded that raising the MLA, particularly to ages 21 and 25, would lead to substantial reductions in smoking prevalence and thereby prevent considerable numbers of smoking-attributable deaths, including lung cancer deaths, and poor maternal and child health outcomes. However, the committee has greater uncertainty about the magnitude of the effects of raising the MLA to age 25 rather than to 19 or 21. The results suggest a range of potential population health benefits that depend on a number of informed assumptions regarding enforcement practices and behavioral responses to the policy change by retailers and other potential sources of tobacco products and by underage individuals in different age and gender groups.

The purpose of this chapter is to help policy makers translate the committee's findings and conclusions into the policy context. First, the chapter highlights a key constraint arising from the committee's charge: Its quantitative estimates and projections relate to the nation as a whole, while the traditional responsibility for enacting and enforcing the MLA lies with states and localities. Second, the chapter revisits several policy assumptions that were explicitly made by the committee (or that are built into the simulation models) as a basis for its estimates of the effects of raising the MLA on adolescent and young adult initiation. These assumptions relate to the scope and enforcement of the MLA policy and to the status of other tobacco control policies. Reviewing them is important because it will enable the policy maker to consider the possible effects of different assumptions. Third, the chapter discusses the possible policy implications of increasing scientific knowledge regarding adolescent development. Finally, the chapter identifies two factors of possible public health relevance that were not taken into account in making the estimates and projections described in the report. The more important of these factors is the possible impact of the marketing and use of new tobacco products, most notably electronic nicotine delivery systems (ENDS). The other is the possible impact of raising the MLA for tobacco use on the use of alcohol or other drugs.

NATIONAL OR STATE ENACTMENT OF MLA

Traditionally, political responsibility for setting the MLA for tobacco products has rested with the states and, depending on state constitutional arrangements, with local governments. However, since 1992 the federal government has played an increasingly significant role. The Family Smoking Prevention and Tobacco Control Act (hereafter referred to as the Tobacco Control Act), enacted by Congress in 2009, directed the Food and Drug Administration (FDA) to revive its 1996 Tobacco Rule, which prescribed a federal MLA of 18. At the same time, however, Congress precluded FDA from raising the MLA without congressional action. In effect, the Tobacco Control Act sets a "floor" of 18 while allowing states and localities to raise the age if they choose to do so. Hence, unless Congress acts to raise the age on a national basis or delegates authority to FDA to do so, one might expect a patchwork of different MLAs in different states and localities, as existed for alcohol for many decades, rather than a uniform MLA across all of the 51 jurisdictions.

It is important to emphasize that the simulations described in Chapters 7 and 8 model a situation in which increases in the MLA would be adopted and implemented on a nationwide basis. However, a state-by-state implementation is more likely. Nationwide implementation would occur only if Congress raises—or authorizes FDA to raise—the national MLA or if every state raises the MLA. To the extent that states choose not to raise the MLA, the effects estimated in Chapters 7 and 8 are not likely to be realized. In addition, to the extent that people who are underage in a high-MLA state could cross state borders to purchase in a low-MLA state, the effects estimated in Chapter 8 may be somewhat optimistic, particularly for small states surrounded by many low-MLA neighbors.

Even if Congress does not choose to set a national MLA higher than 18, there are other mechanisms through which universal or near universal adoption might be motivated. For example, Congress could provide incentives for states to do so by making the level of funding under federal grants contingent on the state raising the MLA. It could do this based on the approach used in the Synar Amendment (up to 40 percent of a state's substance abuse prevention block grant funding is contingent on enforcing the state's MLA) by simply defining underage purchasers under the Synar program as persons under 19, 21, or 25 as the case may be. Alternatively, Congress can use an approach similar to that taken in the National Minimum Drinking Age Act of 1984,[1] which penalized states that did not ban the purchase and public possession of alcoholic beverages under age 21 by reducing their annual federal highway appropriations by 10 percent. By 1995 all 50 states and the District of Columbia were in compliance, thanks to this strong incentive. Although the highway appropriation may not be seen as the most appropriate type of leverage for tobacco policy, federal funds related to public health may be viewed as more suitable for this purpose.

In sum, Congress could decide to raise the MLA at the national level, to provide federal funding incentives for the states to do so, or to leave the matter entirely to the states or local jurisdictions. In the absence of a national MLA, however, the national public health impact of raising the MLA for tobacco would be dependent, first and foremost, on the degree to which local and state governments take up this policy.

EFFECTS OF OTHER TOBACCO CONTROL POLICIES

Both simulation models predict the potential effects on future initiation of increasing the MLA. The SimSmoke model also includes modules for

[1] The National Minimum Drinking Age Act of 1984, Public Law 98-363. 98th Cong. (July 17, 1984). 23 U.S.C. § 158.

modeling the effects of other tobacco control policies: taxation, smoke-free air, marketing restrictions, health warnings, media campaigns, and cessation treatment policies. Tobacco control policies are effective; they reduce tobacco use and hence decrease the adverse health outcomes associated with use. The effects of these policies are modeled as changes in the initiation and cessation of smoking. The effects of past policies are incorporated into the initiation and cessation rates in future years. While the models in general have the capability to project future changes in policies, the models as used here assume that all current policies other than the MLA will remain in effect at their current rates and that no new policies will be implemented. This assumption is useful because it isolates the effects of raising the MLA from other potential policy changes in the modeling of the effects of nationwide implementation. However, a significant change, one way or the other, in the intensity and effectiveness of tobacco control policies in the country as a whole could alter the figures projected by the models for prevalence and health outcomes presented in Chapters 7 and 8.

In this connection, it is important to emphasize that there are significant variations in the strength and efficacy of existing state and local tobacco control programs. These variations reflect differences in the number and intensity of tobacco control activities and in the resources allocated to support them. A comprehensive approach to tobacco control integrates "educational, clinical, regulatory, economic, and social strategies" (CDC, 2014, p. 6). Specifically, such an approach includes activities targeted at preventing initiation of tobacco use, reducing tobacco use and tobacco-related diseases, promoting cessation, and reducing exposure to secondhand smoke, combined with mass media campaigns and community mobilization efforts (CDC, 2014; HHS, 2000). Comprehensive, multifaceted strategies have been shown to effectively reduce tobacco use among adolescents (Farrelly et al., 2013; Kuiper et al., 2005; Laugesen and Swinburn, 2000; Luke et al., 2000; Tauras et al., 2005; Wakefield and Chaloupka, 2000), young adults (Farrelly et al., 2014; Kuiper et al., 2005; Laugesen and Swinburn, 2000; Pierce et al., 2009), and adults (Farrelly et al., 2008; Kuiper et al., 2005; Laugesen and Swinburn, 2000; Stillman et al., 2003; Zaza et al., 2005), as well as to reduce tobacco-related death and disease (Jemal et al., 2003; Kuiper et al., 2005; Laugesen and Swinburn, 2000). Moreover, in a review of comprehensive state-level tobacco control programs, Wakefield and Chaloupka (2000) found that states were able to substantially reduce teenage smoking despite differences in the specific program components that the states used. On the other hand, comprehensive statewide tobacco control programs that lacked optimal funding failed to achieve the full magnitude of their potential effect, despite achieving substantial reductions in tobacco use (Farrelly et al., 2008; Tauras et al., 2005). States and localities that have more comprehensive and intensive tobacco control activities and that devote more resources to support these activities are likely to have a lower prevalence of tobacco use than states and localities with weaker tobacco control programs.

As noted above, the national projections in Chapters 7 and 8 are grounded in models that essentially aggregate each state's tobacco control activities, whether they are strong or weak. To the extent that policy makers in individual states want to try to derive state-based estimates from the findings of national modeling exercise, they will have to take into account whether the existing level of tobacco control activity in their state is comparable to the investment (and intensity of activity) in the "average" state. If it is much weaker, the extrapolation from the modeling used in this report may not be suitable. Similarly, if a state is among the nation's leaders in the tobacco control, the reduction in prevalence and in morbidity and mortality may be greater.

SCOPE AND ENFORCEMENT OF MLA RESTRICTIONS

Before undertaking the task of estimating the effects of raising the MLA on adolescent and young adult initiation, the committee agreed on certain key assumptions about the scope and enforcement of the MLA (51 jurisdictions aggregated nationally). First, the committee assumed that current levels of enforcement and retailer compliance with the MLA restrictions will be sustained for all underage purchasers, including those 18 or older but under the new MLA, if the MLA is raised. Second, the committee assumed that existing bans on noncommercial distribution of tobacco by friends, proxy purchasers, and other "social sources" will continue to be weakly enforced whether or not the MLA is raised and that these sources will continue to provide substantial, though incomplete, substitution for retail purchases for newly underage buyers. Third, the committee assumed that the proportion of underage users who purchase tobacco on the illicit commercial market will remain small. Finally, the committee assumed that sanctions will continue to be directed primarily toward retailers and will not be enforced against underage users on a significant scale. The committee revisits these assumptions here.

Enforcement Against Retailers

Federal support for youth access enforcement, together with funding incentives, has significantly strengthened state enforcement of youth access policies and has thereby curtailed retail availability to underage persons. The committee has assumed that the current levels of enforcement and penalties for violators will continue, creating a credible threat of punishment sufficient to sustain current levels of compliance. In addition, the committee assumes that the deterrent threat will be the same for selling to every underage purchaser, regardless of where the MLA line is drawn.

It is possible, of course, that the intensity of enforcement could be significantly increased against all underage users, in which case the committee's estimates in Chapter 7 about the impact of raising the MLA on the adolescent and young adult initiation rates might be too conservative. On the other hand, it is also possible that increasing the MLA into the years of "adulthood" could generate a backlash and weaken public support for enforcing the law. As emphasized in Chapter 6, curtailing retail access depends on active enforcement and retailer compliance. Those conditions could be undermined if the MLA is set too high. Concerns about under-enforcement would be particularly pronounced if the MLA were set at age 25, and for this reason the committee is relatively more confident about the assumption that current enforcement intensity is more likely to be maintained if the age is increased to 19 or 21 than if it is set at 25. (This is one of the reasons why the range between the lower and upper scenarios is broader in the analysis of the MLA 25 policy option.)

If current levels of enforcement intensity are to be sustained and extended to the older ages, another key question is whether doing so will require a significant increase in current funding for enforcement. Recall that the 1992 Synar Amendment to the Alcohol, Drug Abuse and Mental Health Administration Reorganization Act[2] was designed to incentivize states to enact, enforce, and continuously evaluate laws that prohibit the sale and distribution of tobacco products to individuals under age 18. As discussed in Chapters 1 and 5, states are required to follow specific guidelines for random compliance inspections, surveillance, and reporting as a condition of their receipt of federal Substance Abuse Prevention and Treatment block grant funding. Failure to comply with Synar regulations could result in the withholding of up to 40 percent of block grant funds.

The language of the Synar Amendment focuses specifically on restricting access to tobacco products among persons under age 18. Because the amendment incentivizes states to enforce and track compliance with tobacco purchase laws only for adolescents under age 18, it is not clear whether additional resources would be required to extend significant enforcement activities to individuals above age 18. Ongoing surveillance and the associated random inspections/compliance checks are essential, not only for policy evaluation but also as a strong incentive for retailers and distributors to comply with the law. Extending the training and surveillance systems in place for the Synar Amendment to ensure compliance with an MLA of 19 or above might require additional financial and human resource invest-

[2] ADAMHA Reorganization Act of 1992, Public Law 102-321. 102nd Cong. (July 10, 1992).

ments. Compliance checks must be done with age-appropriate confederates (e.g., 20-year-olds cannot be used for compliance checks for Synar reporting, and under-18 purchasers are not appropriate for surveillance regarding enforcement among 18- to 20-year-olds).

For an MLA of 21, local enforcement activities might dovetail with those for alcohol, and assigning responsibility to the same agency, as some states have already done, might actually reduce the costs of enforcement, particularly given the overlap of licensees.

The committee understands that the relevant agencies in New York State and New York City have reached an agreement that facilitates the enforcement of the city's new Tobacco 21 law without increasing the cost of enforcement. The New York City Department of Consumer Affairs (DCA) enforces the city's Tobacco 21 law with funding from the state Department of Health. Their agreement requires DCA to perform compliance checks with adolescents ages 16 and 17 in compliance with state and federal laws prohibiting tobacco sales to adolescents under age 18. The state will then punish violators detected during these inspections. In addition, DCA will employ a small team of young adults ages 18 to 20 to assess compliance with the city's MLA of 21, and will also punish violators.[3] The agreement also requires DCA to verify that tobacco retailers post required minimum age signage, perform age verification, and comply with other point-of-sale restrictions. Because New York City's Tobacco 21 law is more stringent than both state and federal laws, New York State has agreed that DCA will inspect for city Tobacco 21 signs (as opposed to state signs for MLA 18) and to check that retailers ask for proof of age using photo identification for customers who look under 30 years old (as opposed to state law requiring age verification for customers who look under age 26) (NYCDOHMH, 2014).

In addition to the intensity of enforcement and retailers' perceived risk of getting caught, the severity of the penalty for violation would also play a role in policy effectiveness. For example, in Hawaii County, failure to post signage regarding the MLA 21 policy results in a $500 fine, and any person who sells or distributes tobacco products to a person under age 21 is subject to up to a $2,000 fine. Similarly, the penalties associated with New York City's recent Tobacco 21 law include a $500 fine for failure to post required signage, a $1,000 fine for the first sales violation to someone ages 18 to 20 or any other violation in the same day, and a $2,000 fine for the second and any subsequent violation within 3 years. In addition, a second violation may result in the revocation of the retail tobacco license. Although the committee is not aware of any systematic data regarding the severity of

[3] Personal communication, K. Munn, New York State Department of Health, October 14, 2014.

penalties imposed on violators, it seems likely that the imposition of penalties at this level, particularly the loss of the tobacco license or, as in some states, a lottery license, can achieve meaningful deterrence as long as there is a credible threat of detection for a violation.

Enforcement Against Social Sources

As discussed in Chapter 6, cigarettes obtained from friends, family members or fellow smokers, or from proxy buyers are very good substitutes for the same product bought directly from a retail outlet. So if direct sales become unavailable through effective enforcement efforts, underage users will likely continue to substitute cigarettes obtained from these other sources. Although existing bans on noncommercial distribution of tobacco by friends, proxy purchasers, and other "social sources" are weakly enforced, the committee has concluded that access to social sources does not fully substitute for convenient access to retail purchases because, as economic theory suggests, the use of social sources is more costly. It requires additional time and effort, in addition to money, for someone to obtain cigarettes indirectly instead of purchasing them directly from a store. As such, forcing underage smokers to find and use indirect sources raises their costs of obtaining tobacco products, which in turn is likely to reduce their consumption. It is these additional costs that account for the reduction in underage use attributable to youth access restrictions, especially when smoking is reduced among the members of social networks to which the underage smoker has ready access. The committee has estimated that raising the MLA to ages 19, 21, or 25 will reduce tobacco use by secondary school students who lack ready access to social networks of older youth.

That said, the committee expects that social sources, especially proxy purchases, will remain the primary sources of tobacco for underage persons, and it has been realistic about the high level of continuing availability to adolescents and young adults who are in the workforce or in college environments. Our estimates in this respect are predicated on relatively conservative assumptions. Although access to social sources could be reduced significantly if the laws prohibiting transfers to underage persons were aggressively enforced, the committee does not expect such a radical change in enforcement policy in the foreseeable future, especially under a higher MLA, because of likely public resistance. However, if a state or locality decided to ramp up the threat of detection and punishment against social sources and to sustain this policy, the impact on youth consumption could be greater than the committee has projected.

Black Market Supply to Adolescents and Young Adults

As noted in Chapter 5, a 2015 National Research Council report (NRC, 2015) concluded that a sizable illegal market in untaxed tobacco and cross-border shipments from low-tax states to high-tax states is emerging. (See also Joossens and Raw, 2012; Shelley et al., 2007.) Cigarettes are fairly compact and are not highly perishable. A day's supply weighs about an ounce, which means that black market operators could smuggle nontrivial quantities in the trunk of a car or other small spaces. Under a policy regime that significantly hindered social sources and proxy buyers, it is theoretically possible that a true black market serving underage smokers could emerge (with entrepreneurs organizing their activities to target underage consumers). Nonetheless, it seems quite unlikely that enforcement of the MLA restrictions against social sources and proxy buyers of tobacco will be intensified so substantially as to create underage demand for black market tobacco products. Also, it is difficult for a true black market to emerge when everyone over a certain age is a legitimate purchaser (as has been the experience with alcohol). As such, the committee thinks it highly unlikely that raising the MLA will create a black market with "street dealers" and associated violence, the way that prohibiting an entire product class for all ages (e.g., marijuana) can do and has done. If this supposition proves to be erroneous, the policy significance of an emerging black market in tobacco on the streets of our communities goes way beyond the limited task undertaken here.

Enforcement of PUP Restrictions

As noted in Chapter 5, bans against underage purchase–use–possession (PUP) restrictions are common. Active enforcement of sanctions for PUP violations has rarely been attempted and, in the committee's judgment, is unlikely to occur on a significant scale in the foreseeable future. However, this is not to say that the bans have no instrumental effect; indeed, they empower parents and schools to demand compliance and impose discipline. If raising the MLA was to be accompanied by greater PUP enforcement against underage users, then initiation rates could be reduced more than the committee has estimated. The committee did not attempt to quantify the effects of increased PUP law enforcement because there is so little basis in either the deterrence literature or the tobacco youth access literature for doing so.

Whether laws banning selling tobacco to minors should be accompanied by penalties against the underage purchasers themselves has been debated for a more than a quarter of a century, ever since preventing adolescent and young adult smoking emerged as a key component of tobacco control in the early 1990s. Tobacco control advocates have typically concentrated their attention on the retailers and distributers who provide the tobacco rather than on the buyers themselves (Jason et al., 2007; Wakefield and Giovino, 2003). In addition to making enforcement easier, concentrating policy efforts on the sellers also focuses the moral responsibility for preventing youth access to tobacco products on the retailers and industry distributors rather than on the minors themselves (Craig and Boris, 2007; Forster and Wolfson, 1998).

The case against punishing underage users of tobacco was put forcefully in *Growing Up Tobacco Free*:

> Imposing penalties on minors for buying, possessing, or using tobacco products is controversial. At least 21 states currently prohibit smoking and the use of tobacco products by minors. Proponents of these penalties argue that they may have some deterrent value, and that the failure to make possession illegal sends a mixed message, reinforcing the idea that tobacco use is a trivial infraction. However, the Committee believes that penalizing minors is an unwise and ineffective strategy. Criminal sanctions or delinquency adjudications are grossly disproportionate to the seriousness of the offense and would not be sought by prosecutors or imposed by judges. Even if the offense were punishable with a civil fine, like a traffic ticket, the penalty would rarely be enforced. Because lack of enforcement would erode whatever deterrent effect the law might otherwise achieve, the only remaining rationale for such a prohibition is a symbolic one: the failure to make tobacco use an offense would somehow imply that tobacco use is not harmful or that it is socially acceptable. In the Committee's view, such speculative fears are groundless—social disapprobation is (or should be) strongly communicated by the laws on distribution, by warning labels, and by all of the other policies outlined in this report. Young people will not miss the point simply because their disapproved conduct is not against the law. Furthermore, purely symbolic prohibitions—laws that are not meant to be enforced—are harmful because they undermine respect for the law. Finally, imposing legal penalties on the underage purchaser also impedes the use of underage buyers to monitor retailer compliance with youth access restrictions. The need to obtain waivers unnecessarily increases the cost of enforcement. (IOM, 1994, pp. 222–223)

Notwithstanding the argument set forth in the 1994 IOM report, most states have prescribed penalties for underage purchasers, and some tobacco control advocates have argued that youth access restrictions would be more effective if sanctions against underage purchasers were prescribed and enforced. First, their argument goes, PUP laws signal strong social disapproval by making acquisition and use of tobacco punishable acts (the declarative effect). Under this view, a law that penalizes retailers who sell tobacco products but does not penalize the underage individuals for purchasing, possessing, or using the product is sending a "mixed message," thereby undermining the social norms against tobacco use that tobacco policy makers are trying to instill among young adults in work environments, school settings, and other public and private places. Second, PUP proponents contend, penalties against the underage purchaser would have a significant deterrent effect on purchase and would also make it easier to deter underage proxy sellers. Penalties against underage alcohol users appear to have been enforced to a greater extent than penalties for underage tobacco users and may have functioned to some extent as a deterrent to the purchase and public transport or use of alcohol. For example, some states have implemented so-called brown jug laws under which businesses that sell alcohol are allowed to report underage purchase/use and to receive the fine payments from offenders (IOM and NRC, 2004).

This argument reflects very different views about the effects on PUP laws on underage smoking than those set forth in *Growing Up Tobacco Free* as well as a different perspective on the potential disadvantages and the costs of punishing young people for this sort of minor transgression. There are few rigorous studies regarding the effects of PUP laws on underage use, mainly because the laws are so rarely enforced, and the limited evidence is mixed. It seems likely, in the committee's view, that meaningful enforcement of PUP sanctions against underage persons for purchasing, possessing, or using tobacco products would deter tobacco use by some underage persons, most likely those who are at least risk for becoming addicted. However, the PUP laws on the books in 47 U.S. jurisdictions are essentially unenforced. Under these circumstances, the operative policy is to capture the declarative effects of making the behavior illegal and empowering parents and schools to enforce it without incurring the costs of having to impose legal punishment. The committee assumes that this will be the operative policy in the foreseeable future, and its estimates reflect this conservative assumption.

ADOLESCENT DEVELOPMENT AND THE MLA FOR TOBACCO

In accordance with the committee's charge, this report addresses the "public health implications" of raising the MLA for tobacco products. However, federal, state, and local lawmakers will likely take into account factors other than public health benefits, including the economic interests of tobacco retailers and other businesses that profit from tobacco use. Legislators also will likely give some weight to arguments by and on behalf of young adults that they should be entitled to make their own decisions about whether to use tobacco products, especially in light of the fact that the "age of majority" for many legal purposes is 18 in all but four states (JRank, 2014). This argument may be grounded in a deeper concern about the role of government, especially in the realm of public health, and these ethical concerns about the "nanny state" may affect not only the level of political support for proposals to raise the MLA[4] but also the level of community willingness to enforce a higher MLA if it is enacted. Naturally the strength of these concerns is likely to increase as the proposed MLA is raised from 19 to 21 to 25, all the more so when the policy lever is an outright prohibition rather than an excise tax or a public smoking restriction, which would limit use without banning it completely. A lack of public support could erode the potential public health benefits of raising the MLA.

The policy judgment regarding where to draw the line for the MLA involves a burgeoning scientific literature on adolescent development on which the Supreme Court has recently relied to explain why the Constitution mandates differential treatment of adolescents in the context of criminal punishment (Bonnie and Scott, 2013). That body of research, reviewed in the National Research Council's report *Reforming Juvenile Justice: A Developmental Approach* (2013) and summarized in Chapter 3, documents various distinctive features of adolescent judgment as compared with adults, including a heightened sensitivity to rewards, lower impulse control, and tendencies to take risks—especially when in the presence of peers—and to discount the long-term consequences of actions. These behavioral tendencies are rooted in the different pace of maturation between the brain's motivational and reward systems and the systems in the brain that are responsible for self-regulation and cognitive control. These developmental factors, along with adolescents' vulnerability to the rewarding effects of nicotine and their risk of addiction, are widely thought to justify policies that curtail access to tobacco products by teenagers (IOM, 1994, 2007; IOM and NRC, 2011). It is noteworthy that John Stuart Mill's justly famous defense of the anti-paternalism principle in his essay *On Liberty* (1859) acknowledged that the individual's sovereign control over self-regarding choices applies only to persons "in the maturity of their faculties." Indeed, these same concerns about adolescent vulnerability and immature judgment have been invoked to justify non-prohibitory efforts to curtail smoking by addicted adults. As explained in *Ending the Tobacco Problem* in 2007:

> It can also be argued that paternalism in this context is a justified response to irremediable deficiencies in smokers' capacity to successfully exercise self-interested decision making about whether they should continue to smoke. Although the committee's blueprint need not rest on this argument, many committee members do find elements of it convincing, and that is

[4] A recent publication indicates that more than 70 percent of adults surveyed support raising the age of sale of tobacco products to 21 years of age; majority support is seen across smoking status, geographic region, race, sex, education, and age (Winickoff et al., 2015).

> why we summarize it here. The argument runs as follows: (1) Virtually all addicted adults begin smoking (and probably become addicted) while they are adolescents, before they have developed the capacity to exercise mature judgment about whether or not to become a smoker; (2) the preferences expressed when people begin to smoke, which tend to ignore long-term health risks, are inconsistent with the health-oriented preferences they later come to have, and they soon regret the decision to have become a smoker; and (3) once smokers begin to be concerned about the health dangers of smoking, their judgment is often distorted by optimism bias ("the harms will happen to other people, not to me"), thereby weakening their motivation to quit. (IOM, 2007, p. 150)

Although adolescents' vulnerability to addiction and immaturity of judgment support an underage access restriction, these developmental concerns do not resolve the policy question about the specific age at which the line should be drawn. The argument against raising the MLA above 18 is predicated on the assumption that adolescents older than 17 are mature enough to make their own decisions about what is in their best interests. However, experts on developmental psychology and neuroscience (e.g., IOM and NRC, 2014; Steinberg, 2012) and also specialists in family and adolescent and young adult policy (Goldfarb, 2014; Hamilton, 2012; Scott, 2013) have called attention to the evidence that capacities related to mature judgment, especially judgment in emotionally charged situations or in situations in which peer influence plays are role, are still developing into the early 20s. (See also Chapter 3.) Authorities on adolescent development generally agree that the period of development that is typically labeled adolescence stretches from the onset of puberty into the early 20s (Steinberg, 2012). Many young people in their late teens and early 20s may also still be at elevated risk, developmentally speaking, to becoming addicted to nicotine.

A review of age-specific public policies demonstrates that policy judgments about where to draw age lines relating to adulthood are highly contextual, ranging from ages 14 to 16 (medical decision making) to age 21 (the purchase, use, and possession of alcohol and firearms, fiduciary appointments, and most professional occupational licenses).[5] In short, a balance needs to be struck between the personal interest of young adults in making their own choices and society's legitimate concerns about protecting the public health and protecting young people from decisions they may later regret (IOM, 2007; IOM and NRC, 2004). None of this is to say that the line should be drawn based solely on developmental science; it is only

[5] Although not directly relevant in the present context, it is worth noting that the legally relevant age of eligibility for various types of parental and social support in young adulthood is often around 25 or 26 (IOM and NRC, 2014).

to say that 18 is not the only developmentally plausible place to draw the line. The so-called age of majority functions as a default, and every state sets the legal age for certain activities higher or lower for different policy purposes. In short, state legislators will likely continue to draw the line in different places in different policy contexts, and tobacco will be no exception (Bonnie and Scott, 2013; Hamilton, 2010; Steinberg, 2012).

One inevitable comparison in any discussion of the MLA for tobacco is the 21-year-old MLA for alcohol in all states. The developmental justification for such a comparison is fairly strong in light of the addictive properties of these drugs and the long-term consequences of initiating use during adolescence. However, the intoxicating properties of alcohol are also associated with harm to other persons, especially in relation to driving and aggression, and not only with harm to oneself. The likely counterargument is that the public health burden of tobacco use exceeds the toll associated with any other self-regarding behavior or with the use of any other legal product, making a case for "tobacco exceptionalism" in public health policy (Collin, 2012; Malone and Warner, 2012). Whether this argument is sufficient to trump otherwise strong commitments to individual choice is being played out in the policy arena.

POSSIBLE PUBLIC HEALTH EFFECTS OF NEW TOBACCO PRODUCTS

The prevalence of use of electronic nicotine delivery systems among adolescents and young adults appears to be increasing substantially (see Chapter 2; Arrazola et al., 2013; Wadley and Bronson, 2014). ENDS include electronic cigarettes (e-cigarettes), e-hookahs, and other vapor emitting devices. FDA has begun the process of deeming these products to be "tobacco products" under the Tobacco Control Act and thereby bringing them within the agency's regulatory jurisdiction. States have also been gradually including these products in youth access statutes. The committee assumes that FDA will eventually regulate these products, that they will be subject to the MLA in all states, and that the committee's findings regarding enforcement of the MLA will apply to ENDS and other novel products. It is also important to emphasize that the simulation models used in Chapters 7 and 8 are calibrated to project cigarette use and related outcomes and do not include the public health effects of use of other tobacco products.

The question of greatest relevance to the committee's task is how the use of ENDS or other novel tobacco products is likely to affect the public health impact of increasing the MLA. Assessing this impact is difficult, given the relatively recent introduction of these products and the lack of detailed data on the patterns of ENDS use over time, its relation to cigarette use, and its health effects. Nevertheless, it is possible to speculate in broad terms about several ways in which ENDS use might affect initiation and prevalence of cigarette use and the public health and possibly alter the projections described in Chapters 7 and 8.

Preliminarily, it should be emphasized that even if increasing ENDS use has no effect on current patterns of initiation of cigarette use, it is likely to affect the prevalence of cigarette use over the long term. The challenge in evaluating its impact is that the net effect on conventional cigarette use could be in either direction. For example, it is plausible that some persons already using conventional cigarettes may quit using cigarettes and instead switch to ENDS. In this scenario, there is likely a public health benefit in that early data suggest that, while not harm free, ENDS are probably less harmful than conventional cigarettes (Bhatnagar et al., 2014; Farsalinos and Polosa, 2014; Grana et al., 2014). However, it is also plausible that some persons already using conventional tobacco cigarettes may become dual users of conventional cigarettes and ENDS (Bhatnagar et al., 2014; Dutra and Glantz, 2014; Grana et al., 2014; Pearson et al., 2012; Regan et al., 2013) because it costs less, helps the user reduce conventional cigarette consumption, or serves as a "bridge" for nicotine use during times when smoking conventional cigarettes is prohibited or inconvenient. Emergence of this "dual use" scenario may increase the public health harm attributable to tobacco use if it increases nicotine dependence (due to increased consumption of nicotine), making smoking cessation more difficult, or otherwise prolongs conventional cigarette smoking. While these scenarios are postulated to have no effect on the initiation of cigarette use and are therefore unaffected by raising the MLA, they would affect the quantitative estimates of health benefits attributable to raising the purchase age by reducing the estimated benefits in the first scenario (of increased conventional cigarette cessation) and increasing them under the latter scenario (of increased nicotine dependence and prolonged smoking).

The question of greatest relevance to this report is whether and how use of ENDS will affect initiation of cigarette use. Broadly speaking, there are three possibilities. One scenario is that initiation of ENDS use will *reduce initiation of cigarette use*; that is, some portion of adolescents and young adults who otherwise would have initiated cigarette use will not do so, becoming ENDS users instead. Under this scenario, there may be net public health benefits over the long term, but some portion of those benefits would be attributable to the initiation of ENDS, not to the raising of the MLA. A second possibility is that initiation of ENDS would *delay conventional tobacco use*, as adolescents and young adults who begin with ENDS switch to conventional cigarettes at a later time, due in part to nicotine dependence and to the relatively lower levels of nicotine delivery from ENDS compared to conventional cigarettes. This scenario, involving the possibility of ENDS serving as a gateway to conventional cigarettes, would be particularly worrisome because it would increase the prevalence of cigarette use, possibly offsetting some portion (if not all) of the public health gains of raising the MLA. Finally, as more recent data suggest (Wills et al., 2015), it is possible that some of those who have never considered using conventional tobacco products will *initiate with ENDS and only use ENDS*. In that case, the net public health effect would be entirely attributable to the yet unknown health effects of ENDS use.

All three of these patterns and trajectories of tobacco use—as well as other variations—are likely to emerge, and the committee has no basis for estimating the proportions of adolescents and young adults that will take each path, much less the net effect of ENDS use on initiation of cigarette use. What can be said, then, about the possible effects of raising the MLA for ENDS use on the likelihood of these scenarios? For this purpose, the committee assumes that the MLA will be increased for all tobacco products, including ENDS, and that the intensity of enforcement will be the same for all products. The committee sees no reason to believe that the effects of the legal norm and its enforcement on retailer compliance, retail availability, or access to social sources would differ materially for ENDS compared with other tobacco products. Given the evidence that adolescents who currently initiate tobacco use with ENDS rather than with conventional tobacco products are younger (Wills et al., 2015), the main effect of raising the MLA for ENDS will likely be to reduce the number of adolescents who initiate tobacco use with ENDS. That may translate into reduced initiation of cigarette use for some, but it also may translate into delayed initiation of cigarette use for others, including some proportion who would not have otherwise used conventional cigarettes. Presumably FDA and state policy makers will take these possibilities into account in setting the MLA and will carefully monitor the promotion and use of ENDS, especially by adolescents and young adults.

POSSIBLE EFFECTS OF RAISING THE TOBACCO MLA ON USE OF ALCOHOL AND OTHER DRUGS

In summarizing the estimated health effects of raising the tobacco MLA presented in Chapter 8, the committee has not taken into account the possibility that reducing adolescent and young adult tobacco use could affect the use of alcohol, marijuana, or other illegal drugs and thus has ignored the substantial mortality and morbidity associated with use of those substances. However, it is possible that raising the MLA for tobacco could have indirect effects on the use and abuse of other substances, either by increasing their use (and thereby having a negative effect on public health that might offset some of the effects of reduced tobacco use) or by decreasing their use (and thereby augmenting the public health benefit of reducing tobacco use). Because tobacco use is correlated with the use of many other substances, it could be important to consider the indirect effects of reducing tobacco use on the use of other substances, but definitive statements are difficult to make since the associations need not be causal. The mere fact that people who smoke today have greater rates of abuse or dependence on other substances is not sufficient to infer that an intervention that reduces smoking—such as raising the MLA—would necessarily reduce rates of abuse or dependence on that second substance. There is, however, some literature examining the effects of tobacco control interventions on the use of other substances.

The empirical literature on spillover effects of tobacco policies on alcohol use and abuse is mixed. Picone et al. (2004) found that smoking bans reduce alcohol consumption in older adult females. Gallet and Eastman (2007) obtained a similar but more general result, but Hahn et al. (2010) found no such effect. Young-Wolff et al. (2014) reported that increasing tobacco taxes was associated with modest to moderate reductions in alcohol use in vulnerable groups. McKee and colleagues, in a series of three studies (Kasza et al., 2012; McKee et al., 2009; Young-Wolff et al., 2013), found evidence for the proposition that smoking bans reduce alcohol use and related problems. However, Bernat et al. (2013) did not observe a decline in alcohol-related vehicle accidents when analyzing California and New York's statewide smoke-free policies.

There is also a modest literature investigating whether tobacco and alcohol are "substitutes" or "complements" in the economic sense of these terms. Although some studies find that cigarettes are substitutes for either alcohol in general (Decker and Schwartz, 2000) or liquor in particular (Goel and Morey, 1995), a more common finding is that they are instead complements (e.g., Bask and Melkersson, 2004; Cameron and Williams, 2001; Jones, 1989; Pierani and Tiezzi, 2009; Tauchmann et al., 2013; Zhao and Harris, 2004); that is, they enhance each other's value to a user, and a decrease in the use of one is likely to be associated with a decrease in the use of the other. Thus, the research would suggest that interventions that reduce tobacco use will not increase alcohol use. A study by Hughes (1993) found that smoking cessation treatment among adults does not increase alcohol intake, even among former alcohol abusers.

In theory, tobacco control policies could have indirect effects on the consumption of illicit drugs. However, the literature on this subject is quite sparse and mostly limited to effects on marijuana use. A few studies, such as Cameron and Williams (2001), Chaloupka et al. (1999), and Zhao and Harris (2004), find "complementarity" between tobacco and marijuana; that is, when cigarette prices go up, marijuana use declines. However, Cameron and Williams (2001) found that increases in tobacco prices did not affect cannabis use.

A conceptually separate issue concerns how changes in marijuana policy might affect tobacco use and, hence, the effects of raising the MLA on tobacco use. Marijuana policy is in a state of flux, and there is considerable overlap between the populations who use marijuana and those who use tobacco. Thus, changes in marijuana policy might spill over to affect tobacco use, and vice versa. It is extremely challenging to estimate legalization's effects on marijuana use (Kilmer et al., 2010), let alone its spillover effects on the use of other substances, including whether any spillover effects would enhance or undermine the value of raising the MLA for tobacco. This, however, does not imply that any such effects would be small. If marijuana and tobacco were substitutes, increased marijuana use might lead to lower tobacco use. As noted above, however, what little literature exists on the subject suggests that marijuana and tobacco are more likely to be complements, not substitutes.

Furthermore, although the overlap in North America has tended to be by user (with marijuana smokers more likely than others to smoke tobacco and vice versa), in Europe it is quite common to mix tobacco and marijuana in the same cigarette (UNODC, 2006), as also occurs already in the United States with "blunts." Hence, it is plausible that what adolescents and young adults primarily construe as "marijuana use" might become the vehicle for first exposure to nicotine. Also, the relaxation of marijuana laws has been accompanied by a proliferation of modalities of use, including vaporization as opposed to combustion. It is conceivable that a proliferation of vaporizer pens or other devices acquired initially for marijuana use might facilitate the uptake of consumption of nicotine via ENDS or increase the social acceptability of "vaping."

In sum, it seems plausible that to the extent that raising the MLA reduces tobacco use, it might have some beneficial spillover in the form of indirect effects on the use of and harm from alcohol and, potentially, marijuana. And it seems plausible that changes in marijuana policy and patterns of use could modulate the effects of raising the MLA on tobacco use. However, the existing empirical literature does not allow estimating a specific magnitude or even a potential range of estimates of those effects in the population overall, let alone among adolescents and young adults specifically.

CONCLUDING REMARKS

The committee was charged with assessing the potential public health implications of raising the minimum age of legal access to tobacco products. Studies investigating the effects of setting or raising the MLA for tobacco are sparse. In order to carry out its charge, the committee undertook a thorough review of the available evidence related to tobacco use by adolescents and young adults, the effects of raising the MLA for alcohol, and enforcement of the existing MLA restrictions for tobacco products. This evidence provided a solid foundation for the critical phase of the committee's work—using its collective expert judgment to estimate the effects of raising the MLA on initiation rates at various ages. Using these estimates as inputs, the committee commissioned new modeling studies of aggregate smoking behavior with which to project likely population-level outcomes of changes in the MLA. The most important assumptions required for these estimates have been discussed in this chapter, as have been additional policy-relevant considerations.

Among the key assumptions are relative stability in the intensity of tobacco control activities and the continuation of the MLA enforcement at existing levels. These are relatively conservative assumptions, and the public health benefits could be greater if tobacco control policies and the MLA enforcement were substantially strengthened. It is important to recognize, however, that public health gains also have to be weighed against the costs and other social consequences of enforcing more restrictive MLA policies.

It is also important to emphasize that the committee's modeling estimates are based on nationwide adoption of the increased MLA, although public health benefits of that magnitude will occur only if Congress facilitates federal action or if states with a substantial portion of the nation's population raise the MLA. Over the short term, at least, the projected public health benefits will need to be translated into state-by-state estimates.

Although the full benefits of preventing initiation of tobacco use will take decades to accrue, some direct health benefits, including those from reduced secondhand smoke exposure, will be immediate. Perhaps the greatest uncertainty in the committee's assessment is the currently unpredictable effects of the marketing and use of electronic nicotine delivery systems and other novel tobacco products. However, in the absence of transformative changes in the tobacco market, social norms and attitudes, or the epidemiology of tobacco use, the committee is reasonably confident that raising the MLA will reduce tobacco initiation, particularly among adolescents 15 to 17 years of age, will improve health across the life span, and will save lives.

REFERENCES

Arrazola, R. A., S. Dube, and B. A. King. 2013. Tobacco product use among middle and high school students—United States, 2011 and 2012. *Morbidity and Mortality Weekly Report* 62(45):893–897.

Bask, M., and M. Melkersson. 2004. Rationally addicted to drinking and smoking? *Applied Economics* 36(4):373–381.

Bernat, D. H., M. Maldonado-Molina, A. Hyland, and A. C. Wagenaar. 2013. Effects of smoke-free laws on alcohol-related car crashes in California and New York: Time series analyses from 1982 to 2008. *American Journal of Public Health* 103(2):214–220.

Bhatnagar, A., L. P. Whitsel, K. M. Ribisl, C. Bullen, F. Chaloupka, M. R. Piano, R. M. Robertson, T. McAuley, D. Goff, and N. Benowitz. 2014. Electronic cigarettes: A policy statement from the American Heart Association. *Circulation* 130(16):1418–1436.

Bonnie, R. J., and E. S. Scott. 2013. The teenage brain: Adolescent brain research and the law. *Current Directions in Psychological Science* 22(2):158–161.

Cameron, L., and J. Williams. 2001. Cannabis, alcohol and cigarettes: Substitutes or complements? *Economic Record* 77(236):19–34.

CDC (Centers for Disease Control and Prevention). 2014. *Best practices for comprehensive tobacco control programs—2014*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

Chaloupka, F. J., R. L. Pacula, M. C. Farrelly, L. D. Johnston, and P. M. O'Malley. 1999. Do higher cigarette prices encourage youth to use marijuana? National Bureau of Economic Research Working Paper Series No. 6939.

Collin, J. 2012. Tobacco control, global health policy and development: Towards policy coherence in global governance. *Tobacco Control* 21(2):274–280.

Craig, M. J., and N. W. Boris. 2007. Youth tobacco access restrictions: Time to shift resources to other interventions? *Health Promotion Practice* 8(1):22–27.

Decker, S. L., and A. E. Schwartz. 2000. Cigarettes and alcohol: Substitutes or complements? National Bureau of Economic Research Working Paper Series No. 7535.

Dutra, L. M., and S. A. Glantz. 2014. Electronic cigarettes and conventional cigarette use among U.S. adolescents: A cross-sectional study. *JAMA Pediatrics* 168(7):610–617.

Farrelly, M. C., T. F. Pechacek, K. Y. Thomas, and D. Nelson. 2008. The impact of tobacco control programs on adult smoking. *American Journal of Public Health* 98(2):304–309.

Farrelly, M. C., B. R. Loomis, B. Han, J. Gfroerer, N. Kuiper, G. L. Couzens, S. Dube, and R. S. Caraballo. 2013. A comprehensive examination of the influence of state tobacco control programs and policies on youth smoking. *American Journal of Public Health* 103(3):549–555.

Farrelly, M. C., B. R. Loomis, N. Kuiper, B. Han, J. Gfroerer, R. S. Caraballo, T. F. Pechacek, and G. L. Couzens. 2014. Are tobacco control policies effective in reducing young adult smoking? *Journal of Adolescent Health* 54(4):481–486.

Farsalinos, K. E., and R. Polosa. 2014. Safety evaluation and risk assessment of electronic cigarettes as tobacco cigarette substitutes: A systematic review. *Therapeutic Advances in Drug Safety* 5(2):67–86.

Forster, J. L., and M. Wolfson. 1998. Youth access to tobacco: Policies and politics. *Annual Review of Public Health* 19(1):203–235.

Gallet, C. A., and H. S. Eastman. 2007. The impact of smoking bans on alcohol demand. *The Social Science Journal* 44(4):664–676.

Goel, R. K., and M. J. Morey. 1995. The interdependence of cigarette and liquor demand. *Southern Economic Journal* 62(2):451–459.

Goldfarb, S. F. 2014. Who pays for the "boomerang generation"? A legal perspective on financial support for young adults. *Harvard Journal of Law & Gender* 37:45–106.

Grana, R., N. Benowitz, and S. A. Glantz. 2014. E-cigarettes: A scientific review. *Circulation* 129(19):1972–1986.

Hahn, E. J., M. K. Rayens, S. L. Ridner, K. M. Butler, M. Zhang, and R. R. Staten. 2010. Smoke-free laws and smoking and drinking among college students. *Journal of Community Health* 35(5):503–511.

Hamilton, V. E. 2010. Immature citizens and the state. *Brigham Young University Law Review* 1055(4):1055–1148.

———. 2012. The age of marital capacity: Reconsidering civil recognition of adolescent marriage. *Boston University Law Review* 92:1817–1863.

HHS (Department of Health and Human Services). 2000. *Reducing tobacco use: A report of the Surgeon General*. Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

Hughes, J. R. 1993. Treatment of smoking cessation in smokers with past alcohol/drug problems. *Journal of Substance Abuse Treatment* 10(2):181–187.

IOM (Institute of Medicine). 1994. *Growing up tobacco free: Preventing nicotine addiction in children and youths*. Edited by B. S. Lynch and R. J. Bonnie. Washington, DC: National Academy Press.

———. 2007. *Ending the tobacco problem: A blueprint for the nation*. Edited by R. J. Bonnie. Washington, DC: The National Academies Press.

IOM and NRC (Institute of Medicine and National Research Council). 2004. *Reducing underage drinking: A collective responsibility*. Edited by R. J. Bonnie. Washington, DC: The National Academies Press.

———. 2011. *The science of adolescent risk-taking: Workshop report*. Washington, DC: The National Academies Press.

———. 2014. *Investing in the health and well-being of young adults*. Edited by R. J. Bonnie, C. Stroud, and H. Breiner. Washington, DC: The National Academies Press.

Jason, L. A., S. B. Pokorny, M. Adams, Y. Hunt, P. Gadiraju, T. Morello, M. Schoeny, and C. Dinwiddie. 2007. Youth caught in violation of tobacco purchase, use, and possession laws: Education versus fines. *Behavior Modification* 31(6):713–731.

Jemal, A., V. E. Cokkinides, O. Shafey, and M. J. Thun. 2003. Lung cancer trends in young adults: An early indicator of progress in tobacco control (United States). *Cancer Causes and Control* 14(6):579–585.

Jones, A. M. 1989. A systems approach to the demand for alcohol and tobacco. *Bulletin of Economic Research* 41(2):85–106.

Joossens, L., and M. Raw. 2012. From cigarette smuggling to illicit tobacco trade. *Tobacco Control* 21(2):230–234.

JRank. 2014. Legal ages laws—Information on the law about legal ages. http://law.jrank.org/pages/11848/Legal-Ages.html (accessed October 30, 2014).

Kasza, K. A., S. A. McKee, C. Rivard, and A. J. Hyland. 2012. Smoke-free bar policies and smokers' alcohol consumption: Findings from the International Tobacco Control Four Country Survey. *Drug and Alcohol Dependence* 126(1–2):240–245.

Kilmer, B., J. P. Caulkins, R. L. Pacula, R. J. MacCoun, and P. H. Reuter. 2010. Altered state?: Assessing how marijuana legalization in California could influence marijuana consumption and public budgets. RAND Corporation Occassional Paper Series. http://www.rand.org/content/dam/rand/pubs/occasional_papers/2010/RAND_OP315.pdf (accessed February 22, 2015).

Kuiper, N. M., D. E. Nelson, and M. Schooley. 2005. *Evidence of effectiveness: A summary of state tobacco control program evaluation literature*. Washington, DC: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control and Prevention.

Laugesen, M., and B. Swinburn. 2000. New Zealand's tobacco control programme, 1985–1998. *Tobacco Control* 9(2):155–162.

Luke, D. A., K. A. Stamatakis, and R. C. Brownson. 2000. State youth-access tobacco control policies and youth smoking behavior in the United States. *American Journal of Preventive Medicine* 19(3):180–187.

Malone, R. E., and K. E. Warner. 2012. Tobacco control at twenty: Reflecting on the past, considering the present and developing the new conversations for the future. *Tobacco Control* 21(2):74–76.

McKee, S. A., C. Higbee, S. O'Malley, L. Hassan, R. Borland, K. M. Cummings, G. Hastings, G. T. Fong, and A. Hyland. 2009. Longitudinal evaluation of smoke-free Scotland on pub and home drinking behavior: Findings from the International Tobacco Control Policy Evaluation Project. *Nicotine & Tobacco Research* 11(6):619–626.

Mill, J. S. 1859. O*n liberty*. London: Longman, Roberts & Green.

NRC (National Research Council). 2013. *Reforming juvenile justice: A developmental approach*. Edited by R. J. Bonnie, R. L. Johnson, B. M. Chemers, and J. Schuck. Washington, DC: The National Academies Press.

———. 2015. *Understanding the U.S. illicit tobacco market: Characteristics, policy context, and lessons from international experiences*. Washington, DC: The National Academies Press.

NYCDOHMH (New York City Department of Health and Mental Hygiene). 2014. New law prohibiting sale of cigarettes, tobacco products, and electronic cigarettes to people under age 21 in New York City: What you need to know. http://www.nyc.gov/html/doh/downloads/pdf/smoke/tobacco-21-faq.pdf (accessed January 29, 2015).

Pearson, J. L., A. Richardson, R. S. Niaura, D. M. Vallone, and D. B. Abrams. 2012. E-cigarette awareness, use, and harm perceptions in U.S. adults. *American Journal of Public Health* 102(9):1758–1766.

Picone, G. A., F. Sloan, and J. G. Trogdon. 2004. The effect of the tobacco settlement and smoking bans on alcohol consumption. *Health Economics* 13(10):1063–1080.

Pierani, P., and S. Tiezzi. 2009. Addiction and interaction between alcohol and tobacco consumption. *Empirical Economics* 37(1):1–23.

Pierce, J. P., M. M. White, and K. Messer. 2009. Changing age-specific patterns of cigarette consumption in the United States, 1992–2002: Association with smoke-free homes and state-level tobacco control activity. *Nicotine & Tobacco Research* 11(2):171–177.

Regan, A. K., G. Promoff, S. R. Dube, and R. Arrazola. 2013. Electronic nicotine delivery systems: Adult use and awareness of the "e-cigarette" in the USA. *Tobacco Control* 22(1):19–23.

Scott, E. S. 2013. "Children are different": Constitutional values and justice policy. *Ohio State Journal of Criminal Law* 11(1):71-105.

Shelley, D., M. J. Cantrell, J. Moon-Howard, D. Q. Ramjohn, and N. VanDevanter. 2007. The $5 man: The underground economic response to a large cigarette tax increase in New York City. *American Journal of Public Health* 97(8):1483–1488.

Steinberg, L. 2012. Should the science of adolescent brain development inform public policy? *Issues in Science and Technology* 28(3):67–78.

Stillman, F. A., A. M. Hartman, B. I. Graubard, E. A. Gilpin, D. M. Murray, and J. T. Gibson. 2003. Evaluation of the American Stop Smoking Intervention Study (ASSIST): A report of outcomes. *Journal of the National Cancer Institute* 95(22):1681–1691.

Tauchmann, H., S. Lenz, T. Requate, and C. M. Schmidt. 2013. Tobacco and alcohol: Complements or substitutes? *Empirical Economics* 45(1):539–566.

Tauras, J. A., S. Markowitz, and J. Cawley. 2005. Tobacco control policies and youth smoking: Evidence from a new era. *Advances in Health Economics and Health Services Research* 16:277–291.

UNODC (United Nations Office on Drugs and Crime). 2006. *Bulletin on narcotics: Review of the world cannabis situation, Volume LVIII, nos. 1 and 2*. Vienna: United Nations Office on Drugs and Crime.

Wadley, J., and A. Bronson. 2014. E-cigarettes surpass tobacco cigarettes among teens. Ann Arbor, MI: University of Michigan News Service. http://ns.umich.edu/new/multimedia/videos/22575-e-cigarettes-surpass-tobacco-cigarettes-among-teens (accessed February 6, 2015).

Wakefield, M., and F. Chaloupka. 2000. Effectiveness of comprehensive tobacco control programmes in reducing teenage smoking in the USA. *Tobacco Control* 9(2):177–186.

Wakefield, M., and G. Giovino. 2003. Teen penalties for tobacco possession, use, and purchase: Evidence and issues. *Tobacco Control* 12(Suppl 1):i6–i13.

Wills, T. A., R. Knight, R. J. Williams, I. Pagano, and J. D. Sargent. 2015. Risk factors for exclusive e-cigarette use and dual e-cigarette use and tobacco use in adolescents. *Pediatrics* 135(1):e43–e51.

Winickoff, J. P., R. McMillen, S. Tanski, K. Wilson, M. Gottlieb, and R. Crane. 2015. Public support for raising the age of sale for tobacco to 21 in the United States. *Tobacco Control*. doi: 10.1136/tobaccocontrol-2014-052126. [Epub ahead of print]

Young-Wolff, K. C., A. J. Hyland, R. Desai, J. Sindelar, C. E. Pilver, and S. A. McKee. 2013. Smoke-free policies in drinking venues predict transitions in alcohol use disorders in a longitudinal U.S. sample. *Drug and Alcohol Dependence* 128(3):214–221.

Young-Wolff, K. C., K. A. Kasza, A. J. Hyland, and S. A. McKee. 2014. Increased cigarette tax is associated with reductions in alcohol consumption in a longitudinal U.S. sample. *Alcoholism, Clinical and Experimental Research* 38(1):241–248.

Zaza, S., P. A. Briss, and K. W. Harris. 2005. *The guide to community preventive services: What works to promote health*. New York: Task Force on Community Preventive Services.

Zhao, X., and M. N. Harris. 2004. Demand for marijuana, alcohol and tobacco: Participation, levels of consumption and cross-equation correlations. *The Economic Record* 80(251):394–410.

Appendix A

State and Local Laws on the Minimum Age of Legal Access to Tobacco Products

The 2009 Family Smoking Prevention and Tobacco Control Act established 18 as the minimum age of legal access to tobacco products (MLA) while also allowing states and localities to impose a higher MLA. In the last decade, this has been an active area of tobacco control policy. In Massachusetts, in particular, where state law grants local Boards of Health authority to make "reasonable health regulations,"[1] nearly two dozen communities have raised the MLA above age 18, and numerous others are currently considering proposals. A smaller number of jurisdictions outside of Massachusetts, most notably New York City, have also taken similar steps. This appendix provides a set of tables detailing activities at the state and local levels to raise the MLA. These tables provide a selection of the recent activity in this area of the law and aim to provide examples of the type, range, and scale of such activity as of September 2014. As such, this appendix should be considered a list of illustrative examples rather than a comprehensive and exhaustive list of jurisdictions that have raised or are considering raising the MLA. Tables A-1 and A-2 list states and localities that have raised the MLA to 19 and 21, respectively. Tables A-3 and A-4 list select states and localities that are considering proposals to raise their MLA to 19 and 21, respectively. Tables A-5 and A-6 list select states and localities that have considered but not enacted proposals to raise the MLA.

[1] MASS. GEN. LAWS ch. 111 § 31.

TABLE A-1 Select States and Localities That Have Established a Minimum Age of Legal Access to Tobacco Products of 19

Jurisdiction (state/county/town)	Year Enacted	Regulation/Legislation	Status	Details of Law
Alabama[a]	1997	Legislation	Enacted.	Defines a "minor" for the purposes of this tobacco law as any individual under 19 years of age.
Alaska[b]	1988	Legislation	Enacted.	It is illegal to sell or give tobacco or any product containing nicotine to a minor, defined as someone under 19 years of age.
Massachusetts—Select Towns				
Brookline (Parker, 2013)	2013	Special town meeting action to amend town law	Approved.	Voted to raise the MLA from 18 to 19 years.
Newburyport (Hendrickson, 2013; Quinn, 2014; Wade, 2013)	2014	Town board of health regulation	Approved.	The board of health initially proposed raising the MLA from 18 to 21 years. Mayor Donna Holaday vowed to fight the measure and litigate if necessary. The board subsequently considered and approved a measure to raise the age to 19.
Sudbury[c]	2013	Town board of health regulation	Approved.	The board of health held a public hearing and, at the subsequent board meeting, approved raising the MLA for tobacco products from 18 to 19 years.
Walpole[d]	2013	Town board of health regulation	Approved. Further action to raise the MLA to 21 will be discussed in mid-2015.	The board of health approved raising the MLA for tobacco products from 18 to 19 years. The board also discussed phasing in an MLA of 21 years, and will revisit the issue in mid-2015 to consider further action.

TABLE A-1 Continued

Jurisdiction (state/county/town)	Year Enacted	Regulation/Legislation	Status	Details of Law
Watertown[e]	2012	Town board of health regulation	Approved.	The board of health adopted a new tobacco regulation that defines a "minor" (relative to tobacco) as someone under 19 years of age.
Westwood[f]	2013	Town board of health regulation	Approved.	The board of health adopted a new tobacco regulation that defines a "minor" (relative to tobacco) as someone under 19 years of age.
New Jersey[g]	2006	Legislation	Enacted.	Amended earlier tobacco laws, raising MLA for purchase and sale of tobacco products from 18 to 19 years.
New York—Select Counties				
Nassau[h]	2006	Legislation	Enacted.	Local laws amended to add provisions to Nassau Administrative Code to raise the MLA for tobacco products from 18 to 19 years.
Onondaga[i]	2009	Legislation	Enacted.	Raised the MLA for tobacco products from 18 to 19 years, with the exception of individuals who are 18 years of age and have a valid military ID, who are exempt and may purchase tobacco products.

continued

TABLE A-1 Continued

Jurisdiction (state/county/town)	Year Enacted	Regulation/Legislation	Status	Details of Law
Suffolk[j]	2005	Legislation	Enacted, but amended by 2014 law raising the age to 21. (See table of U.S. Jurisdictions with an MLA of 21 to Purchase Tobacco Products—Enacted.)	New law filed, repealing earlier legislation raising minimum purchasing age from 18 to 19 years.
Utah[k]	1973	Legislation	Enacted. New legislation to raise the MLA from 19 to 21 years introduced in 2013. (See table of U.S. Jurisdictions with an MLA of 21 to Purchase Tobacco Products.)	Prohibits sales tobacco and tobacco products to individuals under 19 years of age. Prohibits business owners from allowing individuals under age 19 from entering businesses while the underage person is using tobacco. "Smoking paraphernalia" was added in 2010.

[a] The Code of Alabama 1975 § 13A-12-3, 28-11-9, 28-11-13.
[b] Alaska Statutes § 11.76.100, 11.76.105-109.
[c] Sudbury, Massachusetts, Board of Health. Minutes of Meeting of September 10, 2013. Available: https://sudbury.ma.us/boardofhealth/?attachment_id=283 (accessed February 25, 2015).
[d] Walpole, Massachusetts, Board of Health. Minutes of Meeting of March 12, 2013. Available: http://www.walpole-ma.gov/sites/walpolema/files/minutes/minutes-file/minutes_march_12_2013.pdf (accessed February 25, 2015).
[e] Watertown, Massachusetts, Board of Health. Minutes of Meeting of August 15, 2012. Available: http://www.ci.watertown.ma.us/Archive/ViewFile/Item/1824 (accessed February 25, 2015).
[f] Town of Westwood, Massachusetts, Board of Health Regulations. Regulation restricting the sale of tobacco products and nicotine delivery product (February 12, 2013).
[g] New Jersey State Legislation. P.L. 2005 c. 384; S2783 (January 15, 2006).
[h] The Nassau County Administrative Code. Title H § 9-25.1–9-25.7. Local Law 5-2006 (April 26, 2006).
[i] Onondaga County, New York, Local Law No. 2-2009 (January 12, 2009).
[j] Suffolk County, New York, Local Law No. 5-2005 (January 3, 2005).
[k] Utah State Legislature. *Ban on sale of smoking paraphernalia to minors* section 76-10-104.1 (March 29, 2010).

TABLE A-2 States and Localities That Have Established a Minimum Age of Legal Access to Tobacco Products of 21

Jurisdiction (state/county/ town)	Year Enacted	Regulation/ Legislation	Status	Details of the Law
California—Select City				
Healdsburg (Alexander and Williams, 2014; Mason, 2013)	2014	Regulation	Passed by city council.	Prohibits the sale of cigarettes, chew, and other tobacco products to anyone under age 21 and institutes new annual license to sell tobacco, with revenues earmarked for enforcing tobacco laws.
Hawaii—Select County				
Hawaii County[a]	2013	Legislation	Enacted. In effect June 30, 2014.	The bill raised minimum purchasing age from 18 years of age to 21.
Illinois—Select City				
Evanston (Blakley, 2014)	2014	Regulation	Passed by city council.	The new ordinance raises the MLA from 18 to 21. An earlier version of the ordinance proposed making underage possession a crime, but the final ordinance holds only retailers responsible for violations.
Massachusetts—Select Towns				
Arlington[b,c]	2013	Town board of health regulation	Approved May 2013, in effect July 2013, and subject to a 3-year phase-in, raised to 20 on July 1, 2014.	From July 1, 2013, to July 1, 2014, the MLA is 19. From July 1, 2014, to July 1, 2015, the MLA is raised to 20. As of July 1, 2015, the MLA is raised to 21.
Ashland[d]	2013	Town board of health regulation	Approved.	Raised the MLA from 18 to 21. Discussed but did not vote on e-cigarette regulations.

continued

TABLE A-2 Continued

Jurisdiction (state/county/ town)	Year Enacted	Regulation/ Legislation	Status	Details of the Law
Belmont[e] (Eisenstadter, 2014)	2012	Town board of health regulation	Approved.	Amendment of existing regulations of the sale of tobacco to minors to raise the age of a "minor" (relative to tobacco purchasing) from 18 to 19 years of age. The MLA raised to 21 in September 2014, to take effect on January 1, 2015.
Braintree (Aicardi, 2014)	2014	Town board of health regulation	Approved.	Regulation raises the MLA to 21 products and establishes an MLA of 21 for electronic cigarettes and other "nicotine-delivery" products.
Canton (Donga, 2013; Turner, 2013)	2013	Town board of health regulation	Approved.	Raises minimum purchasing age from 18 to 21 years. Contains a "sunset" clause, whereby, in 5 years, the MLA will revert to 18 years if there is no major reduction in teen smoking rates. If there is a demonstrable reduction, the MLA of 21 years will automatically renew. With approval from the school superintendent, the board of health will conduct an annual survey of Canton middle and high school students to determine the efficacy of the new regulation.
Dedham[f]	2013	Town board of health regulation	Approved.	Amended existing regulations, raising the MLA from 18 to 21.
Dover[g]	2013	Town board of health regulation	Approved.	Amended existing regulations, raising the MLA from 18 to 21.

TABLE A-2 Continued

Jurisdiction (state/county/town)	Year Enacted	Regulation/Legislation	Status	Details of the Law
Foxborough[b]	2013	Town board of health regulation	Approved.	Held a public hearing and adopted regulations restricting the sale of tobacco, including raising the MLA from 18 to 21.
Hudson (Bartlett, 2014b; Malachowski, 2014)	2014	Town board of health regulation.	Approved.	Raised the MLA from 18 to 21.
Hull (Hanson, 2014)	2014	Town board of health regulation	Approved.	Raised the MLA from 18 to 21 and bans smoking in town parks, playgrounds, and adjacent parking lots.
Malden (City of Malden, 2014)	2014	Town board of health regulation	Approved.	Amends board of health rules and regulations, raising the MLA from 18 to 21.
Medway[i] (Comeau, 2014)	2013	Non-binding referendum question.	Approved by the board of selectmen for a public vote at the annual town election, May 20, 2014.	Board of selectmen voted unanimously in March 2014 to include the proposed raising of the MLA to purchase tobacco products from 18 to 21 as a non-binding referendum question on the May 20 town election ballot, one of three legal options to put the question up for public vote. In 2013 the board of health discussed raising the MLA from 18 to 21 in May, June, and July 2013, but it could not agree whether to make changes to tobacco regulations as a board, wait for quorum, or to go to a public vote.

continued

TABLE A-2 Continued

Jurisdiction (state/county/town)	Year Enacted	Regulation/Legislation	Status	Details of the Law
Melrose (Sacco, 2014)	2014	Town board of health regulation	Approved.	Prohibits the sale of cigarettes, cigars, electronic “vaping devices,” snuff, and related products to persons under age 21.
Needham[j]	2003	Town board of health regulation	Approved. In effect April 1, 2003, and subject to a 3-year phase-in.	From April 1, 2003, to April 1, 2004, the MLA was raised to 19. From April 1, 2004, to April 1, 2005, the MLA was raised to 20. As of April 1, 2005, the MLA was raised to 21.
Newton[k]	2014	Town board of aldermen	Passed ordinance.	Revised town ordinances to raise the MLA to 21 and also cover all nicotine delivery products (including e-cigarettes).
Norwood[l]	2014	Town board of health regulation	Approved.	The board of health issued new regulations defining “minor” as “any individual who is under the age of twenty-one (21).”
Scituate (Bartlett, 2014a,b)	2014	Town board of health regulation	Approved.	Raised the MLA from 18 to 21.
Sharon[m]	2013	Town board of health regulation	Approved.	Raised the MLA from 18 to 21.
Wakefield[n]	2014	Town board of health regulation	Approved.	Raised the MLA from 18 to 21.
Wayland (Wagner, 2014)	2014	Town board of health regulation	Approved. In effect beginning January 1, 2015.	Raised the MLA from 18 to 21 and bans electronic smoking devices anywhere smoking is prohibited in workplaces.
Wellesley[o]	2014	Town board of health regulation	Approved.	Raised the MLA from 18 to 21.

TABLE A-2 Continued

Jurisdiction (state/county/town)	Year Enacted	Regulation/ Legislation	Status	Details of the Law
Westford (Allen, 2014)	2014	Town board of health regulation	Approved.	Prohibits the sale of cigarettes and electronic cigarettes to persons under age 21.
Winchester (McLean, 2014)	2014	Town board of health regulation	Approved.	Raises the MLA and nicotine delivery products (including e-cigarettes) from 18 to 21.
New Jersey—Select Towns				
Englewood (Noda, 2014; Perez, 2014)	2014	City board of health resolution	Approved.	Raises the MLA from 19 to 21 for the purchase of tobacco or tobacco-related products from any vendor in the city.
Sayreville (Loyer, 2014)	2014	Borough council ordinance	Approved.	Raises the MLA from 19 to 21.
New York— Select Counties				
New York City[p]	2013	Legislation	Passed by city council and signed into law by mayor. In effect as of May 2014.	Local law amends the administrative code of the city of New York (including New York, Bronx, Kings, Queens, and Richmond Counties), raising the MLA from 18 to 21 years of age. Establishes an MLA of 21 for electronic cigarettes.
Suffolk County[q] (Schwartz, 2014)	2014	Legislation	Signed into law, to go into effect January 1, 2015.	Raises the MLA from 19 to 21.

[a] The Hawaii County Code 1983 (2005). Bill no. 135. Ordinance no. 13 124 (December 13, 2013).
[b] Town of Arlington, Massachusetts, Department of Health and Human Services; Office of the Board on Health. *Regulation restricting the sale of tobacco products and nicotine delivery products* (May 15, 2013).
[c] Arlington, Massachusetts, Board of Health. Minutes of Meeting of May 15, 2013. Available: http://www.arlingtonma.gov/Home/ShowDocument?id=1084 (accessed February 25, 2015).
[d] Ashland, Massachusetts, Board of Health. Minutes of Meeting of September 10, 2013. Available: http://www.ashlandmass.com/document-center/minutes (accessed February 25, 2015).

continued

TABLE A-2 Continued

[e] Belmont, Massachusetts, Board of Health. Minutes of Meeting of April 30, 2012. Available: http://www.belmont-ma.gov/sites/belmontma/files/minutes/minutes-file/4-30-12.pdf (accessed February 25, 2015).
[f] Board of Health Regulations, Dedham, Massachusetts, *Part IV: Regulation affecting smoking and the sale and distribution of tobacco and nicotine delivery products in Dedham* (November 25, 2013).
[g] Dover, Massachusetts, Board of Health. Minutes of Meeting of May 13, 2013. Available: http://www.doverma.org/wp-content/uploads/2013/02/boh-5-13.pdf (accessed February 25, 2015).
[h] Foxborough, Massachusetts, Board of Health. Minutes of Meeting of June 24, 2013. Available: http://www.foxboroughma.gov/Pages/FoxboroughMA_HealthMin (accessed February 25, 2015).
[i] Medway, Massachusetts, Board of Health. Minutes of Meeting of July 22, 2013, and November 20, 2013. Available: http://www.townofmedway.org/Pages/MedwayMA_Bcomm/BOH/Minutes/2013 (accessed February 25, 2015).
[j] Town of Needham Board of Health Regulations. Section 1.6. *Retail sale of tobacco products* (updated February 4, 2014).
[k] City of Newton Board of Alderman. Ordinance No. A-42 (June 16, 2014).
[l] Norwood, Massachusetts, Board of Health Regulations. *Restricting the sale of tobacco products and nicotine delivery products* (February 27, 2014).
[m] Sharon, Massachusetts, Board of Health. Minutes of Meeting of April 8, 2013. Available: http://www.townofsharon.net/node/2013/minutes (accessed February 25, 2015).
[n] Wakefield, Massachusetts, Board of Health Regulations. Regulation of the Wakefield Board of Health restricting the sale of tobacco and nicotine delivery devices (March 19, 2014).
[o] Wellesley, Massachusetts, Board of Health. Minutes of Meeting of September 12, 2013. Available: http://www.wellesleyma.gov/Pages/WellesleyMA_HealthMin/2013 (accessed February 25, 2015).
[p] New York City Administrative Code. Section 17-706a-c, as amended by Local Law 69-2009 (November 19, 2013).
[q] A local law to raise the legal age for the sale of tobacco products in Suffolk County. Resolution No. 1039-2014. Suffolk County Legislation (January 2, 2014).

TABLE A-3 States and Localities Currently Considering Proposals to Raise the Minimum Age of Legal Access to Tobacco Products to 19

Jurisdiction (state/county/ town)	Year of Proposal	Regulation/ Legislation	Status	Details of Law
Massachusetts—Select Town				
Franklin[a] (Tota, 2014)	2013	Town board of health regulation	Proposal discussed and currently open for public comment.	The board of health held a public hearing on new proposed tobacco regulations, including raising the MLA from 18 to 19 years.
Missouri—Select City				
Columbia (Denney, 2014)	2014	Legislation	Under review by the city's board of health and substance abuse advisory commission.	Proposal raises the MLA to 21 and also bans e-cigarette use indoors.
New York—Select County				
Westchester (Ganga, 2014)	2014	Legislation	Proposed and under consideration by the county board of legislators.	New law would raise the MLA for "cigarettes and tobacco-related products" from 18 to 19.

[a] Town of Franklin, Massachusetts, Code. Chapter 262: Regulation affecting smoking and the sale and distribution of tobacco and nicotine delivery products in the town of Franklin (March 19, 2014).

TABLE A-4 States and Localities Currently Considering Proposals to Raise the Minimum Age of Legal Access to Tobacco Products to 21

Jurisdiction (state/county/town)	Year of Proposal	Regulation/Legislation	Status	Details of the Law
Hawaii—Select City				
Honolulu (Sadoy, 2014)	2014	Legislation	Bill advanced by the Honolulu city council's Public Safety and Economic Development Committee.	Bill would make it illegal for people under age 21 to purchase tobacco or electronic smoking devices.
Massachusetts—Select Towns				
Andover (Lima, 2014b)	2014	Town board of health regulation	Board of health expected to vote on proposed regulations on November 17, 2014 (Lima, 2014a).	Proposed regulations include raising the MLA to 21 and requiring tobacco retailers to include at least two smoking cessation products on half of a sales display featuring tobacco and nicotine products.
Lawrence (Tennant, 2014)	2014	Town board of health regulation	Public hearing scheduled for November 18, 2014.	New antismoking regulations include several sales restrictions (e.g., permitting restrictions, minimum pack size and bans on other tobacco products, etc.) as well as raising the MLA to purchase tobacco to age 21.
Saugus (Gaffney, 2014)	2014	Town board of health regulation	Public hearing scheduled for November 3, 2014.	Proposed amendment to town tobacco regulations includes raising the MLA to purchase tobacco to age 21 and banning flavored tobacco products.

TABLE A-4 Continued

Jurisdiction (state/county/ town)	Year of Proposal	Regulation/ Legislation	Status	Details of the Law
New Jersey[a] (Wilson, 2014)	2014	Legislation	Passed by State Senate, awaiting House vote in 2014 (Mickle, 2014).	Amendment of existing laws, raising the MLA for purchase and sale of tobacco and electronic smoking devices from 19 to 21.
Washington (Rhodan, 2014)	2014	Legislation	King County (covers Seattle) Alcoholism and Substance Abuse Administrative Board approved resolution, for consideration by Washington State legislators.	Resolution calls for Washington State legislators to change the legal age of tobacco purchase to 21 across the state.

[a] Raises minimum age for purchase and sale of tobacco products and electronic smoking devices from 19 to 21. New Jersey Senate Bill 602. State of New Jersey 216th Legislature, passed Senate June 30, 2014. Received in the Assembly July 11, 2014; referred to Health and Senior Services Committee; New Jersey Assembly Bill 3254.

TABLE A-5 States and Localities That Have Considered But Not Enacted Proposals to Raise the Minimum Age of Legal Access to Tobacco Products to 19

Jurisdiction (state/county/town)	Year of Proposal	Regulation/ Legislation	Status	Details of Law
Illinois[a]	2001	Legislation	Proposed. Not enacted.	Proposed to amend existing law to raise the MLA for tobacco, tobacco products, and other smoking herbs from 18 to 19 years.
Maine[b]	2003	Legislation	Proposed. Not enacted.	Proposed to amend existing law to raise the MLA from 18 to 19 years.
Massachusetts[c]	2005	Legislation	Proposed. Not enacted.	Proposed to prohibit the sale and possession of tobacco products to persons under 19 years of age.
New York[d,e]	2005	Legislation	Proposed. Not enacted.	Proposed raising the MLA from 18 to 19. Proposed to prohibit the sales of tobacco products and herbal cigarettes to any individual under the age of 19.
North Dakota[f,g]	2005	Legislation	Failed to pass.	Proposed to amend the North Dakota Century Code to raise the MLA for sales, purchase, possession, and use of tobacco to 18, and to provide a penalty.

[a] *An act concerning tobacco*. HB1034, 92nd Illinois General Assembly Legislation, 2001-2002 regular sess. (2001).
[b] *An act to increase the legal age for the purchase of tobacco products,* Title 22, Chapter 262-A § 1555-B, § 1557, § 1558, and § 1559, Maine Revised Statutes 121st Legislature, 1st reg. sess.
[c] HB 1824, Part IV, Title I, Chapter 270, § 6, Commonwealth of Massachusetts, presented by Rep Jones (2005).
[d] Regulation of Tobacco Products and Herbal Cigarettes; Distribution to minors (also known as "Adolescent Tobacco Use Prevention Act"), Article 13-F, § 1399-aa–§ 1399-ee, New York State Public Health Laws.
[e] *An act to amend the public health law and the penal law, in relation to increasing the purchasing age for tobacco products from eighteen to nineteen*. Bill No. A5883-A, New York State Public Health Laws, reg. sess. (March 2, 2005).

TABLE A-5 Continued

[f] Miscellaneous Offenses, Title 12.1-31-03, Criminal Code, North Dakota Century Code, North Dakota Legislative Branch.
[g] *A bill for an Act to amend and reenact section 12.1-31-03 of the North Dakota Century Code, relating to the sale of tobacco to individuals under the age of nineteen and the use of tobacco by minors; to provide a penalty; and to provide for application.* HB 1183, 59th Legislative Assembly of North Dakota, introduced by Rep. DeKrey (January 7, 2005, date of last action on bill).

TABLE A-6 States and Localities That Have Considered But Not Enacted Proposals to Raise the Minimum Age of Legal Access to Tobacco Products to 21

Jurisdiction (state/county/ town)	Year of Law	Regulation/ Legislation	Status of Law	Details of the Law
California[a]	2003	Legislation	Proposed. Not enacted.	Proposed to amend existing Code to raise the MLA from 18 to 21.
Colorado[b] (Lee, 2014)	2014	Legislation	House Finance Committee voted 7 to 6 to reject the bill, March 19, 2014.	Amends existing law to raise the MLA from 18 to 21 for sales and other forms of distribution. Would grandfather in persons born on or before June 30, 1996 (currently 18).
Connecticut[c,d,e]	2003	Legislation	Proposed. Not enacted.	Proposed that the general statutes be amended to raise the legal age for use of tobacco products to 21.
District of Columbia[f]	2013	Legislation	Introduced. Failed to make it out of committee.	The bill would raise prohibition of sales of tobacco products to minors by redefining minors from age 18 to 21. Prohibits licenses to operate vending machines selling tobacco products for establishments that admit individuals under age 21.
Maryland[g]	2014	Legislation	Introduced. Unfavorable report by judiciary committee.	The bill raises prohibition of sales of tobacco products to minors and restricting minors from purchasing or possessing tobacco by redefining minors from age 18 to 21.

TABLE A-6 Continued

Jurisdiction (state/county/ town)	Year of Law	Regulation/ Legislation	Status of Law	Details of the Law
Massachusetts—Select Towns				
Cohasset (Dale, 2014a,b)	2014	Town board of health regulation	Proposed. Not enacted.	Board approved a ban on selling tobacco products at pharmacies and restricting the sale of e-cigarettes, but kept the MLA at 18. The proposal would have raised the MLA from the state minimum of 18 to 21.
Hopkinton (Krantz, 2013)	2013	Town board of health regulation	Rejected. The board of health discussed holding a town meeting for public vote.	Proposal would amend regulations to raise the MLA from 18 to 21.
New York State[b,i]	2005	Legislation	Proposed. Not enacted.	Proposed raising the MLA from 18 to 19 to 20 to 21 over time.
Amherst (Habuda, 2014; Rey, 2014)	2014	Legislation	Proposed. Not enacted.	City council dropped provision to raise the MLA from 18 to 21 in final approved resolution to prevent and reduce underage smoking.
Nassau (Brodsky, 2014)	2014	Legislation	Introduced into Nassau County legislature, and blocked from a vote by Republican county legislators.	Proposed raising the MLA from 19 to 21, in line with neighboring Suffolk County and New York City.
Oregon[j]	2013	Legislation	Introduced. Failed to make it out of committee.	Proposed new laws and amendments to make it a crime to distribute, sell, or cause to be sold tobacco in any form to an individual under the age of 21.

continued

TABLE A-6 Continued

Jurisdiction (state/county/ town)	Year of Law	Regulation/ Legislation	Status of Law	Details of the Law
South Carolina[k,l,m]	2003	Legislation	Introduced. Failed to make it out of committee.	Proposed amending the Code of Laws of South Carolina raising the MLA from 18 to 21.
Texas[n]	2013	Legislation	Proposed. Not enacted. Similar bill also introduced in 2003.	Proposed raising the MLA from 18 to 21.
Utah[o]	2014	Legislation	State senate voted against the measure on March 3, 2014.	Proposes raising the MLA from 19 to 21. Prohibits sales of tobacco and tobacco products to individuals under 21 years of age. Prohibits business owners from allowing individuals under age 21 from entering businesses while the underage person is using tobacco.
Vermont[p]	2005	Legislation	Introduced. Failed to make it out of committee.	Proposed raising the MLA from 18 to 21.

[a] *An act to amend Sections 17537.3, 22952, 22956, 22958, and 22963 of, and to add Section 22964 to, the Business and Professions Code, and to amend Section 308 of the Penal Code, relating to tobacco,* SB1821, California General Assembly, 2003-04 reg. sess., introduced by Sen. Dunn (February 20, 2004).

[b] *A bill for an act concerning the prohibition of tobacco transactions for persons under twenty-one years of age,* HB14-1263, 69th General Assembly, State of Colorado, 2nd reg. sess. (March 19, 2014).

[c] General Statutes of Connecticut. Vol. 4, Title 12: Taxation, Chapter 214 § 12-295 (a, b, c, d & e), Vol. 13, Title 53: Crimes, Chapter 946 § 53-344 (revised to January 13, 2013).

[d] *An Act Raising the Legal Age for Use of Tobacco Products.* Proposed SB 769, LCO No. 2394, Connecticut General Assembly, January sess. (January 27, 2003).

[e] *An Act Prohibiting the Possession of Tobacco by Minors.* Proposed HB 5035, LCO No. 2850, Connecticut General Assembly, January sess. (February 6, 2003).

[f] *Prohibition Against Selling Tobacco Products to Individuals Under 21 Amendment Act of 2013.* B20-0567, 20th Council of the District of Columbia, 23rd sess. (November 5, 2013).

[g] *An Act Concerning Criminal Law—Tobacco Products—Minimum Age.* HB 278, Maryland General Assembly, Department of Legislative Services, Regular sess. (February 17, 2014).

[h] *New York State Regulation of Tobacco Products, Herbal Cigarettes and Smoking Paraphernalia; Distribution to Minors.* Article 13-F, § 1399-aa–§ 1399-ee. 2012.

TABLE A-6 Continued

[i] *Raises the minimum age for the sale of tobacco and tobacco products from 18 years of age to 19 years of age to 20 years of age to 21 years of age over time.* Bill no. S05301, New York State Assembly (2005).
[j] *A bill for an act relating to tobacco; creating new provisions; and amending ORS 163.575, 165.800, 165.813, 167.400, 167.401, 167.402, 167.404, 167.407, 323.718, 339.883, 431.840, 431.853, 433.835 and 807.500.* HB 2974, 75th Oregon Legislative Assembly, 2009 regular sess. (June 29, 2009).
[k] *South Carolina Code of Laws,* Title 16 Crimes and Offenses, Chapter 17 Offenses Against Public Policy § 16-17-500-504 (eff. June 7, 2013).
[l] HB A35, R67, H3538, 120th sess., South Carolina General Assembly (signed June 7, 2013).
[m] HB 3084, general bill, South Carolina General Assembly, 115th sess., sponsored by Rep. Talley and others (2003–2004).
[n] *A bill to be entitled an Act relating to the distribution, possession, purchase, consumption, and receipt of tobacco products; providing penalties.* SB No. 313, 83rd Texas State Senate, 83rd sess. (2013).
[o] *Ban on Smoking Paraphernalia to Minors.* HB 206, Section 1 § 76-10-104.1, 56th Utah House of Representatives, 2010 general sess. (2010).
[p] *An Act Relating to Increasing the Legal Smoking Age.* H.0105, General Assembly of the State of Vermont, 2005–2006 legislative sess. (2005).

REFERENCES

Aicardi, R. 2014. Braintree tobacco purchase age increasing to 18. *The Braintree Forum* (June 25, 2014). http://braintree.wickedlocal.com/article/20140625/News/140627895 (accessed January 13, 2015).

Alexander, K., and K. Williams. 2014. No tobacco purchases until age 21? Healdsburg passes ban. *SFGate* (October 22, 2014). http://www.sfgate.com/bayarea/article/In-a-first-Healdsburg-bans-under-21-tobacco-sales-5837820.php (accessed January 13, 2015).

Allen, S. 2014. Westford board votes to ban cigarette sales to those younger than 21. *Lowell Sun* (April 15, 2014). http://www.lowellsun.com/local/ci_25569105/westford-board-votes-ban-cigarette-sales-those-younger (accessed January 13, 2015).

Bartlett, J. 2014a. Scituate increases tobacco-purchasing age to 21. *Boston.com* (February 25, 2014). http://www.boston.com/yourtown/news/scituate/2014/02/scituate_increases_tobacco_purchasing_age_to_21.html (accessed January 13, 2015).

———. 2014b. Two more towns hike cigarette age. *The Boston Globe* (March 2, 2014). http://www.bostonglobe.com/metro/regionals/south/2014/03/02/scituate-and-hudson-raise-tobacco-buying-age/nwLUD2x0rv7w1Tp2Iic7PJ/story.html (accessed January 13, 2015).

Blakley, D. 2014. Evanston becomes first Illinois city to raise cigarette-buying age to 21. *CBS Chicago-Local*. http://chicago.cbslocal.com/2014/11/07/evanston-becomes-first-illinois-city-to-raise-cigarette-buying-age-to-21 (accessed February 24, 2015).

Brodsky, R. 2014. Nassau GOP to block vote on bill raising age limit to buy tobacco products. *Newsday* (March 30, 2014). http://www.newsday.com/long-island/nassau/nassau-gop-to-block-vote-on-bill-raising-age-limit-to-buy-tobacco-products-1.7551518 (accessed January 14, 2015).

City of Malden. 2014. *City of Malden board of health raises minimum age to buy cigarettes to age 21*. http://www.cityofmalden.org/content/city-malden-board-health-raises-minimum-age-buy-cigarettes-age-21 (accessed February 24, 2015).

Comeau, Z. 2014. Medway selectmen approve tobacco age ballot question, talk regionalization. *Milford Daily News* (March 18, 2014). http://www.milforddailynews.com/article/20140318/News/140316629 (accessed January 13, 2015).

Dale, E. 2014a. Cohasset health board keeps age for tobacco purchase at 18. *The Cohasset Mariner* (June 12, 2014). http://cohasset.wickedlocal.com/article/20140612/NEWS/140618682/0/SEARCH (accessed January 14, 2015).

———. 2014b. Should tobacco age be 21? *Patriot Ledger* (March 14, 2014). http://www.patriotledger.com/article/20140314/News/140317981 (accessed January 14, 2015).

Denney, A. 2014. Chadwick proposes increasing legal age to buy tobacco products. *Columbia Daily Tribune* (September 16, 2014). http://www.columbiatribune.com/news/local/chadwick-proposes-increasing-legal-age-to-buy-tobacco-products/article_e77b76c4-8c57-5eef-ab9d-f2d531dcba0f.html (accessed January 14, 2015).

Donga, E. 2013. Canton raises age to buy tobacco products, doesn't ban e-cigarettes. *The Patriot Ledger* (August 13, 2014). http://www.patriotledger.com/news/x273448480/Canton-raises-legal-age-to-buy-cigarettes (accessed January 13, 2015).

Eisenstadter, D. 2014. Belmont raises age for purchasing tobacco to 21. *The Belmont Citizen-Herald*. http://belmont.wickedlocal.com/article/20140918/News/140916159 (accessed February 4, 2015).

Gaffney, M. 2014. Board considers raising tobacco purchase age to 21 in Saugus. *The Saugus Advertiser* (October 16, 2014). http://saugus.wickedlocal.com/article/20141016/News/141018204 (accessed January 14, 2015).

Ganga, E. 2014. Westchester legislators tout bill to increase age to buy tobacco. *LoHud* (April 2, 2014). http://polhudson.lohudblogs.com/2014/04/02/westchester-legislators-tout-bill-increase-age-buy-tobacco (accessed January 14, 2015).

Habuda, J. 2014. Amherst OKs measure to limit youth smoking. *The Buffalo News* (August 4, 2014). http://www.buffalonews.com/city-region/amherst/amherst-oks-measure-to-limit-youth-smoking-20140804 (accessed January 14, 2015).

Hanson, F. 2014. Hull raising age to buy tobacco products to 21. *The Patriot Ledger* (October 10, 2014). http://www.patriotledger.com/article/20141001/News/141009750 (accessed January 13, 2015).

Hendrickson, D. 2013. Newburyport lightens up on new tobacco regs. *Newburyport News* (December 21, 2013). http://www.newburyportnews.com/news/local_news/newburyport-lightens-up-on-new-tobacco-regs/article_f63ce3ec-93f6-5a8a-b3d4-166ada84e8e3.html (accessed January 13, 2015).

Krantz, L. 2013. Hopkinton board rejects tobacco age increase. *MetroWest Daily* (December 7, 2013). http://www.metrowestdailynews.com/x1275649067/Hopkinton-board-rejects-tobacco-age-increase (accessed January 14, 2015).

Lee, K. 2014. Raising age to 21 for purchase of cigarettes in Colorado rejected. *Denver Post* (March 19, 2014). http://www.denverpost.com/news/ci_25377056/raising-age-21-purchase-cigarettes-colorado-tough-climb#axzz2wRfaI6yy (accessed January 14, 2015).

Lima, T. 2014a. Retailers challenge tobacco changes. *Eagle-Tribune* (October 21, 2014). http://www.eagletribune.com/news/retailers-challenge-tobacco-changes/article_52fd512c-5038-591a-8002-b15975f7e3cf.html (accessed January 14, 2015).

———. 2014b. Retailers challenge tobacco changes; argue higher age will hurt business, spark bootlegging. *The Andover Townsman Online* (October 23, 2014). http://www.andovertownsman.com/news/local_news/retailers-challenge-tobacco-changes-argue-higher-age-will-hurt-business/article_05b7e327-9743-578b-a26e-47faa7a68e6e.html (accessed January 14, 2015).

Loyer, S. 2014. *Sayreville bans the sale of tobacco to anyone under 21*. http://www.mycentraljersey.com/story/news/local/middlesex-county/2014/09/12/sayreville-smoking-ban-teens/15535341/;%20http:/halfwheel.com/sayreville-n-j-raises-tobacco-purchase-age-21/69995 (accessed January 13, 2015).

Malachowski, J. 2014. Hudson raises age to buy cigarettes to 21. *MetroWest Daily News* (February 25, 2014). http://www.metrowestdailynews.com/article/20140226/News/140227597 (accessed January 13, 2015).

Mason, C. 2013. Healdsburg: Ban tobacco sales to those under 21. *The Press Democrat* (December 5, 2013). http://www.pressdemocrat.com/article/20131205/articles/131209729#page=0 (accessed January 13, 2015).

McLean, D. 2014. Winchester BoH raises tobacco sales age to 21. *Winchester Star* (March 19, 2014). http://winchester.wickedlocal.com/article/20140319/News/140315825 (accessed January 13, 2015).

Mickle, T. 2014. More cities raise tobacco age to 21. *The Wall Street Journal* (October 28, 2014). http://www.wsj.com/articles/more-cities-raise-tobacco-age-to-21-1414526579 (accessed January 14, 2015).

Noda, S. 2014. Englewood raises age limit to 21 to buy tobacco products. *Northern Valley Suburbanite* (August 7, 2014). http://www.northjersey.com/news/city-raises-age-limit-for-cigarettes-1.1063714 (accessed January 13, 2015).

Parker, B. 2013. Law raising age to buy cigarettes to 19 takes effect in Brookline. *Boston Globe* (June 3, 2013). http://www.boston.com/yourtown/news/brookline/2013/06/law_raising_age_to_buy_cigaret.html (accessed January 13, 2015).

Perez, C. 2014. Englewood board of health backs smoke-free policy. *Northern Valley Suburbanite* (April 11, 2014). http://www.northjersey.com/news/health-board-backs-smoke-free-policy-1.917641?page=all (accessed January 13, 2015).

Quinn, C. 2014. Newburyport latest Massachusetts community to raise tobacco-buying age. *Mass Live* (April 3, 2013). http://www.masslive.com/news/boston/index.ssf/2014/04/newburyport_latest_massachuset.html (accessed January 13, 2015).

Rey, J. 2014. Amherst to take up stricter tobacco laws. *The Buffalo News* (August 1, 2014). http://www.buffalonews.com/city-region/amherst/amherst-to-take-up-stricter-tobacco-laws-20140801 (accessed January 14, 2015).

Rhodan, M. 2014. New push to raise tobacco age in Washington state. *Time*. http://time.com/74400/tobacco-age-21-washington-state-proposal (accessed February 23, 2015).

Sacco, J. 2014. Melrose raises purchasing age to 21 for tobacco, nicotine products. *Melrose Free Press* (April 24, 2014). http://melrose.wickedlocal.com/article/20140424/NEWS/140428078/12448/LIFESTYLE (accessed January 13, 2015).

Sadoy, A. 2014. Should the legal age to buy tobacco products on O'ahu be raised to 21. *Ka Leo* (September 23, 2014). http://www.kaleo.org/opinion/do-you-think-it-s-fair-that-the-legal-age/article_5e86778e-435a-11e4-9f0f-0017a43b2370.html (accessed January 14, 2015).

Schwartz, D. 2014. Suffolk bill raising age to purchase tobacco to 21 becomes law. *Newsday* (April 14, 2014). http://www.newsday.com/long-island/suffolk/suffolk-bill-raising-age-to-purchase-tobacco-to-21-becomes-law-1.7703911 (accessed January 13, 2015).

Tennant, P. 2014. Beginning March 1, tobacco buyers must be 21 in Lawrence. *The Eagle-Tribune* (December 17, 2014). http://www.eagletribune.com/news/beginning-march-tobacco-buyers-must-be-in-lawrence/article_203d53e7-cf32-5c17-a175-6f019781e8cd.html (accessed February 23, 2015).

Tota, M. 2014. Tobacco purchase age still 18. *Milford Daily News* (January 8, 2014). http://www.milforddailynews.com/article/20140107/NEWS/140109804/0/SEARCH (accessed January 14, 2015).

Turner, J. 2013. BOH approves landmark tobacco regulations. *The Canton Citizen* (August 15, 2013). http://www.thecantoncitizen.com/2013/08/15/board-of-health-approves-landmark-tobacco-regulations (accessed January 13, 2015).

Wade, C. M. 2013. Proposal on teen smoking decried. *Boston Globe* (December 1, 2013). http://www.bostonglobe.com/metro/regionals/north/2013/12/01/board-plan-increase-tobacco-buying-age-newburyport-riles-store-owners-mayor/9IcbV2ra3L5nCi06jILJJK/story.html (accessed January 13, 2015).

Wagner, S. L. 2014. Raising legal age in Wayland for tobacco sales. *Wayland Town Crier* (October 1, 2014). http://wayland.wickedlocal.com/article/20141001/News/141009775 (accessed January 13, 2015).

Wilson, R. 2014. New Jersey smoking age could be raised to 21. *The Washington Post* (July 1, 2014). http://www.washingtonpost.com/blogs/govbeat/wp/2014/07/01/new-jersey-smoking-age-could-be-raised-to-21 (accessed February 23, 2015).

Appendix B

State Laws—
Tobacco Transfers to Minors

The following table (see Table B-1) summarizes state laws for all 50 states and the District of Columbia specifically in reference to the transfer of a tobacco product to a minor by both commercial and noncommercial sources.

The information for this table is adapted from the State Legislated Actions on Tobacco Issues (SLATI) database,[1] which is maintained by the American Lung Association. It should not be considered a comprehensive analysis of state law but rather an illustration of state-level variance in tobacco control legislation.

[1] American Lung Association. State Legislated Legal Actions on Tobacco Issues (SLATI) State Pages. http://www.lungusa2.org/slati/about.php (accessed October 8, 2014).

TABLE B-1 State Laws—Tobacco Transfers to Minors

State	Applies to Whom	Explicitly Illegal to…	Product in Question	Classification of the Transfer
Alabama	Any person	Sell, barter, exchange, or give away*	Cigarettes, cigarette tobacco, cigarette paper or substitute for either of them*	Not specified*
	Permit holder, member, employee, officer			
Alaska	Any person (non licensee)	Sell, exchange, or give*	Cigarette, cigar, or tobacco product; a product containing nicotine*	Violation
	Licensee			Not specified
Arizona	Any person	Knowingly sell, give, or furnish	Tobacco product, vapor product including e-cigarettes, or any instrument designed for smoking/ ingestion of tobacco	Petty offense
Arkansas	Any person	Sell, give, or barter*	Tobacco products or cigarette papers; alternative nicotine product, cartridge or component of such; e-cigarette*	Not specified
	Licensee			Violation

* Applies to all tobacco transfers in the given state.

Penalty for First Offense	Increase for Subsequent Offenses?	Suspend License?	Employee or Licensee Punished?	Affirmative Defense?
Fine, 10<x<50 and may also be imprisoned for <30 days	Not specified	Not specified	Not specified*	Not specified*
Fine	Yes	Yes		
Fine >300	Not specified	Not specified	Not specified*	Not specified*
Suspend license + civil penalty	Yes	Yes		
Not specified	Not specified	Not specified	Not specified	Not specified
Fine*	Not specified	Not specified	Employee of retail permittee in violation is subject to fine <100 in addition to business owner's fine*	Not specified
	Yes	Yes		Yes

* Applies to all tobacco transfers in the given state.

continued

TABLE B-1 Continued

State	Applies to Whom	Explicitly Illegal to…	Product in Question	Classification of the Transfer
California	Person, firm, corporation	Knowingly sell, give, or furnish	Tobacco products or paraphernalia including blunt wraps; e-cigarettes	Misdemeanor or civil action
Colorado	Any person	Sell, distribute, or offer for sale	Cigarettes or tobacco products including e-cigarettes, cigars, cigarillos and pipes*	Class 2 petty offense
	Retailer	Sell or permit the sale of		Not specified
Connecticut	Any person	Sell, give, or deliver to*	Tobacco	Not specified*
	Dealer or distributor		Cigarettes or tobacco products	
Delaware	Any person; excluding parent/guardian	Sell or distribute, purchase on behalf of	Tobacco product	Not specified

* Applies to all tobacco transfers in the given state.

Penalty for First Offense	Increase for Subsequent Offenses?	Suspend License?	Employee or Licensee Punished?	Affirmative Defense?
Fine	Yes	Not specified	California Department of Health Services may assess civil penalties against a the owner/licensee in addition to the criminal/civil penalties against an individual. An employee against whom civil penalties are sought cannot additionally have criminal penalties	Yes
Fine	Not specified	Not specified*	Not specified*	Yes*
Written warning	Yes			
Fine <200*	Yes Yes—retailer and employee	Not specified Yes	The dealer/distributor is assessed a penalty. The employee who perfomed the transaction may also be fined*	Yes*
Fine	Yes	Yes	Licensee/owner is responsible for fine, employee may ALSO be charged	Yes: affirmative defense for licensee if can prove that purchaser showed valid or seemingly valid proof of age, affirmative defense for retailer/employer if can prove that policies were in place to prevent illegal sales

* Applies to all tobacco transfers in the given state.

continued

TABLE B-1 Continued

State	Applies to Whom	Explicitly Illegal to…	Product in Question	Classification of the Transfer
District of Columbia	Any person	Sell, give or furnish	Tobacco product	Misdemeanor
Florida	Any person	Sell, deliver, barter, or furnish, directly or indirectly	Tobacco product	Misdemeanor (2nd degree)
Georgia	Any person	Knowingly sell or barter, directly or indirectly, to advise, counsel, or compel any minor to smoke, inhale chew, or use cigarettes or tobacco-related objects	Cigarettes or tobacco related object, including cigar wraps	Misdemeanor
Hawaii	Any person	Sell or furnish	Tobacco, including chewing tobacco and snuff, and electronic smoking device	Not specified
Idaho	Non-permittee	Sell, distribute, or offer	Tobacco products or e-cigarettes	Not specified*
	Permitee	Sell or distribute	Tobacco products	

* Applies to all tobacco transfers in the given state.

Penalty for First Offense	Increase for Subsequent Offenses?	Suspend License?	Employee or Licensee Punished?	Affirmative Defense?
Fine 100<x<500 and/or imprisonment <30 days	Yes	Yes	Not specified	Not specified
Fine	Yes	Yes	May mitigate penalties against a dealer if employee performed illegal sale and dealer had provided adequate training beforehand	Yes
Not specified	Not specified	Not specified	Not specified	Not specified
Fine	Yes	Not specified	Retail clerks, and not the owners or licensees are cited for violations	Not specified
Fine	Not specified	Not specified	Penalty appears to be for permittee ONLY	Yes*
Warning	Yes	Yes		

* Applies to all tobacco transfers in the given state.

continued

TABLE B-1 Continued

State	Applies to Whom	Explicitly Illegal to…	Product in Question	Classification of the Transfer
Illinois[a]	Any person	Sell, buy for, distribute samples of, or furnish	Tobacco products	Petty offense
		Knowingly sell, deliver, or give away	Cigarette papers or other tobacco accessories	Class C misdemeanor
			Wrapping paper or leaf for rolling	Petty offense
Indiana	Any person	Knowingly sell or distribute, purchase for delivery to a minor	Tobacco products, including dissolvable tobacco products and e-cigarettes*	Class C infraction
	Retailer	Sell or distribute		Not specified
Iowa	Any person	Sell, give, or otherwise supply*	Tobacco products*	Simple misdemeanor
	Retailer/ employee of retailer			Not specified

[a] In Illinois, "classification of transfer" and "penalty for first offense" vary based on the product and the illegal action (e.g., knowingly selling a pack of cigarette papers is a Class C misdemeanor while knowingly selling a leaf for rolling is a petty offense).

* Applies to all tobacco transfers in the given state.

Penalty for First Offense	Increase for Subsequent Offenses?	Suspend License?	Employee or Licensee Punished?	Affirmative Defense?
Fine 200	Yes	Not specified*	Not specified*	Not specified*
Not specified	Not specified			
Fine 100<x<1,000	Not specified			
Fine <500	Not specified	Yes*	Not specified*	Yes*
Fine 200<x<1,000	Yes			
Not specified	Not specified	Yes*	If an employee of the retailer commits the violation, the retailer is not charged if the employee took the proper state tobacco compliance training. Otherwise, penalty to the retailer	Not specified*
Fine + potential additional civil penalty	Yes			

* Applies to all tobacco transfers in the given state.

continued

TABLE B-1 Continued

State	Applies to Whom	Explicitly Illegal to…	Product in Question	Classification of the Transfer
Kansas	Any person	Sell, furnish, or distribute	Cigarettes, e-cigarettes, or tobacco products	Class B misdemeanor
Kentucky	Any person	Sell or cause to be sold, solicit a minor to purchase	Tobacco products	Not specified
Louisiana	Any person	Sell or distribute*	Tobacco products*	Not specified*
	Permittee (manufacturer, distributor, dealer, retailer)			
Maine	Any person	Sell, furnish, give away, or offer to sell, furnish or give away	Tobacco products	Civil violation

* Applies to all tobacco transfers in the given state.

Penalty for First Offense	Increase for Subsequent Offenses?	Suspend License?	Employee or Licensee Punished?	Affirmative Defense?
Fine >200	Not specified	Yes	The person who violates the law is the individual directly selling the tobacco product. A licensee can be assessed additional civil penalties for selling to minors	Yes
Fine 100<x<500	Not specified	Not specified	Not specified	Not specified
Fine <50 Subject to suspension or revocation of permit and/or civil penalties	Yes*	Yes*	Sale of tobacco products to a minor by a retail dealer's employee is considered an act of the retailer for the purpose of suspension or revocation of a permit or the assessment of civil penalties, unless employee attends state approved training program*	Not specified*
Fine 50<x<1,500 + court costs	Not specified	Yes	The employer of the person who violates the law also commits a civil violation which can be fined 50<x<1,500 + court costs. The district court can also impose fines listed above or suspend/revoke licenses for violation of sales laws	Yes

* Applies to all tobacco transfers in the given state.

continued

TABLE B-1 Continued

State	Applies to Whom	Explicitly Illegal to…	Product in Question	Classification of the Transfer
Maryland[b]	Retailer	Distribute	Tobacco products or paraphernalia	Not specified
	Any person	Purchase for, deliver to, sell	Tobacco products or paraphernalia	Not specified
		Sell, distribute, or offer for sale	Electronic device that can be used to deliver nicotine, including e-cigarettes, cigars, cigarillos, and pipes	Misdemeanor
Massachusetts[c]	Any person excluding parent/guardian	Sell or give	Tobacco in any form	Not specified*
		Sell	Rolling papers	
Michigan	Any person excluding parent/guardian	Sell or furnish	Tobacco products	Misdemeanor
Minnesota	Any person	Sell or furnish	Tobacco or tobacco-related devices; product containing or delivering nicotine or lobelia intended for consumption that is not tobacco	Misdemeanor

[b] In Maryland, the law applying to "any person" applies different penalties according to the type of item and transfer. For example, the penalty for purchasing tobacco products on behalf of a minor is a fine not to exceed $300, while the misdemeanor offense of selling an e-cigarette to a minor is punishable by a fine of up to $1,000 per violation.
[c] In Massachusetts, the penalty for first offense depends on the product in question. For example, the sale of tobacco to a minor is punishable by a fine no less than $100, while the sale of rolling papers is punishable by a fine of no less than $25.

* Applies to all tobacco transfers in the given state.

Penalty for First Offense	Increase for Subsequent Offenses?	Suspend License?	Employee or Licensee Punished?	Affirmative Defense?
Not specified	Not specified	Not specified*	Not specified*	Yes*
Fine <300	Yes			
Fine <1,000 per violation	Not specified			
Fine >100	Yes*	Not specified*	Not specified*	Not specified*
Fine >25				
Fine <50	Not specified	Not specified	Not specified	Yes
Not specified	Escalation in criminality with subsequent offenses	Yes	If a licensee or an employee of a licensee violates the law, the licensee is charged an administrative penalty. The individual must also be charged an administrative penalty. Penalty can escalate with subesequent offenses	Yes

* Applies to all tobacco transfers in the given state.

continued

TABLE B-1 Continued

State	Applies to Whom	Explicitly Illegal to...	Product in Question	Classification of the Transfer
Mississippi	Any person or retailer	Sell, barter, deliver, or give	Tobacco products or rolling papers	Not specified*
		Directly or indirectly (by agent, employee, or vending machine) sell, offer for sale, give, or furnish	Alternative nicotine product, any cartridge or component of an alternative nicotine product	
Missouri	Any person (excluding family members on private property)	Sell, provide, or distribute	Tobacco products or rolling papers	Not specified
Montana	Any person	Sell or distribute	Tobacco products	Not specified

* Applies to all tobacco transfers in the given state.

Penalty for First Offense	Increase for Subsequent Offenses?	Suspend License?	Employee or Licensee Punished?	Affirmative Defense?
Fine 50*	Yes*	Yes*	The permittee will be sent a warning letter for the first violation, and required to enroll in and complete a state tobacco retailer education program. If the retailer has directed employees to sign an agreement stating that they understand the state laws regarding youth tobacco sales*	Yes Not specified
Fine 100	Yes	Yes	Owner of establishment issued a reprimand in addition to penalties listed. Exempt from above penalties if they have an employee compliance program in place	Not specified
Verbal notification	Yes	Yes	Employee pays $25 per violation if not licensee	Not specified

* Applies to all tobacco transfers in the given state.

continued

TABLE B-1 Continued

State	Applies to Whom	Explicitly Illegal to…	Product in Question	Classification of the Transfer
Nebraska	Any person	Sell or furnish	Tobacco products*	Class III misdemeanor*
	Licensee	Sell, give, or furnish in any way, or allow to be taken from their place of business		
Nevada	Any person	Sell, distribute, or offer to sell	Tobacco in any form or cigarette papers	Not specified
New Hampshire	Any person	Sell, give, furnish, or cause or allow or procure to be sold, given, furnished	Tobacco products, e-cigarettes, or liquid nicotine	Violation (2nd and on, misdemeanor)
		Sell, give, or furnish	Rolling papers	Violation

* Applies to all tobacco transfers in the given state.

Penalty for First Offense	Increase for Subsequent Offenses?	Suspend License?	Employee or Licensee Punished?	Affirmative Defense?
Not specified*	Not specified*	Yes*	Licensee is subject to forfeiture. Any officer, director, or manager of the business of any corporation that violates the provision, if they are aware, is subject to the same penalty*	Not specified*
Fine <500 + civil penalty <500	Not specified	Not specified	The owner of an establishment is not held responsible for an employee violation of the law if they had no knowledge of the violation and establish employee education to prevent future violations	Yes
Civil penalty <250	Yes*	Yes*	Not specified*	Not specified
<250				

* Applies to all tobacco transfers in the given state.

continued

TABLE B-1 Continued

State	Applies to Whom	Explicitly Illegal to…	Product in Question	Classification of the Transfer
New Jersey	Any person	Directly or indirectly (by agent, employee, or vending machine) sell, offer for sale, distribute for commercial purpose at no cost or minimal cost with coupons or rebate offers, give or furnish	Cigarettes, cigarette paper, tobacco in any form including smokeless, or any electronic smoking device including e-cigarettes, cigars, cigarillos, pipes, or any cartridge or component or related product	Petty disorderly persons offense
New Mexico	Any person	Knowingly sell or offer to sell	Tobacco products	Misdemeanor
New York	Retailer	Sell	Tobacco products, herbal cigarettes, shisha, e-cigarettes, or smoking paraphernalia	Not specified
North Carolina	Any person	Distribute, aid, assist, or abet in distribution, purchase on behalf of	Tobacco products, including tobacco-derived products or vapor products, cigarette wrapping papers	Class 2 misdemeanor
North Dakota	Any person	Sell or furnish, procure on behalf of	Tobacco products	Infraction, criminal misdemeanor
Ohio	Manufacturer, distributor, wholesaler or retailer, or employee thereof	Sell or otherwise distribute	Tobacco products	4th degree misdemeanor

* Applies to all tobacco transfers in the given state.

Penalty for First Offense	Increase for Subsequent Offenses?	Suspend License?	Employee or Licensee Punished?	Affirmative Defense?
Civil penalty 250	Yes	Yes	The licensee is subject to administrative charges, although the individual responsible for the sale is liable for the penalty	Yes
Imprisonment <year +/or fine <1,000	Not specified	Not specified	Not specified	Not specified
Fine 300<x<1,000	Yes	Yes	Not specified	Yes
Not specified	Not specified	Not specified	Not specified	Yes
Not specified	Not specified	Not specified	Not specified	Not specified
Not specified	Escalation in criminality with subsequent offenses	Not specified	Not specified	Yes

* Applies to all tobacco transfers in the given state.

continued

TABLE B-1 Continued

State	Applies to Whom	Explicitly Illegal to…	Product in Question	Classification of the Transfer
Oklahoma	Any person	Sell, give, or furnish in any manner	Tobacco products	Not specified
Oregon	Any person	Knowingly distributes, sells, or causes to be sold	Tobacco product or device for the use of tobacco	"Endangering the welfare of a child"/Class A violation
Pennsylvania	Any person	Sell or furnish*	Tobacco products*	Summary offense*
	Retailer			
Rhode Island	Any person	Sell, give, deliver	Tobacco in the form of cigarettes, bidi cigarettes, cigars, little cigars (flavored and unflavored), blunt wraps, cigarette rolling papers, cigarillos, tiparillos, pipe tobacco, chewing tobacco, or snuff	Not specified*
	Licensee or employee thereof	Sell, distribute, or deliver	Tobacco product	
South Carolina	Any person	Sell, furnish, give, distribute, purchase for or provide	Tobacco product or alternative nicotine product	Misdemeanor

* Applies to all tobacco transfers in the given state.

Penalty for First Offense	Increase for Subsequent Offenses?	Suspend License?	Employee or Licensee Punished?	Affirmative Defense?
Fine <100	Yes	Yes	If the sale is made by the employee of the licensee, the employee shall be guilty of the violation and subject to the fine. Each violaton by an employee shall be a violation against the owner for purposes of a license suspension	Yes
Fine >100	Not specified	Not specified	Not specified	Not specified
Fine 100<x<250	Yes*	Yes*	Not specified*	Not specified
Fine 100<x<500				Yes
Not specified	Not specified	Yes*	The licensee is responsible for all violations that occur at the location for which the license is issued. If courts find the licensee has taken adequate measures to ensure employees are not performing illegal transactions, courts may chose to not suspend license*	Not specified*
Fine 250	Yes			
Fine 100<x<200	Yes	Not specified	Not specified	Not specified

* Applies to all tobacco transfers in the given state.

continued

TABLE B-1 Continued

State	Applies to Whom	Explicitly Illegal to…	Product in Question	Classification of the Transfer
South Dakota	Any person	Knowingly distribute, purchase on behalf of, give	Tobacco products	Class Two misdemeanor
Tennessee	Any person	Sell, distribute, or purchase on behalf of. Persuade, entice, send, or assist a minor to purchase, acquire, receive or attempt to purchase, acquire or receive	Tobacco product or e-cigarette	Not specified
Texas	Any person	With criminal negligence, sell, give, or causes to be sold or given	Cigarette or tobacco product	Class C misdemeanor

* Applies to all tobacco transfers in the given state.

Penalty for First Offense	Increase for Subsequent Offenses?	Suspend License?	Employee or Licensee Punished?	Affirmative Defense?
Not specified	Not specified	Not specified	Not specified	Yes
Warning letter	Yes	Not specified	Commissioner of Agriculture is authorized to assess the penalty against any person or persons determined to be responsible, in whole or part, for contributing to or causing the violation to occur, including but not limited to the owner, manager, or employee of the store at which the violation occurred	Yes
Not specified	Not specified	Not specified	If the offense occurs in connection with a sale by an employee of a licensee, the employee is criminally responsible and subject to prosecution	Yes

* Applies to all tobacco transfers in the given state.

continued

TABLE B-1 Continued

State	Applies to Whom	Explicitly Illegal to...	Product in Question	Classification of the Transfer
Utah	Any person	Knowingly, intentionally, recklessly, or with criminal negligence provides	Cigar, cigarette, e-cigarette or tobacco in any form, or tobacco paraphernalia	Class C misdemeanor*
		Sell, offer for sale, give, or furnish	Clove cigarette	
Vermont	Any person	Sell or provide	Tobacco products, tobacco substitutes (e-cigarette and related products), or related paraphernalia	Not specified
Virginia	Any person	Sell, distribute, purchase for, or knowingly permit the purchase by	Tobacco product including but not limited to cigarettes, cigars, bidis and wrappings	Not specified
Washington	Any person (non licensee)	Sell, give, permit to be sold or given*	Cigar, cigarette, cigarette paper or wrapper, tobacco in any form or a vapor product*	Gross misdemeanor*
	Licensee			
West Virginia	Any person	Sell, give or furnish, cause to be sold or furnished*	Tobacco product or cigarette paper*	Misdemeanor*
	Firm or corporation			

* Applies to all tobacco transfers in the given state.

Penalty for First Offense	Increase for Subsequent Offenses?	Suspend License?	Employee or Licensee Punished?	Affirmative Defense?
Not specified*	Escalation in criminality with subsequent offenses*	Yes*	If the licensee or employee thereof has sold tobacco to someone <19 years old, the agency may impose adminstrative penalties on the licensee*	Not specified*
Fine <100	Yes	Yes	Not specified	Not specified
Fine <100	Yes	Not specified	Not specified	Yes
Fine 50	Yes*	Yes*	Not specified*	Yes*
Fine 100				
Fine <100	Yes*	Not specified*	The employer may dismiss an employee for selling or furnishing tobacco products to minors*	Yes*
Fine 50				

* Applies to all tobacco transfers in the given state.

continued

TABLE B-1 Continued

State	Applies to Whom	Explicitly Illegal to...	Product in Question	Classification of the Transfer
Wisconsin	Any person	Purchase on behalf of, or provide to	Cigarettes, tobacco products or nicotine products*	Not specified*
	Retailer, direct marketer, manufacturer, distributor or agent/employee thereof	Sell or provide for nominal or no consideration		
Wyoming	Any person	Sell, offer for sale, give, or deliver	Tobacco products*	Misdemeanor*
	Retailer	Sell, permit the sale of, offer for sale, give, or deliver		

* Applies to all tobacco transfers in the given state.

Penalty for First Offense	Increase for Subsequent Offenses?	Suspend License?	Employee or Licensee Punished?	Affirmative Defense?
Fine <500 if no violation in previous 30 months or Fine <500 +/or 1 month imprisonment if violation in previous 30 months	Yes*	Yes*	Not specified*	Not specified
Fine <500				Yes
Fine <50*	Yes*	Yes*	No penalty to the permittee for first violation if permittee can prove plan in place to prevent illegal sale to minors*	Yes*

* Applies to all tobacco transfers in the given state.

Appendix C

State Laws—Tobacco Purchase–Use–Possession by Minors

The following table (see Table C-1) summarizes state law for all 50 states and the District of Columbia specifically in reference to purchase–use–possession laws (PUP) of a tobacco product by a minor. Throughout this report, the minimum age of legal access to tobacco products (MLA) focuses on youth access laws and enforcement policies that curtail retail access to tobacco products by underage persons, with little emphasis on punishing underage users of tobacco products. Despite that focus, MLA in the following table, as in the report, therefore covers youth access restrictions that both punish distributors of tobacco products to underage users and the underage users themselves.

The information for this table is adapted from the State Legislated Actions on Tobacco Issues (SLATI) database,[1] which is maintained by the American Lung Association. It should not be considered a comprehensive analysis of state law but rather an illustration of state-level variance in tobacco control legislation.

[1] American Lung Association. State Legislated Legal Actions on Tobacco Issues (SLATI) State Pages. http://www.lungusa2.org/slati/about.php (accessed October 8, 2014).

TABLE C-1 State Laws—Tobacco Purchase–Use–Possession Laws for Minors

State	MLA	Explicitly Illegal for Minors to…	Classification	Penalties for PUP Violations Among Minors
Alabama	19	Purchase, use, possess, transport	Not listed	Fine and notify parent/guardian
Alaska	19	Knowingly possess	Violation	Not listed
Arizona	18	Purchase, possess, knowingly accept	Petty offense	Fine or community service
Arkansas	18	Use, possess, purchase, or attempt to purchase	Not listed	Confiscate the tobacco product, may require community service and enrollment in tobacco education program
California	18	Purchase, receive, possess	Not listed	Fine and community service
Colorado	18	Purchase or attempt to purchase	Class two petty offense	Fine or participate in tobacco education program; may perform community service instead of fine
		Possession	Noncriminal offense	Not listed
Connecticut	18	Purchase	Not listed	Fine
Delaware	18	Purchase, accept receipt of, use a coupon for	Not listed	Fine and community service
District of Columbia	18	Purchase, attempt to purchase, possess, attempt to possess	Not listed	Fine
Florida	18	Knowingly possess, purchase, attempt to purchase	Not listed	Fine or community service; minor must attend anti-tobacco education
Georgia	18	Purchase, attempt to purchase, possess	Not listed	Community service, attendance at a lecture on the hazards of smoking or both

Graduated Penalty?	Applies to...	Illegal to Present Fake or Borrowed ID	Suspend Driver's License?
Not listed	Tobacco, tobacco products, alternative nicotine products	✓	
Not listed	Tobacco products		
Not listed	Tobacco products, vapor product including e-cigarettes, hookah, waterpipe	✓	
Not listed	Tobacco in any form, cigarette papers	✓	
Not listed	Tobacco product or paraphernalia		
Not listed	Tobacco products		
Not listed	Tobacco products		
Yes; increasing fines only	Tobacco products	✓	
Yes; more community service hours for second and subsequent offenses	Tobacco products	✓	
Yes; increasing fine for fake ID	Cigarette or other tobacco product	✓	
Yes	Tobacco products	✓	✓
Not listed	Cigarettes or tobacco related objects		

continued

TABLE C-1 Continued

State	MLA	Explicitly Illegal for Minors to…	Classification	Penalties for PUP Violations Among Minors
Hawaii	18	Purchase	Not listed	Fine
Idaho	18	Purchase, receive, sell, possess, use, distribute, consume	Misdemeanor	Imprisonment and/or a fine; may also require attendance at tobacco awareness programs, community service
Illinois	18	Purchase, possess	Petty offense	Fine and community service
Indiana	18	Purchase, accepts for personal use or possess	Class C Infraction	Fine
Iowa	18	Smoke, use, possess, purchase, or attempt to purchase	Violation	Fine and community service
Kansas	18	Purchase, attempt to purchase; possess or attempt to possess	"Tobacco infraction"	Fine
Kentucky	18	Possess or use	Not listed	Product is confiscated
		Purchase or accept receipt of	Not listed	Fine and community service
Louisiana	18	Purchase or possess	Not listed	Fine
Maine	18	Present fraudulent ID for the purposes of purchasing/possessing/using	Civil violation	Fine and/or community service
Maryland	18			
Massachusetts	18			
Michigan	18	Purchase, attempt to purchase, possess, attempt to possess, use	Misdemeanor	Fine and community service, health promotion program participation

Graduated Penalty?	Applies to…	Illegal to Present Fake or Borrowed ID	Suspend Driver's License?
Yes, fine increases and community service for second and subsequent offenses	Tobacco product or electronic smoking device		
Not listed	Tobacco products or electronic cigarettes	✓	
Yes	Tobacco products	✓	
Not listed	Tobacco products or electronic cigarettes		
Yes; higher fines and more community service	Tobacco products	✓	
Not listed	Cigarettes, e-cigarettes, or tobacco products		
Not listed	Tobacco products	✓	
Yes; higher fines and more community service	Tobacco products		
Yes; increase in fine	Tobacco products		
Yes; increase in fine and community service	Tobacco products	✓	
Yes; increase in number of hours; fine stays the same	Tobacco product	✓	

continued

TABLE C-1 Continued

State	MLA	Explicitly Illegal for Minors to...	Classification	Penalties for PUP Violations Among Minors
Minnesota	18	Use fraudulent ID to purchase, attempt to purchase	Misdemeanor	If fake ID is used—driver's license is suspended
		Possesses, smokes, chews, ingests, purchases, attempts to purchase	Petty misdemeanor	If fake ID is used—driver's license is suspended
Mississippi	18	Purchase, possess	Not listed	Fine and/or community service
Missouri	18	Purchase, attempt to purchase, possess	Infraction	Confiscation of product
Montana	18	Knowingly possess or use; purchase	Not listed	Fine and/or community service/tobacco cessation education
Nebraska	18	Use	Class V misdemeanor	Not listed
Nevada	18			
New Hampshire	18	Purchase, attempt to purchase, use, possess	Violation	Fine and/or community service, maybe also tobacco education
New Jersey	19			
New Mexico	18	Procure or attempt to procure	Not listed	Fine or community service
New York	18			
North Carolina	18	Purchase, accept receipt, attempt to purchase or accept receipt	Class two misdemeanor	Not listed
North Dakota	18	Purchase, possess, smoke, use	Noncriminal offense	Fine
Ohio	18	Consume, possess, purchase, attempt to purchase	Not listed	Fine and/or tobacco education

Graduated Penalty?	Applies to…	Illegal to Present Fake or Borrowed ID	Suspend Driver's License?
Not listed	Tobacco or tobacco related devices	✓	✓
Not listed	Tobacco or tobacco related devices		
Not listed	Tobacco product	✓	
Second offense: tobacco education/ smoking cessation program; none else listed	Cigarettes or tobacco products	✓	
Yes; increased fines listed	Tobacco products		
Not listed	Tobacco products	✓	
Not listed	Tobacco product, e-cigarette, liquid nicotine; rolling paper	✓	
Not listed	Tobacco products	✓	
Not listed	Tobacco products including tobacco derived products or vapor products	✓	
Not listed	Tobacco products	✓	
Yes; increase fine, require community service, suspend license/learner permit	Tobacco products	✓	✓

continued

TABLE C-1 Continued

State	MLA	Explicitly Illegal for Minors to…	Classification	Penalties for PUP Violations Among Minors
Oklahoma	18	Purchase, receive, possess	Not listed; if does not provide seller when asked, misdemeanor	Fine, imprisonment (only for the misdemeanor)
Oregon	18	Purchase, attempt to purchase or acquire	Violation	Tobacco education or community service
		Possess	Class D violation	Not listed
Pennsylvania	18	Purchase, attempt to purchase	Summary offense	Fine and/or tobacco education/community service/suspend license
Rhode Island	18	Purchase	Not listed	Not listed
		Smoke, chew, possess	Not listed	Community service or tobacco education
South Carolina	18	Purchase, attempt to purchase, possess, attempt to possess	Noncriminal offense	Fine or tobacco education or community service
South Dakota	18	Purchase, attempt to purchase, receive, attempt to receive, possess, consume	Class Two misdemeanor	Not listed
Tennessee	18	Purchase, possess, accept	Civil offense	Fine
Texas	18	Possess, purchase, consume, accepts	Not listed	Fine and tobacco education or community service
Utah	19	Purchase, attempt to purchase, possess	Class C misdemeanor	Fine and tobacco education
Vermont	18	Possess, purchase, attempt to purchase	Not listed	Confiscate product and fine
Virginia	18	Purchase, attempt to purchase, possess	Not listed	Fine or community service

Graduated Penalty?	Applies to…	Illegal to Present Fake or Borrowed ID	Suspend Driver's License?
Increase in fine; may suspend driver's license	Tobacco products	✓	✓
Yes; subsequent offense = fine, suspend license	Tobacco products	✓	✓
Not listed	Tobacco products		
Not listed	Tobacco product	✓	✓
Not listed	Tobacco in the form of cigarettes, bidi cigarettes, cigars, pipe tobacco, chewing tobacco, snuff		
Not listed	Tobacco in any form, cigarette papers		
Not listed	Tobacco product, alternative nicotine product	✓	✓
Not listed	Tobacco products		
Yes; add tobacco education and community service for subsequent offenses	Tobacco products	✓	
Not listed	Cigarette or other tobacco product	✓	✓
Not listed	Cigar, cigarette, e-cigarette, or tobacco in any form	✓	
Not listed	Tobacco products, tobacco substitutes or paraphernalia	✓	✓
Yes, higher fine or more community service hours	Tobacco product		

continued

TABLE C-1 Continued

State	MLA	Explicitly Illegal for Minors to…	Classification	Penalties for PUP Violations Among Minors
Washington	18	Purchase, possess, attempt to purchase, or obtain	Class Three civil infraction	Fine and/or community service; maybe tobacco education
West Virginia	18	Possess	Not listed	Fine and community service
Wisconsin	18	Possess, purchase	Not listed	Not listed
Wyoming	18	Possess, use, purchase, attempt to purchase	Misdemeanor	Fine or community service or tobacco cessation

Graduated Penalty?	Applies to…	Illegal to Present Fake or Borrowed ID	Suspend Driver's License?
Not listed	Tobacco products		
Yes, higher fine and more community service hours	Tobacco products		
Not listed	Tobacco products, nicotine products	✓	
Yes, increase in fine	Tobacco products	✓	

Appendix D

Supplemental Information About the Models

By Theodore R. Holford and David T. Levy

The CISNET smoking population model tracks individuals by age and U.S. birth cohort beginning in 1864 as the individuals progress through various smoking stages (i.e., reconstructed smoking prevalence, initiation, and cessation rates) to estimate the smoking prevalence and the rates of smoking initiation, cessation, and intensity in the United States by age and gender from 1964 through 2012 (Anderson et al., 2012; HHS, 2014; Holford et al., 2014a). The model reports population levels of smoking, non-lung cancer mortality, and overall mortality (Anderson et al., 2012; Holford and Clark, 2012; Holford et al., 2014b; Jeon et al., 2012). The CISNET smoking population model can also simulate individual smoking trajectories using a "smoking history generator" (Jeon et al., 2012). The CISNET smoking population model was recently used to assess smoking patterns and estimate the smoking rates of initiation and cessation in the United States from 1964 to 2012 (Holford et al., 2014a) and the number of premature deaths prevented in the United States by tobacco control from 1964 to 2014 (Holford et al., 2014b). The model can also simulate lung cancer incidence and mortality when coupled with lung cancer natural history models (de Koning et al., 2014; McMahon et al., 2014; Meza et al., 2014; Moolgavkar et al., 2012). The CISNET smoking and lung cancer models were used to estimate the number of lung cancer deaths in the United States prevented by historical tobacco control efforts from 1975 to 2000 (Moolgavkar et al., 2012). More recently, the CISNET smoking and lung cancer models were used to provide estimates of the potential benefits and harms of computerized tomography lung cancer screening in the United States (de Koning et al., 2014; McMahon et al., 2014; Meza et al., 2014). The CISNET smoking population model accounts for differences in mortality rates by gender, age, birth cohort and smoking status (Holford et al., 2014b; Rosenberg et al., 2012), and it breaks the population into never smoked, former smoker, and six categories of current smokers varying by intensity. The same approach is applied to projections of U.S. mortality rates based on the Lee-Carter model (Sprague, 2009). The CISNET smoking model does not account explicitly for the effects of tobacco control policies. Instead, the model uses historical U.S. rates of smoking prevalence, initiation, cessation and intensity by age, gender, and birth cohort estimated from National Health Interview Survey (NHIS) data. These rates capture the temporal variations in U.S. smoking patterns and the indirect effects of tobacco control policies as implemented historically.

The SimSmoke model tracks the number of never, current, and former smokers by age and gender in the modeled population by year and evaluates the impacts of tobacco control policies through their effects on smoking prevalence as a function of the assumed associated changes in smoking initiation and cessation rates based on literature review and expert judgment (Levy et al., 2005, 2010b, 2012a). The SimSmoke model estimates the number of annual smoking-attributable deaths and the effects of tobacco control policies on smoking prevalence and attributable mortality, with applications to the entire United States (Levy and Friend, 2000, 2001; Levy et al., 2000a,b, 2001a, 2004, 2005, 2010b) as well as at the state level (Levy et al., 2007, 2008, 2012b), and other countries (Levy et al., 2010a, 2012a, 2013a,b, 2014, in press).

The tobacco control policies modeled in SimSmoke include tax changes, smoke-free air laws, health warnings, the Fairness Doctrine, advertising restrictions, mass media interventions, availability of cessation treatments, and youth access policies considered individually and in combination (Levy et al., 2005, 2010b, 2012a). The initial development and validation of the SimSmoke model used data from the Tobacco Use Supplement of the Current Population Survey (TUS-CPS) (Levy et al., 2005). The SimSmoke model does not consider smoking intensity and does not account for varying patterns by birth cohort.

As is the case with CISNET, the SimSmoke model considers differential mortality rates by gender, age, and smoking status (Holford et al., 2014b; Rosenberg et al., 2012) and breaks the population into never smoked, current smoker, and 16 categories of former smokers differentiated by the number of years since they quit. The SimSmoke model explores the potential effects of raising the minimum age of legal access to tobacco (MLA) on smoking initiation rates in order to make predictions of the policy effects on future smoking prevalence and smoking-attributable deaths and maternal and child health outcomes (i.e., low birth weight, pre-term births and sudden infant deaths) while simultaneously accounting for ongoing tobacco control efforts.

CISNET MODEL (BY HOLFORD)

Smoking History Summary for the United States, 1965–2012

The data from 36 NHISs conducted from 1965 to 2012 were analyzed using the method employed by CISNET (Holford et al., 2014b). Results from this analysis provided summary estimates for birth cohorts starting in 1864 and ending in the calendar year 2012. These estimates included

a. Current smoker prevalence;
b. Former smoker prevalence;
c. Never smoker prevalence;
d. Yearly smoking initiation probabilities for never smokers;
e. Yearly smoking cessation probabilities for current smokers; and
f. Distribution of categories for reported daily cigarettes per day (CPD): CPD≤5, 5<CPD≤15, 15<CPD≤25, 25<CPD≤35, 35<CPD≤45, 45<CPD.

Smoking Prevalence Model

A compartment (macro) model that characterizes a typical smoking history in which a subject begins to smoke at some point (never → current smoker) after which they may quit (current → former smoker) was used. While this over simplifies what can be much more complex in reality, it does provide a useful characterization of the experience for most of the population. Smoking cessation can be especially difficult to characterize because it is often not successful on the first attempt. Hence, we adopted the rule that subjects who report quitting must have done so at least 2 years before the interview, otherwise their period of observation is regarded as being truncated at the given age at cessation.

We defined the basic quantities of interest conditional on a hypothetical case with no transitions to death. Let a represent age, t period or calendar year, and c cohort or year of birth, and all three temporal components may play a role when constructing the basic parameters affecting smoking history. These temporal indicators are related by $c = t - a$, therefore, when presenting the relationships among the basic model parameters, we can without loss of generality represent them as functions of age and cohort. The smoking initiation probability, $p(a,c)$, is the conditional probability of smoking initiation at age a for cohort c, if not a smoker at $a - 1$, i.e.,

$$p(a,c) = \Pr\{\text{Smoker at } a \mid \text{Not smoker at } (a-1),c\}.$$

It is related to the cumulative proportion of ever smokers at a conditional on remaining alive,

$$\begin{aligned} P_E(a,c) &= 1 - \prod_{i-1}^{a} \left[1 - p(i,c)\right] \\ &= 1 - \left[1 - P_E(a-1,c)\right]\left[1 - p(a,c)\right] \end{aligned} \tag{1}$$

where $P_E(0,c) = 0$, which is equivalent to the actuarial approach for estimating the survival curve. If smoking did not affect mortality then one would expect equation (1), which is conditional on remaining alive, to also hold in a population followed over time. But, of course, mortality is affected by smoking so that the observed proportion of the population who have ever smoked at a particular age is given by $P_E{}^*(a,c) \le P_E(a,c)$. Initiation probabilities estimated at a particular survey would be similarly affected by differential mortality; and we represented these by $p^*(a,c) = p(a,c)/C_p$ where $C_p \ge 1$ is a constant correction factor introduced to adjust for this effect. We assumed that differential mortality among smoking categories had little effect early in life and the impact intensified with age. Cohorts born before 1935 would only have survey data for ages over 30 when one might expect differential mortality to begin to introduce substantial bias in the unadjusted estimate, $\hat{p}^*(a,c)$. In recent cohorts, almost all smoking initiation occurred before age 30, but for those born early in the twentieth century it was not so uncommon for initiation to occur later in life, especially in women. Later smoking initiation would also tend to postpone the effect of differential mortality in the cohort. We assumed that the differential mortality resulting from cigarette smoking occurred at ages, $a \ge a_0$, and $P_E{}^*(a,c) = P_E(a,c)$ for $a < a_0$. Initiation probabilities corrected for differential mortality were found by solving

$$P_E(a_0,c) = 1 - \prod_{i-1}^{a_0} \left[1 - C_p p^*(i,c)\right]$$

for C_p, i.e., by matching the cumulative initiation rates to the estimated prevalence at age a_0. We assumed that a_0 was the age at first survey in 1965 or 30, whichever was older.

Smoking cessation was assumed to be a function of age for each cohort. The smoking cessation probability conditional on the subject being alive and currently smoking is

$$q(a,c) = \Pr\{\text{Former smoker at } a \mid \text{Smoker at } (a-1),c\}.$$

We assumed that $q(a,c) = 0$ for $a < 15$ and we estimated it for $15 \le a \le 99$. The cumulative proportion of smokers in cohort c who had not ceased smoking by age a is given by

$$Q(a,c) = \prod_{i-15}^{a} \left[1 - q(i,c)\right]. \tag{2}$$

For simplicity, we assumed that this quantity does not depend on the age an individual started smoking, number of cigarettes per day or other factors that may be related to an individual's success in quitting. Because initiation tends to occur in a fairly narrow age range, variation in age of initiation becomes less of a factor affecting mortality as a cohort gets older. Introducing intensity of smoking into a model for cessation would require detailed lifetime histories of smoking which were not commonly obtained by NHIS, a limitation in the available data.

Current smokers represent ever smokers who have not quit, and given our assumption that this only depends on age for a given cohort, the prevalence is

$$P_C(a,c) = P_E(a,c)Q(a,\mathrm{c}).$$

Former smokers are those who have smoked at some point in their lives, but quit before age a, and the proportion of these individuals is

$$\begin{aligned} P_F(a,c) &= P_E(a,c) - P_C(a,c) \\ &= P_E(a,c)[1 - Q(a,c)]. \end{aligned}$$

Finally, the proportion of cohort c who have never smoked is the complement of those who ever smoked,

$$P_N(a,c) = 1 - P_E(a,c).$$

For a given age and cohort, the sets of current, former, and never smokers are exhaustive, i.e.,

$$P_C(a,c) + P_F(a,c) + P_N(a,c) = 1.$$

Estimation of smoking parameters Data were only obtained for a restricted range of ages, a in [amin,amax], and periods, t in [tmin,tmax] so that the earliest cohort would be cmin – tmin – amax and the latest cmax = tmax – amin. Available data for a given cohort c, would cover an age range that would vary by cohort, i.e., a in [tmin – c, tmax – c]. To fill in smoking history that was not represented in the survey, we represented each temporal effect as a nonparametric function that we applied outside the range of observed data.

Cross-sectional estimates of ever smokers For years covered by surveys, i.e., 1965–2012, participants provided information that could be used to estimate the prevalence of ever smokers by age, a, for the corresponding cohort, $c = t - a$. Let Y_i be 1 if the i-th individual ever smoked and 0 otherwise, where the probability of the response is a function of age and cohort, $P_E(a,c)$. We assume an additive logistic model for Y_i, so that

$$\text{logit}\,\{P_E(a,c)\} = \beta_0 + \beta_a(a) + \beta_c(c)$$

where β_0 is an intercept and $\beta_\cdot(\bullet)$ is a function given by a constrained natural spline. The model was fitted using PROC GENMOD in SAS® with knots specified as

Age: 40, 50, 60, 70
Cohort: 1910, 1920, 1930, 1940, 1945, 1950, 1955, 1960, 1965, 1970, 1980

We assumed that the cohort effect remained constant for those born after 1979, the most recent cohort that would provide data to a survey regarding smoking history after age 30 in 2012 which was the age used to identify C_p. Values used for subsequent cohorts were set to be identical to those for the 1982 birth cohort.

Smoking initiation probability Unadjusted estimates of annual age-specific smoking initiation probabilities for a given cohort, $\hat{p}^*(a,c)$, were directly derived from NHIS data. For each cohort represented in a survey, we determined the number of subjects who started to smoke, $d(a,c)$, and who had never smoked to that point, $n(a,c)$. These comprised the response data introduced into a linear logistic model in which the temporal factors were nonparametric functions to be estimated. Each NHIS survey represented participants who survived until that time, and because this group would overrepresent individuals in a cohort who started smoking late or not at all, these cohort-specific initiation probabilities would be biased downward. The correction factor was found by specifying the target value for the estimated cumulative initiation at a specific age, a_0, to be equal to the value estimated from the cross-sectional analysis, i.e.,

$$\hat{P}_E(a^*,c) = 1 - \prod_{i=1}^{a^*}\left[1 - \hat{C}_p\hat{p}^*(a,c)\right]$$

and finding $\hat{C}_p$ which satisfies this condition.

To determine the crude initiation probability estimates, an age-period-cohort model was fitted to the tabulated data given number of subjects who start smoking and are at risk of starting at a given age,

$$\text{logit}\ \{p^*(a,c)\} = \beta_0 + \beta_a(a) + \beta_t(t) + \beta_c(c)$$

where β_0 is an intercept and $\beta.(\bullet)$ is given by a constrained natural spline. We were only interested in the fitted values for the initiation probabilities, which were not affected by the well-known identifiability problem in age-period-cohort models. Knots were specified as:

age: 10, 15, 20, 50, 60
period: 1910, 1920, 1930, 1940, 1950, 1960, 1970, 1980
cohort: 1910, 1920, 1930, 1940, 1945, 1950, 1955, 1960, 1965, 1970, 1980

Age for the target used to determine the correction factor was age in 1965 (year of the first NHIS survey) or 30, whichever was older, $a^* = \max\{1965 - c, 30\}$. The target value for the cumulative probability of being a smoker was the estimate derived in the analysis of the prevalence curve, $\hat{\Pi}(a^*, c)$.

Smoking cessation probability An individual was identified as having quit smoking if they had not smoked for 2 years. Because of the 2-year lag used in the definition of quitting, an individual who reports cessation at age $a - 2$ or later could not be classified and they would be truncated at that age. Hence, current smokers were similarly truncated at age $a - 2$. Data used for this analysis were from surveys conducted from 1970–2012, including subjects reporting ages from 17–98. If the reported age of cessation was younger than 8, it was set to 8. For each year of age following smoking, a binary response was created based on our definition of quitting. Yearly estimates of the linear logistic age-period-cohort model were fitted in which

$$\text{logit}\ \{q(a,t,c)\} = \beta_0 + \beta_a(a) + \beta_t(t) + \beta_c(c)$$

where β_0 is an intercept and $\beta.(\bullet)$ are given by a constrained natural splines. We were only interested in the fitted values for the cessation probabilities, which are not affected by the well-known identifiability problem in age-period-cohort models. Knots were specified as follows:

age: 30, 40, 50, 60
period: 1920, 1930, 1940, 1950, 1960, 1970, 1980
cohort: 1910, 1920, 1930, 1940, 1950, 1960, 1970

Estimates of the yearly cessation probability for age a and cohort c were the fitted values for ages 15–99, $\hat{q}\,(a, a + c, c)$. The conditional cessation probabilities were used to generate the cumulative probabilities of not quitting, $\hat{Q}\,(a, a + c, c)$, using equation (2).

Cigarettes smoked per day Reports of the number of cigarettes smoked per day showed an extremely high degree of digit preference, especially concentrated at half or whole U.S. packs. Therefore, dose was analyzed as an ordered categorical response with half pack being at the center of the category, which was also usually the mode and close to the mean. The intervals (approximate interval center) employed were: CPD≤5 (3); 5<CPD≤15 (10); 15<CPD≤25 (20); 25<CPD≤35 (30); 35<CPD≤45 (40); and 45<CPD (60). A cumulative logistic model was fitted to the data using PROC LOGISTIC in SAS® with age, period and cohort represented by additive nonparametric factors function of time using constrained natural splines. Knots were specified as:

age: 25, 30, 35, 40, 45, 50, 55, 60, 65, 70
period: 1970, 1975, 1980, 1985, 2000, 2005
cohort: 1910, 1920, 1930, 1940, 1950, 1960, 1970, 1980

The fitted estimates of the probabilities for each category of smoking dose for each cohort for ages 0 to 99 were used as parameters for the smoking history generator. Estimates for cohorts born before 1920 were constrained to be the same as for the 1920 birth cohort. Similarly, estimates for cohorts born after 2002 were constrained to be identical to those of the 2002 cohort, who would be 7 in 2012, i.e., the year before the earliest age at initiation considered in this analysis.

Estimation of current, former, and never smokers for 1-year cohorts Estimates of smoking prevalence were derived from the estimated curves for ever smokers, $\hat{P}_E(a,c)$, and the corresponding survival function for not quitting, $\hat{Q}(a,c)$. The estimated prevalence of current smokers by age and cohort is

$$\hat{P}_C(a,c) = \hat{P}_E(a,c)\,\hat{Q}(a,c).$$

Prevalence of former smokers is

$$\begin{aligned}\hat{P}_F(a,c) &= \hat{P}_E(a,c) - \hat{P}_C(a,c)\\ &= \hat{P}_E(a,c)[1 - \hat{Q}(a,c)].\end{aligned}$$

Finally, prevalence of never smokers is

$$\hat{P}_N(a,c) = 1 - \hat{P}_E(a,c).$$

Estimated Smoking History Measures, 2012–2100

In order to assess the impact of a change in the minimum legal age of purchase of cigarettes we assume that the impact will primarily affect smoking initiation probabilities and not cessation probabilities or smoking intensity distribution, which were assumed to remain unchanged for future birth cohorts who would experience the policy change. The model status quo initiation and cessation rates are available on the CISNET resources website.[1] We assumed that a change to the MLA in 2015 would primarily affect those who were 15 or older, i.e., the 2000 or later birth cohorts. Using the methods described elsewhere (Holford et al., 2014b), the postulated changes in initiation probabilities yielded ever-smoker prevalence estimates in the subsequent birth cohorts. In addition, using the methods described, we obtained estimates of current and former smoker prevalence estimates. The distribution of smoking intensity categories was assumed to remain the same in future birth cohorts.

Smoking status–specific death rates (current smoker by intensity, former smoker, and never smoker), $\mu_i(t)$, were obtained using the Human Mortality Database (HMD) mortality rates for the United States by age, calendar year and gender combined with the method described by Rosenberg et al. (2012). HMD rates were then projected to 2100 using the Lee-Carter model (Sprague, 2009) and then further broken down by smoking status using the Rosenberg et al. method. The death rate at age *t* for a particular scenario was determined by the given distribution of smoking status, $p_i(t)$,

$$\bar{\mu}(t) = \sum_i p_i(t)\mu_i(t),$$

where *i* represents the various smoking status/intensity combinations. These death rates were used to modify the population distribution in order to reflect the effect of the change in mortality rate (Holford et al., 2014a). The resulting death rates and estimated populations for 2012–2100 were used to obtain summary measures of the effect of a given scenario.

Premature Deaths Due to Tobacco Use

The excess death rate resulting from tobacco use was estimated by the difference between the death rate under the given scenario and the death rate for never smokers, $\left[\bar{\mu}(t) - \mu_0(t)\right]$, where $\mu_0(t)$ is the death rate at age *t* for never smokers. If $P(t)$ is the population size at age *t*, then the number of premature deaths due to tobacco use is given by

[1] See https://resources.cisnet.cancer.gov/projects/#shg/iomr.

$$\sum_t P(t)\left[\bar{\mu}(t) - \mu_0(t)\right].$$

Population estimates by single years of age (0–84 and 85+) were obtained from the U.S. Census for years 1964 through 2060 (USCB, 2013a,b). Population estimates going to 2100 were obtained by following the population from the previous year and assuming that the proportional change would remain the same. For age 0, we assume that after 2060 the proportional increase will be the same as the change estimated by the U.S. Census for 2059 to 2060.

Years of Life Lost

Using the age-specific death rates for a cohort, the expected years of life remaining at age t, $e(t)$, was calculated. For a death that occurs at age t, life expectancy for never smokers, $e_0(t)$, would estimate the mean number of years of life lost. The total years of life lost by smokers who died early is given by

$$\sum_t P(t)\left[\bar{\mu}(t) - \mu_0(t)\right] e_0(t).$$

Lung Cancer Deaths Avoided

The two-stage clonal expansion (TSCE) model (Hazelton et al., 2012; Meza et al., 2008) was used to estimate the lung cancer mortality rate. For current smokers, the model gives the rate at age t as a function of age at initiation and smoking intensity. We assume that the age at initiation is independent of intensity, so the joint distribution is obtained as the product of the probability of initiation at a given age and the probability of a particular smoking intensity level. These were then used to obtain the mean lung cancer mortality rate for current smokers. Similarly, for former smokers we obtain the mean lung cancer mortality rate for a particular age of interest by first determining the joint distribution of age at initiation, age at cessation, and smoking intensity. Multiplying this joint distribution by the lung cancer mortality rate obtained from the TSCE model and then summing over all combination of initiation and cessation times provides the probability of lung cancer death at age t. Finally, we obtain the overall rate for a particular scenario by taking a weighted average of the lung cancer mortality rates for never, current, and former smokers. The excess rate is obtained by taking the difference between the rate for the scenario and the rate for never smokers. Multiplying this by the population gives the number of lung cancer deaths avoided for a given age, and taking the sum over all ages provides the overall number of lung cancer deaths avoided.

Birth Cohort and Period Temporal Perspectives

The models used to estimate the fundamental parameters of smoking initiation, cessation, intensity, and ever-smoker prevalence were derived from the birth cohort perspective. This captures the life course of different generations, and it provides useful summaries of the groups that would have experienced a change in the MLA at a point in life in which they are most likely to initiate cigarette smoking. Viewed from this perspective, we determined life expectancy, premature deaths from smoking, and excess lung cancer deaths caused by smoking from the temporal perspective of following these individuals through life. Because these individuals would be classified as belonging to a group upon enactment of a change in the MLA, the model assumptions would result in no further changes in the birth cohort smoking history, which would result in constant age-specific death rates for all causes and specific causes. Any changes in the number of subjects affected reflect trends in the size and the age structure of the population.

Results are also presented from the period or calendar year perspective, which describe the view experienced by the health community. Mortality rates differ little in absolute magnitude until after age 40, and diseases like lung cancer have long latency. Hence, the effect of changing MLA would not be discernable until decades after enactment of a change. However, once the effect becomes observable, it will continue to increase until it reaches steady state. The summaries from the period perspective include estimates of the number of premature deaths from all causes or from a specific cause in a given calendar year. Life expectancy estimates given for a period represent a summary of the age-specific death rates in a given year, which is identical to the traditional demographic summary that is commonly used as one summary measure of the health of the country. In contrast to the estimates derived from the cohort perspective, this summary does not correspond to the life course of a population.

SIMSMOKE (BY LEVY)

The U.S. SimSmoke Model

SimSmoke divides the population in 1965 into (1) never smokers (Neversmokers, indicated in subscripts by “ns”), (2) smokers (Smoker, indicated in subscripts by “s”), and (3) 15 categories of former smokers (Formersmokers$_k$, where k = 1, . . . ,14, 15+, corresponding to the year quit). Individuals are classified as never smokers from birth until they initiate smoking or die, as shown below, where t is the year and a is the age of the individual:

$$\text{Neversmokers}_{t,a} = \text{Neversmokers}_{t-1,a-1} * (1 - \text{MortRate}_{t-1,a-1,ns})*(1 - \text{Initiation rate}_{t-1,a-1}).$$

Never smokers can become smokers through initiation. Once they have become smokers, individuals continue in that category until they quit or die. Former smokers continue in that category until they die or re-enter the group of smokers through relapse. The number of smokers is tracked as:

$$\begin{aligned}\text{Smokers}_{t,a} =\ & \text{Smokers}_{t-1,a-1}*(1 - \text{MortRate}_{t-1,a-1,s})*(1 - \text{Cessation rate}_{t-1,a-1}) \\ & + \sum_{k=2}^{15+} \text{Former smokers}_{t-1,\, a-1,k}*(1 - \text{MortRate}_{t-1,a-1,k})*(\text{Relapse rate}_{a-1,k}) \\ & + \text{Neversmokers}_{t-1,a-1}*(1 - \text{MortRate}_{t-1,a-1,ns})*\text{Initiation rate}_{t-1,a-1}.\end{aligned}$$

First-year former smokers are determined by the first-year cessation rate applied to surviving smokers in the previous year. After the first year quit, individuals who have been former smokers for k = 2, . . . , 14 are defined as:

$$\text{Former smokers}_{t,a,k} = \text{Former smokers}_{t-1,a-1,k-1}*(1 - \text{MortRate}_{a,k})*(1 - \text{Relapse rate}_{a,k-1}).$$

For those who have quit smoking for 15 or more years, 15+, the equation above includes all individuals who have quit more than 15 years from the previous year.

Data on smoking rates are from Holford et al. (2014a) and are based on NHIS. Smoking prevalence is defined as the percentage of people in the population who have smoked 100 cigarettes during their lifetime and currently smoke. Initiation rates through age 30 are based on responses for age of initiation and having smoked 100 cigarettes. Cessation is tracked from age 16, because data from NHIS on cessation begins at that age. Cessation rates are defined in terms of having quit for 2 years, which reflects a trade-off between higher cessation rates in the first year and relapse in later years. After 1965, relapse rates are also distinguished by age and gender, and the number of years since quitting (HHS, 1990; Hughes et al., 2008). The SimSmoke model status quo initiation and cessation rates are available on the CISNET resources website.[2]

[2] See https://resources.cisnet.cancer.gov/projects/#shg/iomr.

Smoking-Attributable Deaths

To estimate smoking-attributable deaths (SADs), we used age- and gender-specific current and never-smoker mortality rates used by Holford et al. (2014b) based on the Cancer Prevention Studies (CPS-I and CPS-II) and the Nutrition Follow-up to CPS-II. For smokers, SADs are defined in terms of the excess death rate of current smokers (smoker mortality rate minus never-smoker mortality rate). Mortality rates for former smokers decrease progressively from the current smoker toward the never-smoker level as years since quitting increase, according to CPS-II data (Burns et al., 1997). SADs are estimated for current and former smokers by age (a), gender (g), and year (t) by summing over age (a) as:

$$\sum_{a=40}^{85} \text{excess death risk}_{a,g,t} * \text{prevalence}_{a,g,t} * \text{projected population}_{a,g,t}.$$

Policy Analysis

Separate policy modules estimate the effects of past tax changes, smoke-free air laws, health warnings, advertising restrictions, mass media, cessation treatment, and youth access policies. The original policy parameters used to generate the predicted effects are based on thorough reviews of the literature and the advice of an expert panel (Friend and Levy, 2001, 2002; Levy and Friend, 2000, 2001, 2002a,b; Levy et al., 2000a,b, 2001a,b, 2004). The policy effects (PEs) are calculated in percentage terms, i.e., PE = (post-policy rate – initial rate)/initial rate, with PE < 0, assuming an effective policy where the post-policy rate is less than the initial rate. For most policies, the greatest effect will occur in the first few years in which the policy is in effect, modeled as a permanent additive effect on smoking prevalence, i.e., $\text{Smokers}_{t,a} * (1 + \text{PPE}_{i,t,a})$ for policy i at time t, age a, with PPE defined as the prevalence of PE. If the policy is maintained, the effects of the policy are sustained throughout future years as: $\text{Initiation rate}_a * (1 + \text{IPE}_{i,a})$, with IPE defined as the initiation PE. The effect of a maintained policy increase in the cessation rate over time is given as: $\text{Cessation rate}_a * (1 - \text{CPE}_{i,t,a})$, with CPE defined as the cessation PE. SimSmoke projects smoking rates through 2014, based on policies that were implemented over the period 1964–2014. The effect sizes are shown in Table D-1.

Data on the levels of policies were input into the SimSmoke model for the years 1965 through 2012. We calibrated model cessation rates against data on smoking prevalence through 1985, leading to a reduction in those rates of 9 percent for females, 10 percent for males ages 55–64, and 20 percent for males of ages 65 and above. Table D-2 shows the sources and specifications for the data used in SimSmoke in this report.

TABLE D-1 Policy Inputs and Effect Sizes in SimSmoke

Policy	Description	Potential Percentage Effect[a]
Cigarette Taxes (Levy et al., 2000a)		
Cigarette price	The state level average price for a pack of cigarettes (including branded and generic), including state and federal excise taxes. Tobacco Institute (Orzechowski and Walker, 2012), adjusted for inflation using the consumer price index (www.bls.gov/cpi/home.htm)	For each 10% price increase: 6% reduction ages 15–17, 4% reduction ages 18–24, 2% reduction ages 25–34, and 1% reduction ages 35 and above
Smoke-free Air Laws (Levy et al., 2001b)		
Worksite ban, well-enforced	Smoking banned in all indoor worksites in all areas	6% reduction
Worksite restrictions, weak	Smoking in restricted areas only	2% reduction
Restaurant and bar ban, well-enforced	Ban in all indoor restaurants in all areas	2% reduction
Restaurant ban, weak	Smoking in restricted areas only	1% reduction
Other places bans	Ban in three of four (retail stores, arenas, public transportation, and elevators)	1% reduction
Enforcement and publicity	Compliance reflecting norms and publicity as tobacco control campaign variable	Effects reduced by as much as 50% if no compliance or publicity
Fairness Doctrine and Advertising Restrictions (Lewit et al., 1981; Warner, 1989; Warner and Murt, 1983)		
Existence of fairness doctrine	Airing of antismoking messages on radio and television from July 1, 1967, to January 1, 1971, and banning of cigarette advertising on radio in 1970 and television in 1971	39% reduction in initiation rates, 8% increase in cessation rates
Tobacco Control Campaigns (Levy and Friend, 2001)		
Well-funded campaign	Campaign expenditures meeting the pre-2009 CDC minimum recommended	6.5% reduction
Moderately funded campaign	Campaign expenditures meeting 50% of the pre-2009 minimum recommended	3.6% reduction
Low funded campaign	Campaign expenditures meeting <25% of the pre-2009 minimum recommended	1.2% reduction

TABLE D-1 Continued

Policy	Description	Potential Percentage Effect[a]
Health Warnings (Azagba and Sharaf, 2013; Hammond et al., 2007; Huang et al., 2014)		
Weak health warnings	Non-graphic warning covers less than one-third of the package. Reports, score = 2	1% reduction in prevalence and 2% increase in cessation only
Cessation Treatment Programs (Levy and Friend, 2002a; Levy et al., 2010b)		
Availability of NRT and Bupropion	If NRT is provided by either general store or pharmacy with Rx = 1 and = 2 If NRT is provided by general store or pharmacy (no Rx required). If Bupropion is provided by either general store or pharmacy with Rx = 1.	1% reduction if score of 3[b]
Provision of treatments	Types of facilities distinguished, specified as primary care facilities, hospitals, offices of health professionals. Community and other. MPOWER: 0 = None, Yes in some = 1, Yes in most = 2.	2.25% reduction if indicator = 2 for all facilities and program is well publicized[b]
Quit line	Operating active quit line	0.5% reduction[b]
Comprehensive cessation treatment	A proactive quit line with NRT, complete treatment coverage through insurance	~3% reduction in prevalence, and 20% increase in cessation[b]
Youth Access Restrictions (Levy et al., 2001a)		
Strongly enforced and publicized	Compliance checks are conducted 4 times per year per outlet, penalties are potent and enforced, and with heavy publicity and community involvement	20% reduction for those ages 16–17 and 30% reduction for those age <16[c]
Moderate enforcement	Compliance checks are conducted at least once per year per outlet, penalties are moderate, and with some publicity	10% reduction for those ages 16–17 and 15% reduction for those age <16[c]
Low enforcement	Compliance checks are conducted sporadically, penalties are weak, there is little merchant awareness and minimal community participation	2.5% reduction for those ages 16–17 and 4% reduction for those age <16[c]

[a] The effect sizes are shown relative to the absence of any policy. Unless otherwise specified, the same percentage effect is applied as a percentage reduction in the prevalence in the initial year and as a percentage reduction in initiation rate and a percentage increase in the cessation rate in future years, and is applied to all ages and both genders.
[b] Applied to prevalence and first year quit rates only.
[c] Applied to initiation and prevalence only.

TABLE D-2 Data Used in SimSmoke

Variable	Current Source	Current Specifications
I. Population model		
A. Population	1965–2065 Census and Census Projections and Projections by Ted Holford from 2066 through 2100	Breakdowns by age and gender
B. Mortality rates	1965–2065 Multiple Cause-of-Death File and Cancer Prevention Study I and II and the Nutrition Follow-up to CPS-II Projected U.S. mortality rates based on the Lee-Carter model (Sprague, 2009)	Breakdowns by age, gender, and smoking status (current, former, never)
II. Smoking model—initialized in 1965, with future changes in initiation and cessation rates due to policies through policy modules		
A. Baseline smoking rates for current and ex-smokers	1965 National Health Interview Survey (NHIS) for age 10+	100+ cigarettes lifetime, distinguished by current and former smokers. (<1, 1–2, 3–5, 6–10, 11–14, 15+ years) by age and gender
B. Initiation rates	1965 National Health Interview Survey (NHIS) for age 10+	Breakdowns by age and gender
C. First year cessation rates	1965 National Health Interview Survey (NHIS) for age 16+	Breakdowns by age and gender
D. Relapse rates	Previous studies (Gilpin et al., 1997; HHS, 1990; Hughes et al., 2008)	Breakdowns by age and gender
E. Excess death risks of smokers and ex-smokers	1965–2100 death rates by current, former, and never smokers as developed by CISNET (Holford et al., 2014b)	Breakdowns by age, gender, and smoking status
III. Policy modules—levels from 1965–2014		
A. Price and taxes	Orzechowski and Walker, (2013) www.bls.gov/cpi/home.htm	Prices and CPI for 1965–2014
B. Smoke-free air laws	www2.cdc.gov/nccdphp/osh/state/report_index.asp and www.impacteen.org	Different types of laws and their stringency and compliance rates
C. Media and other educational campaigns	CDC and tobaccofreekids.org	Expenditures per capita by state
D. Cessation treatment programs	MPOWER Reports (Levy et al., 2010b; WHO, 2008, 2013)	Indicators of when pharmacotherapies became available, cessation treatment locations and quitlines

TABLE D-2 Continued

Variable	Current Source	Current Specifications
E. Health warnings	HHS (2014)	Indicator of strength
F. Fairness doctrine	Warner (Warner, 1989; Warner and Murt, 1983)	Indicator of extent of implementation
G. Youth access enforcement	CDC, SAMHSA (Levy et al., 2001a)	Enforcement checks, penalties, community campaigns, self-service and vending machine bans

The percent changes in smoking prevalence from SimSmoke were validated against the percent change in NHIS rates for four age groups (18–24, 25–44, 45–64, 65+) over the period 1965–2012. By 2012 male adult smoking prevalence (18 and above) from both NHIS and SimSmoke showed a decline of 61 percent relative to the initial 1965 level. Female smoking prevalence from the NHIS declined 54 percent, compared with 53 percent from SimSmoke. Generally, SimSmoke predicted prevalence rates for females and males that were similar to the NHIS rates, except for underestimating the reduction for males between the late 1970s and late 1990s. By 2012 SimSmoke obtains estimates for male smoking prevalence by age group that are very similar to the NHIS estimates, but it underestimated rates during the 1980s and early 1990s. For females, SimSmoke predicted the relative decline in smoking prevalence by 2012 well for all age groups, except for the 65-and-above age group.

The effects of a change in the MLA are modeled through initiation rates beginning in 2015. The 2015 initiation rates used to predict the effects of the change in the MLA are those derived from SimSmoke based on the policy effects applied to changes in policy levels between 1965 through 2014. The initiation rates are constant from 2015 through 2100.

Estimating Smoking-Attributable Birth Outcomes[3]

SimSmoke considers three smoking-attributable adverse birth outcomes (SAABOs): sudden infant death syndrome (SIDS), low birth weight (LBW), and pre-term birth (PTB). To calculate the number of cases of modeled SAABO, we use the method employed in the Smoking-Attributable Mortality, Morbidity, and Economic Costs (SAMMEC) software (Melvin et al.,

[3] The methods and data regarding maternal and child health outcomes are presented in more detail than other outcomes for transparency, because they have not yet been published.

2000). SAFs, based on the attributable-fraction formula originally described by Levin (1953) and expanded upon by Lilienfeld (1980), are multiplied by the total number of events of each modeled outcome. Separate estimates are calculated for each year (t) by age group (a), i.e, for each outcome.

$$SAABO_{a,t} = \text{Number of Observed Events}_{a,t} \times SAF_{a,t}$$

Number of Observed Events represents the total observed adverse birth cases for a given outcome in the population, including those for both smoking and nonsmoking mothers. Measures of outcome prevalence are multiplied by the size of the corresponding population. In SimSmoke, the number of outcomes is available for each smoking outcome by age of the mother for SIDS, LBW, and PTB as well as for others aggregated over all maternal ages. SAFs are calculated using the smoking prevalence and relative risk of current maternal smokers aged 15–49, or some subset thereof. SAFs for each outcome by year (t) and age group (a) are derived using the following formula:

$SAF_{a,t} = [(1 - p_{a,t}) + p_{a,t} \times RR - 1] / [(1 - p_{a,t}) + p_{a,t} \times RR]$, where
p = percentage of pregnant women who are nonsmokers during pregnancy, and
RR = relative risk of outcome where maternal smokers relative to nonsmokers.

While the maternal smoking prevalence can vary by age and year in the above formulation, we assume that relative risks are constant over time and by age since past studies do not adequately distinguish by age. Summing across age categories for a particular year (t) provides the estimate of SAABO for each health outcome for that year.

Figure D-1 provides a flowchart of the estimation process for maternal and child health (MCH) outcomes.

Data

Adverse MCH outcomes For LBW and PTB, National Center for Health Statistics (NCHS) data on adverse MCH outcomes by age and gender for 2012 were obtained from CDC Wonder, the epidemiological database operated by the Centers for Disease Control and Prevention (CDC) (HHS et al., 2014b). For SIDS, data were obtained for all ages from CDC Wonder for 2011 (the most recent year) (HHS et al., 2014a), and the proportions by age group were based on overall infant mortality (Matthews and MacDorman, 2013). Because overall rates for each MCH outcome have been relatively constant in recent years, the percent of maternal outcomes in 2012 is maintained for all future years. The data by age are presented in Table D-3. LBW, PTB, and SIDS are highest at younger ages and for above

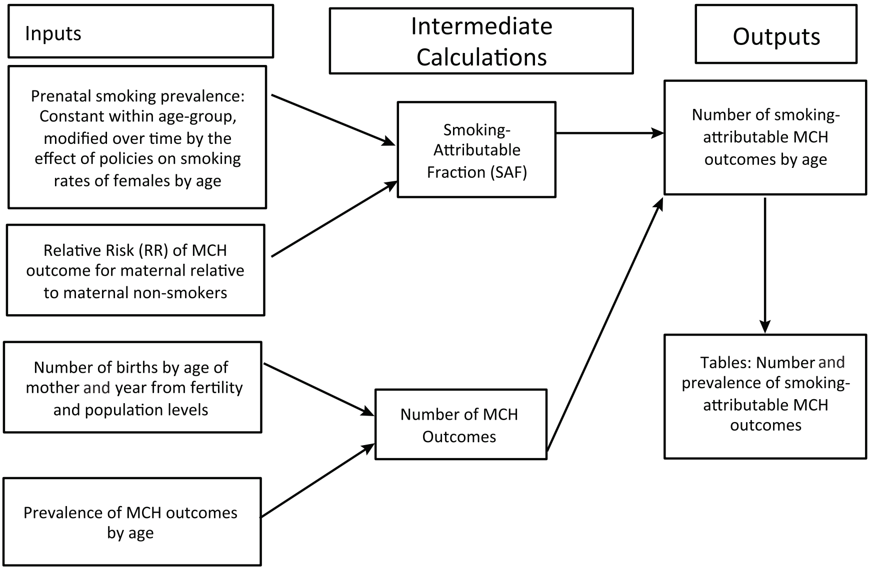


FIGURE D-1 Relationship of the components for each maternal and child health (MCH) outcome.

TABLE D-3 Gestational Age and Birth Weight, 2012

Age group	PTB, LBW	PTB NW	FTB, LBW	All PTB	All LBW	FTB, NW	Total
<15	8.8%	12.1%	3.7%	20.9%	12.5%	75.4%	3,657
15–19	7.3%	7.3%	3.5%	14.6%	10.8%	81.9%	309,849
20–24	5.1%	6.4%	3.2%	11.6%	8.3%	85.2%	904,623
25–29	5.4%	5.7%	2.5%	11.2%	7.9%	86.3%	1,130,250
30–34	5.1%	5.9%	2.4%	10.9%	7.5%	86.7%	1,011,765
35–39	6.0%	6.8%	2.6%	12.8%	8.6%	84.6%	471,499
40–44	8.3%	8.7%	3.4%	17.0%	11.7%	79.6%	103,127
45–49	14.0%	10.7%	5.1%	24.7%	19.1%	70.2%	7,122

NOTE: FTB = non-preterm; LBW = low birth weight; NW = normal weight; PTB = pre-term birth.

age 40. In addition, it should be noted that there is overlap between PTB and LBW, especially at younger ages. We assume that the rates are constant from 2012 onward, but the model is flexible enough to allow for trends in the prevalence of MCH outcomes over time.

The total number of adverse MCH outcomes over time depends on fertility rates. The fertility rates were obtained from the NCHS through CDC WONDER (U.S. Department of Health and Human Services for the year 2012 categorized by age of the mother) (HHS et al., 2014b). We use projected fertility rates by the United States (CDC, 2014; USCB, 2014) through 2060 to extrapolate for future years through 2100. The projections show fertility rates that are slowly decreasing over time, and it is assumed that rates after 2060 stay constant. Since the projected rates are not distinguished by age, the age distribution from 2012 is assumed to remain constant. The fertility rates are multiplied by the projected population used in the model (see above) to obtain the total number of births by age.

Relative risks to MCH The estimates of relative risks to MCH are based on reviews (Cnattingius, 2004; HHS, 2004) and recent studies (Aliyu et al., 2010, 2011; Anderka et al., 2010; Dietz et al., 2010; Steyn et al., 2006; van den Berg et al., 2013; Zhang and Wang, 2013) for each of the outcomes: PTB, LBW, and SIDS. We estimate a relative risk of 1.4 for PTBs, 2.0 for LBW and 2.5 for SIDS. We assumed the same relative risks for all women (ages 15 to 49) and for all years. In addition, we do not distinguish risks by smoking intensity or by the month of quitting if the women stopped smoking at some point during pregnancy. The relative risks used to estimate MCH outcomes are shown in Table D-4.

Maternal smoking prevalence Data were developed based on women reporting smoking while pregnant. Data on the prevalence of pregnant women for the United States were obtained from NCHS for 2012 disaggregated by age-group (15–19, 20–24, . . . , 40–44, 45–49) (HHS et al., 2014b). These data are based on birth certificates and now cover most of the states. Many states were excluded after the 2003 revision in how

TABLE D-4 Relative Risks Used in Estimating Maternal and Child Health Outcomes in SimSmoke

MCH Outcome	Best Estimate	Lower Bound	Upper Bound
Pre-term Birth (PTB)	1.4	1.1	1.7
Low Birth Weight (LBW)	2.0	1.5	2.5
Sudden Infant Death Syndrome (SIDS)	2.5	1.4	4.0

tobacco was reported because they did not adopt the 2003 revision, but by 2012 only 13 states (Alabama, Alaska, Arizona, Arkansas, Connecticut, Hawaii, Maine, Michigan, Mississippi, New Jersey, Rhode Island, Virginia, and West Virginia) were excluded. We confined the analysis to the year 2012, when most states' reports had adopted the 2003 revisions, and project forward from that year. The data are shown in Table D-5.

After comparing the prenatal smoking rates from NCHS to estimates from the Pregnancy Risk Assessment Monitoring System (PRAMS) and the National Survey on Drug Use and Health (NSDUH) for 2011, the most recent year for which data from all three datasets are available, we found the rates from NCHS (9.0 percent) were lower than from PRAMS (10.5 percent) and NSDUH (15.9 percent). The NCHS data and also the PRAMS data are known to consistently underestimate smoking rates because of underreporting. For example, Tong et al. (2013) analyzed the PRAMS 2008 questionnaire and the eight states that also used the 2003 BC revision. Using the same age stratification, the 20–24 age group again had the highest prevalence in both the BC and PRAMS prevalence, but the combined prevalence for the <20 age group had a slightly higher prevalence (22.6 percent compared to 22.5 percent). Tong and colleagues also found that the NCHS data understated smoking prevalence compared to the combined estimates by 65 per-

TABLE D-5 Tobacco Use by Pregnant Women by Age of Mother, Data from NCHS

Age Group	2012								
	<15	15–19	20–24	25–29	30–34	35–39	40–44	45–49	Total
Total births*	3.0	254.4	761.8	939.5	846.6	395.7	91.8	6.1	3,298.8
% tobacco use	2.8%	10.9%	13.5%	8.9%	5.6%	4.3%	4.2%	2.6%	8.6%
% not stated	2.6%	2.0%	2.0%	1.7%	1.6%	1.7%	1.8%	2.2%	1.7%
% births, tobacco use not reported	17.1%	16.7%	16.9%	16.4%	16.5%	16.2%	16.2%	15.4%	16.5%

* In thousands; "total births" limited to births in those states for which tobacco use is reported. Births in states that used incompatible birth certificates version are omitted from the "total births." "% births, tobacco use not reported" is the percentage of all births from all states for that year.

cent for the <20 age group (13.7 percent in NCHS versus. 22.6 percent combined), by 35 percent for the 20–24 age group (16.7 percent in NCHS versus. 22.5 percent combined), by 27 percent for the 25–29 age group (13.2 percent NCHS versus. 16.7 percent combined) and by 30 percent for the 30 and above group (6 percent NCHS versus. 7.8 percent combined). We applied these correction factors to the NCHS data.

We calibrated the 2012 smoking prevalence from SimSmoke to the adjusted NCHS maternal smoking prevalence by determining adjustment factors that equilibrated the smoking prevalence to the adjusted maternal prevalence by 5-year age groups (15–19, 20–24, . . . , 45–49). In SimSmoke, estimates of prenatal smoking prevalence may change as a result of policies through changes in prevalence, initiation or cessation rates (see above). For changes in the MLA, the changes only take place through the initiation rate.

Detailed Results for the MLA from SimSmoke

The status quo policy level for smoking rates among female adults (age 18 and above) is predicted to decline from 15 percent in 2015 to 10.8 percent in 2065 and then to remain steady at that rate. The prevalence shows little fluctuation throughout the years for females in age group 15–17, with only small reductions for those ages 18–20 and 21–24.

The results for changes in the MLA are based on best estimates of their effects with the lower and upper plausible ranges in parentheses. The relative percentage reductions in smoking rates for each age group increase with the MLA. For example, by implementing the new MLA in 2015, the smoking prevalence of adult (ages 18 and above) females in the year 2010 is projected to fall relative to the status quo by 3.1 percent (range 2.2 to 4.1 percent) under an MLA of 19, 11.6 percent (range 9.4 to 14.2 percent) under MLA 21, and 16.5 percent (range 11.7 to 23.2 percent) under MLA 25. Due to the assumption of a 2-year initiation rebound for MLA 19 and MLA 21, slight increases in smoking prevalence and MCH outcomes for the age of the MLA and the next age are predicted in the early years.

LBW Under the status quo, in 2015 the incidence rate of smoking-attributable LBW babies is about 0.8 percent among the total births for all the women of childbearing age (ages 14–49), but 1.3 percent for the ages 20–24 years. The rates decrease after 2015, except for the maternal age group 15–19, in which the rate increases to 1.6 percent in 2100 due to the sustained growth of the fertility rate. For all women of childbearing age, an estimated 3.8 million LBW infants are projected to be born between 2015 and 2100 because of the mother's prenatal smoking.

By raising the MLA to 19, SimSmoke estimates that there will be a cumulative total of 2,000 LBW outcomes averted (range 1,200–2,800) in the first 5 years (2015–2020), 60,700 (range 44,600–79,000) within 50 years, and 122,800 (range 90,700–159,200) within 85 years. If the MLA is increased to 21, the number of averted cases each year will be more than twice as high as for MLA 19. For all women of childbearing age, an MLA of 21 is predicted to avert about 217,900 LBW cases (range 176,700–267,000) from 2015 to 2065 and about 435,100 cases (range 353,500–532,600) between 2015 and 2100. Increasing the MLA to 25 is predicted to avert a total of 593,000 LBW cases averted (range 419,100–842,800) within 85 years.

PTB Under the status quo, the smoking-attributable PTB incidence rate for mothers of age 15–19 increases slightly, from 0.94 percent in 2015 to 0.95 percent in 2100, while the rates for other age groups all show slight declines. For all women of childbearing age, the incidence rate is 0.51 percent in 2015, decreasing to 0.49 percent by 2100. Because of escalating birth rates, however, the number of smoking-attributable PTBs is estimated to increase from 20,800 in 2015 to 28,200 in 2065 and 33,500 in 2100. A total of about 2,307,000 smoking-attributable PTBs are predicted between 2015 and 2100.

An MLA of 19 is estimated to prevent a total of 1,300 smoking-attributable PTBs (range 810–1,880) for all women of childbearing age compared to the status quo level over the first 5 years, an additional 39,000 (range 29,500–52,000) within 50 years, and a total of 81,000 (range 60,000–105,000) for the entire span from 2015 to 2100. By increasing the MLA to 21, the number of averted cases is predicted to be more than two times higher than for an MLA of 19 for the age group 15–19 and more than three times higher for age groups 20–24, 25–34, and 35–49. For all women, MLA 21 is predicted to prevent a total of about 142,000 PTB cases (range 116,000–174,000) by 2065 and 283,300 cases (range 231,000–346,000) by 2100. Increasing the MLA to 25 is predicted to prevent a total of 385,000 PTBs (range 273,000–543,000) between 2015 and 2100.

SIDS Under the status quo policy, the incidence rate of smoking-attributable SIDS for the maternal age group 15–49 is 0.008 percent in 2015. Since birth rates are projected to increase, the estimated smoking-attributable SIDS cases will slightly increase over time. From 2015 to 2100, the total number of annual SIDS cases will increase by about 200 (from 320 to 520), with a total of 35,600 smoking-attributable deaths over that period.

Over the period from 2015 to 2100, SimSmoke predicts a total of 1,100 (range 832–1,455) SIDS deaths would be averted by raising the MLA to 19; a total of 3,980 (range 3,200–4,900) deaths would be averted (range 3,200–4,900) under MLA 21; and 5,400 (range 3,800–7,700) deaths would be averted under MLA 25.

In summary, raising the MLA to 19, 21, or 25 is projected to have an increasingly larger impact on LBW, PTB, and SIDS, especially in raising the MLA to 21. Between 2015 and 2100, about 122,800 LBW cases, 80,900 PTBs, and 1,100 SIDS cases are projected to be averted under MLA 19; this would increase to 435,100 LBW cases, 283,300 PTBs, and 3,980 SIDS cases under MLA 21; and it would become 593,000 LBW cases, 384,600 PTBs, and 5,400 SIDS cases under MLA 25. Thus, about three times more cases would be averted under MLA 21 than MLA 19, and about 1.35 times more cases would be prevented under MLA 25 than MLA 21.

In applying SimSmoke to estimate adverse birth outcomes, five limitations merit consideration: (1) The analysis does not distinguish the overlap in diagnosis between LBW babies and PTBs. Consequently, the sum of the two outcomes is an overstatement. (2) The analysis does not specifically incorporate the time quit or the amount of cigarettes smoked by those who continue smoking while pregnant. The analyses can be extended to consider these factors as well as to allow for age-specific variations in relative risks as better information becomes available. (3) In examining maternal smoking over time, important differences in smoking behaviors by socioeconomic status were not considered. (4) The under-diagnosis and underreporting of adverse MCH outcomes merit further consideration as they apply to estimating smoking-attributable risks. (5) The model does not directly incorporate changes in policies that target pregnant smokers such as smoking cessation and other health care–related programs.

RESULTS FROM UPPER AND LOWER SCENARIOS FOR INITIATION RATE ASSUMPTIONS FOR DIFFERENT MLA POLICY OPTIONS

We present smoking prevalence, mortality, and health outcome projections from both models under the upper and lower initiation scenarios. Corresponding figures and tables for the mid-initiation scenario are shown in Chapter 8. Figures D-2 through D-5 show projections of smoking prevalence from 2015 to 2100. Tables D-6 through D-9 show premature deaths prevented for selected years for both models. Tables D-10 through D-13 show projected years of life lost for the CISNET model. Figures D-6 and D-7 show projected cumulative lung cancer deaths prevented according to the CISNET model.

ADDITIONAL MODEL OUTPUTS

In this section we present additional outcomes from the CISNET model. Figures D-8 and D-9 show projections of premature deaths due to smoking from 2000 to 2100 by gender for all initiation scenarios. The figures also

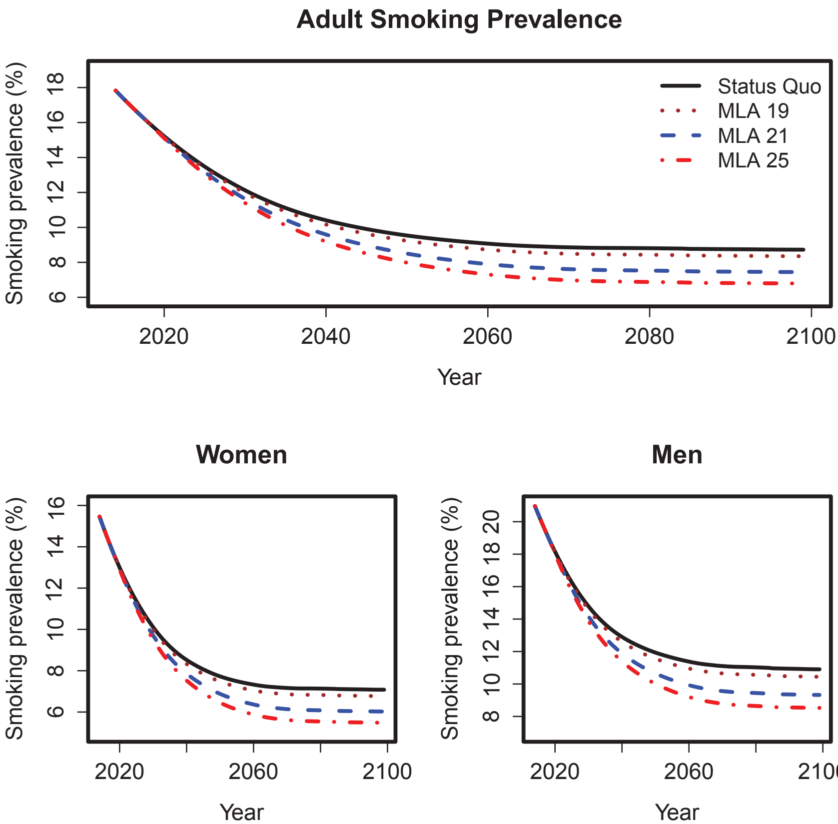


FIGURE D-2 CISNET model–projected smoking prevalence for the upper scenarios of the three MLA policy options for adults (18+), adult women, and adult men in the United States for 2014–2100.

show projections under an idealized scenario where all smoking initiation stops in 2015 (Ideal).

Figures D-10 and D-11 show projected mean-pack years for adults ages 40 or older for all initiation scenarios.

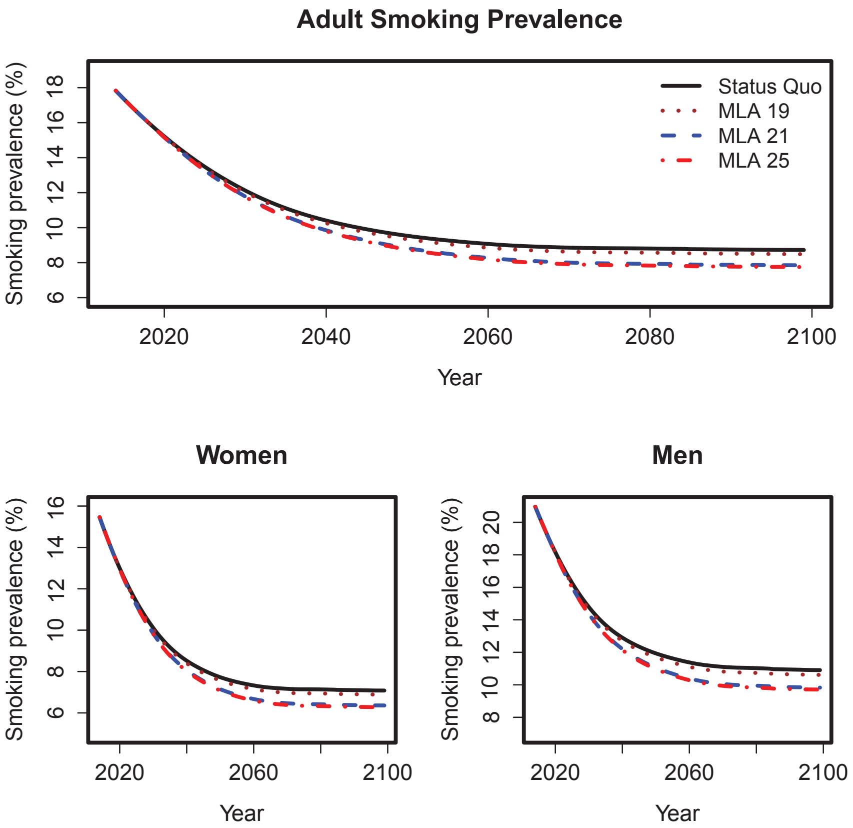


FIGURE D-3 CISNET model–projected smoking prevalence for the lower scenarios of the three MLA policy options for adults (18+), adult women, and adult men in the United States for 2014–2100.

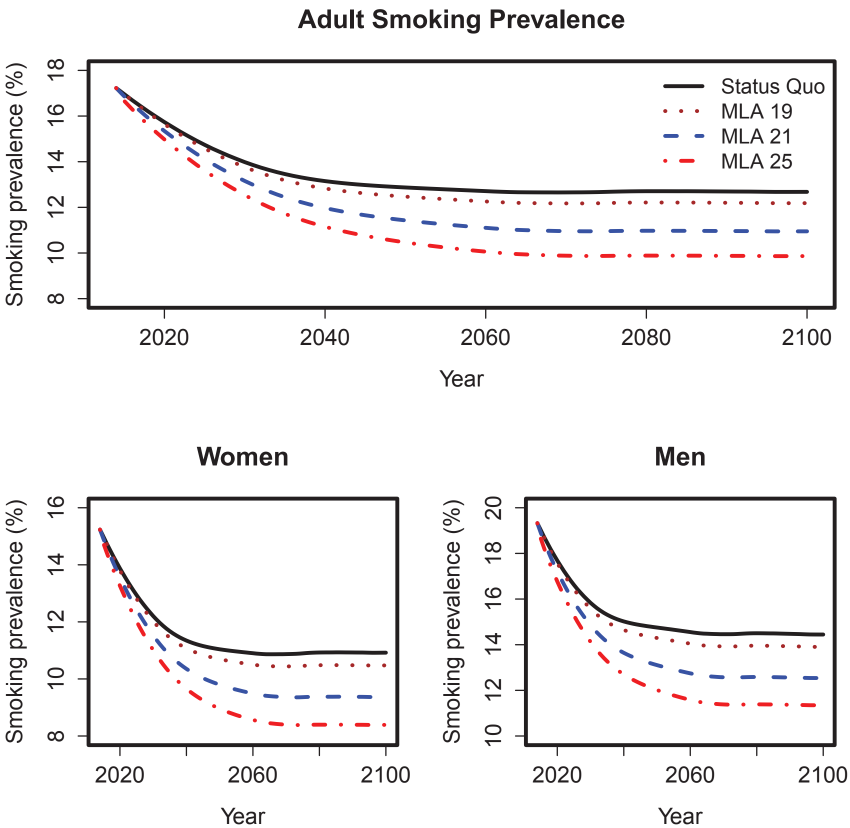


FIGURE D-4 SimSmoke model–projected smoking prevalence for the upper scenarios of the three MLA policy options for adults (18+), adult women, and adult men in the United States for 2014–2100.

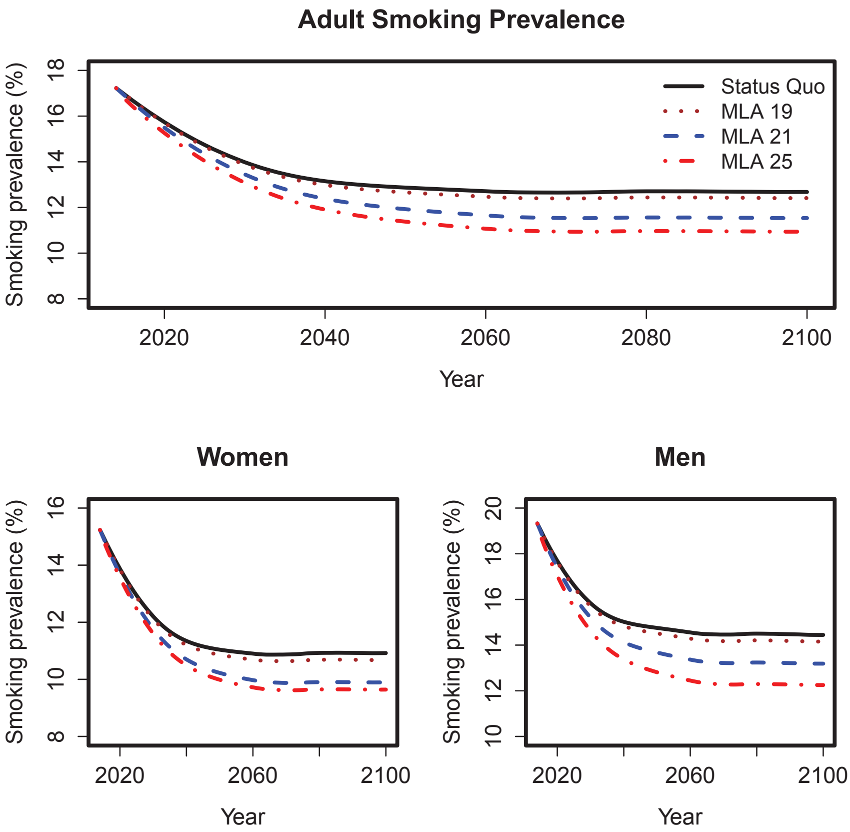


FIGURE D-5 SimSmoke model–projected smoking prevalence for the lower scenarios of the three MLA policy options for adults (18+), adult women, and adult men in the United States for 2014–2100.

TABLE D-6 Cumulative Premature Deaths Expected and Prevented by Period: CISNET Upper Scenarios

MLA/Outcome	2020–2039	2040–2059	2060–2079	2080–2099	2015–2100
Status Quo					
Premature deaths expected	6,782,000	4,568,000	2,927,000	1,996,000	18,978,000
MLA 19					
Deaths prevented	—	4,000	26,000	57,000	87,000
Percentage reduction	0.0%	0.1%	0.9%	2.9%	0.5%
MLA 21					
Deaths prevented	—	13,000	91,000	199,000	304,000
Percentage reduction	0.0%	0.3%	3.1%	10.0%	1.6%
MLA 25					
Deaths prevented	—	20,000	140,000	306,000	465,000
Percentage reduction	0.0%	0.4%	4.8%	15.3%	2.4%

NOTE: Assumes upper scenarios and that the policy is implemented in 2015. Although the table carries many significant figures to aid in reproducibility, precision is limited to one or two digits.

TABLE D-7 Cumulative Premature Deaths Expected and Prevented by Period: CISNET Lower Scenarios

MLA/Outcome	2020–2039	2040–2059	2060–2079	2080–2099	2015–2100
Status Quo					
Premature deaths expected	6,782,000	4,568,000	2,927,000	1,996,000	18,978,000
MLA 19					
Deaths prevented	—	2,000	16,000	36,000	55,000
Percentage reduction	0.0%	0.0%	0.5%	1.8%	0.2%
MLA 21					
Deaths prevented	—	9,000	62,000	136,000	207,000
Percentage reduction	0.0%	0.2%	2.1%	6.8%	1.1%
MLA 25					
Deaths prevented	—	10,000	70,000	154,000	234,000
Percentage reduction	0.0%	0.2%	2.4%	7.7%	1.2%

NOTE: Assumes lower scenarios and that the policy is implemented in 2015. Although the table carries many significant figures to aid in reproducibility, precision is limited to one or two digits.

TABLE D-8 Cumulative Premature Deaths Expected and Prevented by Period: SimSmoke Upper Scenarios

MLA/Outcome	2020–2039	2040–2059	2060–2079	2080–2099	2015–2100
Status Quo					
Premature deaths expected	8,108,000	6,393,000	4,963,000	4,277,000	26,840,000
MLA 19					
Deaths prevented	—	14,000	71,000	142,000	226,000
Percentage reduction	0.0%	0.2%	1.4%	3.3%	0.8%
MLA 21					
Deaths prevented	1,000	65,000	285,000	521,000	873,000
Percentage reduction	0.0%	1.0%	5.7%	12.2%	3.3%
MLA 25					
Deaths prevented	5,000	139,000	528,000	873,000	1,546,000
Percentage reduction	0.1%	2.2%	10.6%	20.4%	5.8%

NOTE: Assumes upper scenarios and that the policy is implemented in 2015. Although the table carries many significant figures to aid in reproducibility, precision is limited to one or two digits.

TABLE D-9 Cumulative Premature Deaths Expected and Prevented by Period: SimSmoke Lower Scenarios

MLA/Outcome	2020–2039	2040–2059	2060–2079	2080–2099	2015–2100
Status Quo					
Premature deaths expected	8,108,000	6,393,000	4,963,000	4,277,000	26,840,000
MLA 19					
Deaths prevented	—	5,000	32,000	73,000	109,000
Percentage reduction	0.0%	0.1%	0.6%	1.7%	0.4%
MLA 21					
Deaths prevented	—	39,000	180,000	341,000	561,000
Percentage reduction	0.0%	0.6%	3.6%	8.0%	2.1%
MLA 25					
Deaths prevented	4,000	92,000	339,000	550,000	985,000
Percentage reduction	0.0%	1.4%	6.8%	12.9%	3.7%

NOTE: Assumes lower scenarios and that the policy is implemented in 2015. Although the table carries many significant figures to aid in reproducibility, precision is limited to one or two digits.

TABLE D-10 Years of Life Lost (YLL) by Period: CISNET Model, Upper Scenario

	Status Quo	YLL Under MLA 19 Upper Scenario	MLA 19 % Reduction	YLL Under MLA 21 Upper Scenario	MLA 21 % Reduction	YLL Under MLA 25 Upper Scenario	MLA 25 % Reduction
2000–2019	134,823,000	—	0.0%	—	0.0%	—	0.0%
2020–2039	106,126,000	—	0.0%	—	0.0%	—	0.0%
2040–2059	68,217,000	128,000	0.2%	429,000	0.6%	662,000	1.0%
2060–2079	46,490,000	7,212,000	1.6%	2,416,000	5.2%	3,731,000	8.0%
2080–2099	36,688,000	1,240,000	3.4%	4,152,000	11.3%	6,416,000	17.5%

NOTE: Although the table carries many significant figures to aid in reproducibility, precision is limited to one or two digits.

TABLE D-11 Lifetime Years of Life Lost (YLL) by Cohort: CISNET Model, Upper Scenario

	Status Quo	YLL Under MLA 19 Upper Scenario	MLA 19 % Reduction	YLL Under MLA 21 Upper Scenario	MLA 21 % Reduction	YLL Under MLA 25 Upper Scenario	MLA 25 % Reduction
2000–2019	40,116,000	1,518,000	3.8%	5,082,000	12.7%	7,855,000	19.6%
2020–2039	36,447,000	1,459,000	4.0%	4,884,000	13.4%	7,547,000	20.7%
2040–2059	36,084,000	1,445,000	4.0%	4,837,000	13.4%	7,475,000	20.7%
2060–2079	37,412,000	1,498,000	4.0%	5,015,000	13.4%	7,750,000	20.7%
2080–2099	38,874,000	1,557,000	4.0%	5,211,000	13.4%	8,053,000	20.7%

NOTE: Although the table carries many significant figures to aid in reproducibility, precision is limited to one or two digits.

TABLE D-12 Years of Life Lost (YLL) by Period: CISNET Model, Lower Scenario

	Status Quo	YLL Under MLA 19 Lower Scenario	MLA 19 % Reduction	YLL Under MLA 21 Lower Scenario	MLA 21 % Reduction	YLL Under MLA 25 Lower Scenario	MLA 25 % Reduction
2000–2019	134,823,000	—	0.0%	—	0.0%	—	0.0%
2020–2039	106,126,000	—	0.0%	—	0.0%	—	0.0%
2040–2059	68,217,000	83,000	0.1%	292,000	0.4%	333,000	0.5%
2060–2079	46,490,000	467,000	1.0%	1,645,000	3.5%	1,875,000	4.0%
2080–2099	36,688,000	803,000	2.2%	2,827,000	7.7%	3,224,000	8.8%

NOTE: Although the table carries many significant figures to aid in reproducibility, precision is limited to one or two digits.

TABLE D-13 Lifetime Years of Life Lost (YLL) by Cohort: CISNET Model, Lower Scenario

	Status Quo	YLL Under MLA 19 Lower Scenario	MLA 19 % Reduction	YLL Under MLA 21 Lower Scenario	MLA 21 % Reduction	YLL Under MLA 25 Lower Scenario	MLA 25 % Reduction
2000–2019	40,116,000	982,000	2.4%	3,459,000	8.6%	3,946,000	9.8%
2020–2039	36,447,000	944,000	2.6%	3,324,000	9.1%	3,792,000	10.4%
2040–2059	36,084,000	935,000	2.6%	3,292,000	9.1%	3,755,000	10.4%
2060–2079	37,412,000	970,000	2.6%	3,414,000	9.1%	3,894,000	10.4%
2080–2099	38,874,000	1,007,000	2.6%	3,547,000	9.1%	4,046,000	10.4%

NOTE: Although the table carries many significant figures to aid in reproducibility, precision is limited to one or two digits.

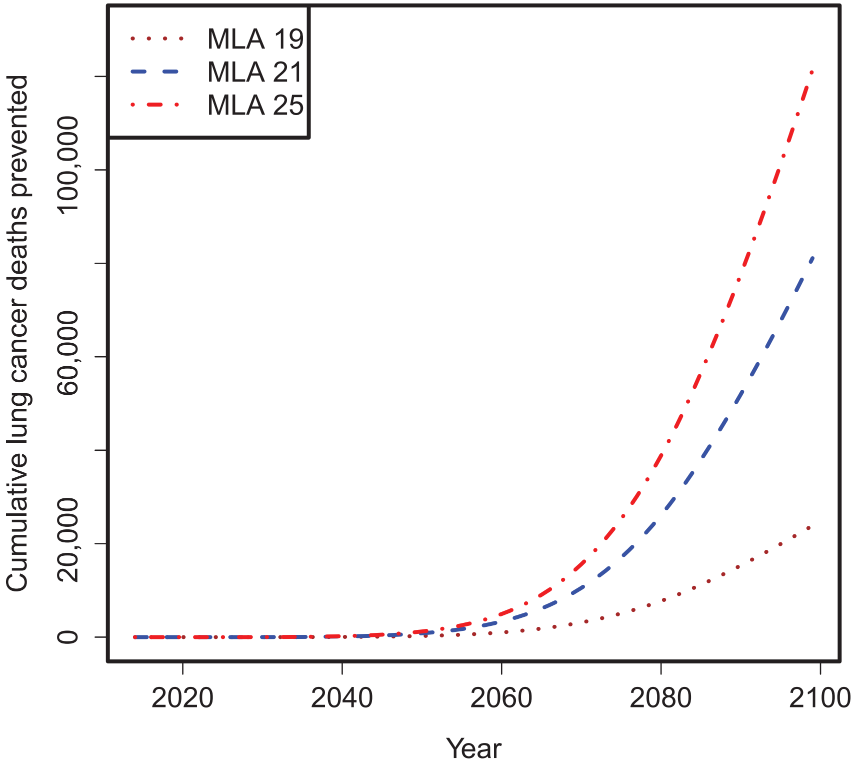


FIGURE D-6 CISNET model–estimated number of cumulative lung cancer deaths prevented per year for the three MLA policy options: Upper scenarios.

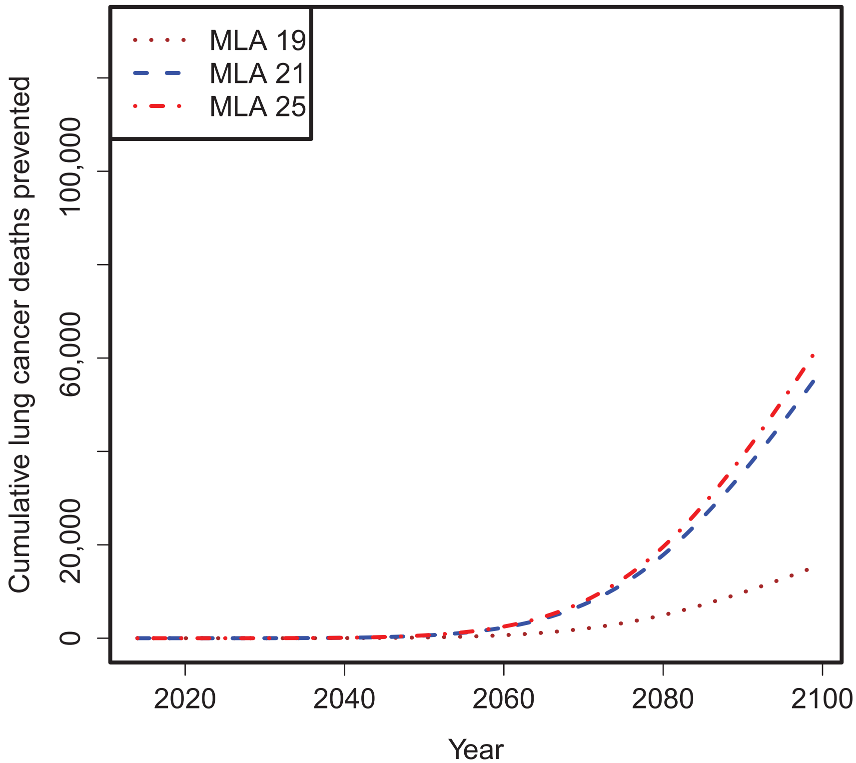


FIGURE D-7 CISNET model–estimated number of cumulative lung cancer deaths prevented per year for the three MLA policy options: Lower scenarios.

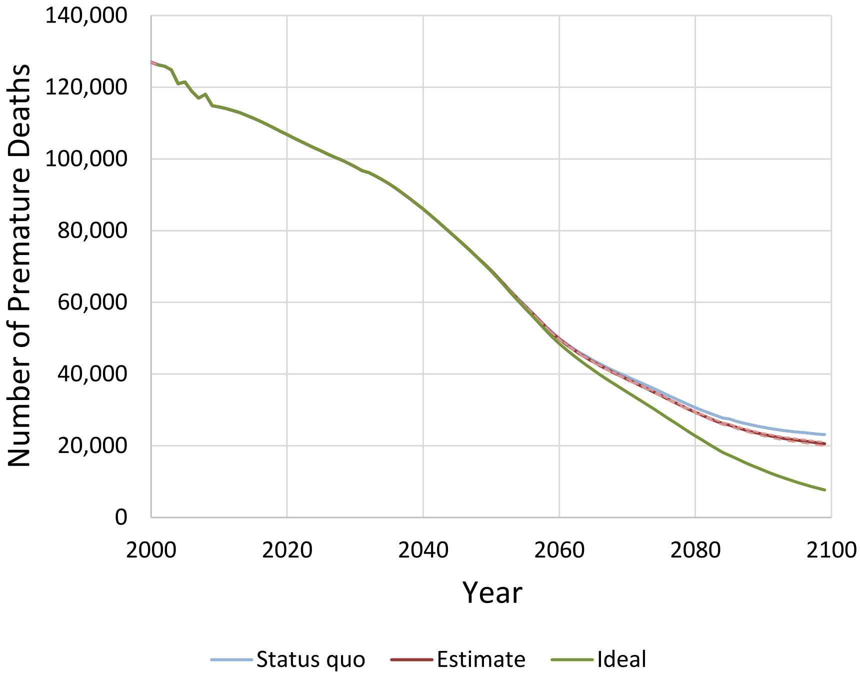


FIGURE D-8 CISNET model–projected number of female deaths prevented per year for MLA 21. Ideal represents a scenario where no smoking initiation occurs after 2015.

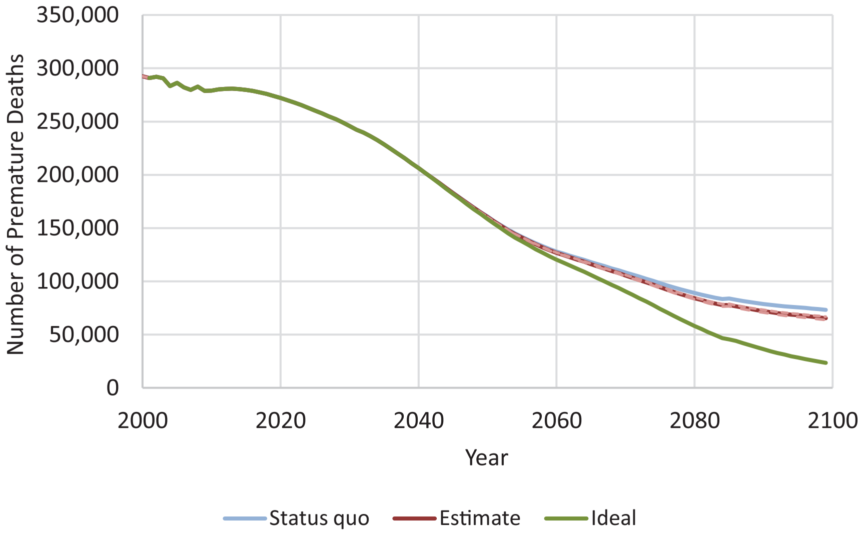


FIGURE D-9 CISNET model–projected number of male deaths prevented per year for MLA 21. Ideal represents a scenario where no smoking initiation occurs after 2015.

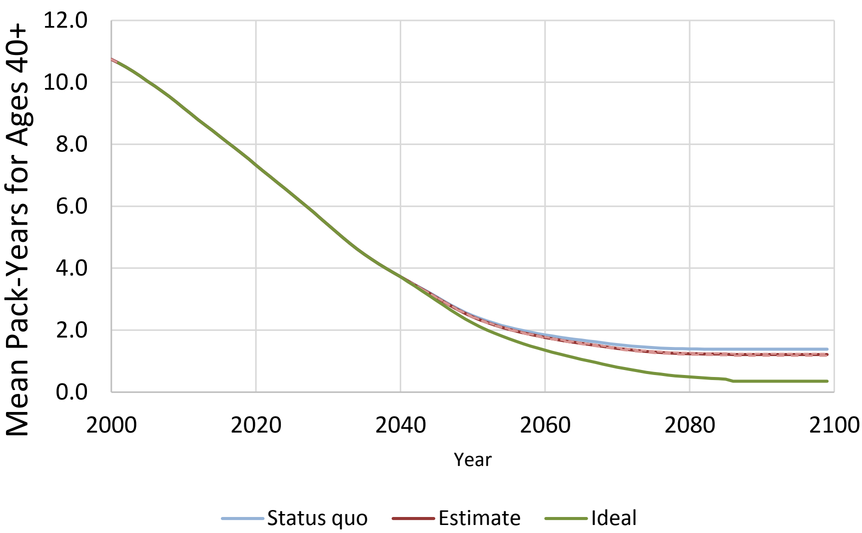


FIGURE D-10 CISNET model–projected mean smoking pack-years for women age 40 or older for MLA 21.

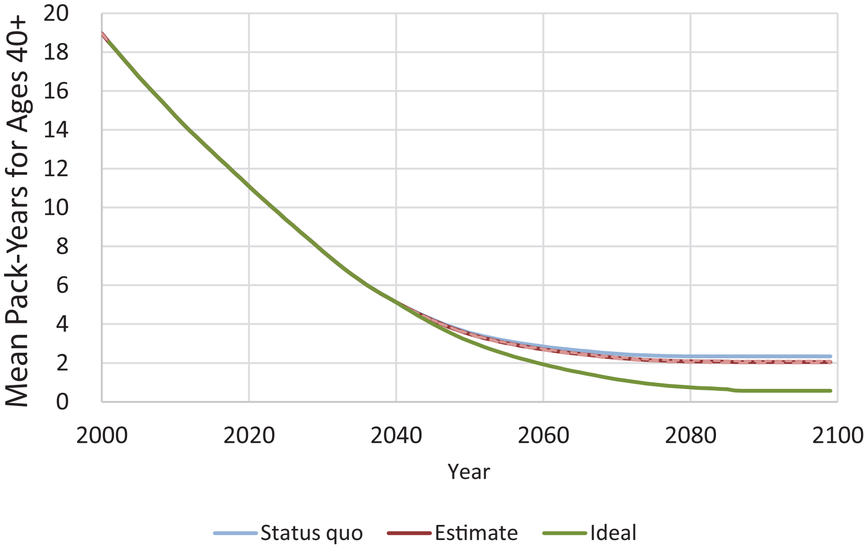


FIGURE D-11 CISNET model–projected mean smoking pack-years for men age 40 or older for MLA 21.

REFERENCES

Aliyu, M. H., O. Lynch, R. Saidu, A. P. Alio, P. J. Marty, and H. M. Salihu. 2010. Intrauterine exposure to tobacco and risk of medically indicated and spontaneous preterm birth. *American Journal of Perinatology* 27(5):405–410.

Aliyu, M. H., O. Lynch, R. E. Wilson, A. P. Alio, S. Kristensen, P. J. Marty, V. E. Whiteman, and H. M. Salihu. 2011. Association between tobacco use in pregnancy and placenta-associated syndromes: A population-based study. *Archives of Gynecology and Obstetrics* 283(4):729–734.

Anderka, M., P. A. Romitti, L. Sun, C. Druschel, S. Carmichael, G. Shaw, and National Birth Defects Prevention Study. 2010. Patterns of tobacco exposure before and during pregnancy. *Acta Obstetricia et Gynecologica Scandinavica* 89(4):505–514.

Anderson, C. M., D. M. Burns, K. W. Dodd, and E. J. Feuer. 2012. Chapter 2: Birth-cohort-specific estimates of smoking behaviors for the U.S. population. *Risk Analysis* 32(Suppl 1):S14–S24.

Azagba, S., and M. F. Sharaf. 2013. The effect of graphic cigarette warning labels on smoking behavior: Evidence from the Canadian experience. *Nicotine & Tobacco Research* 15(3):708–717.

Burns, D., L. Garfinkel, and J. Samet (eds.). 1997. *Changes in cigarette-related disease risks and their implication for prevention and control*. Bethesda, MD: National Cancer Institute.

CDC (Centers for Disease Control and Prevention). 2014. CDC WONDER. http://wonder.cdc.gov (accessed January 16, 2015).

Cnattingius, S. 2004. The epidemiology of smoking during pregnancy: Smoking prevalence, maternal characteristics, and pregnancy outcomes. *Nicotine & Tobacco Research* 6(Suppl 2):S125–S140.

de Koning, H. J., R. Meza, S. K. Plevritis, K. ten Haaf, V. N. Munshi, J. Jeon, S. A. Erdogan, C. Y. Kong, S. S. Han, J. van Rosmalen, S. E. Choi, P. F. Pinsky, A. Berrington de Gonzalez, C. D. Berg, W. C. Black, M. C. Tammemagi, W. D. Hazelton, E. J. Feuer, and P. M. McMahon. 2014. Benefits and harms of computed tomography lung cancer screening strategies: A comparative modeling study for the U.S. Preventive Services Task Force. *Annals of Internal Medicine* 160(5):311–320.

Dietz, P. M., L. J. England, C. K. Shapiro-Mendoza, V. T. Tong, S. L. Farr, and W. M. Callaghan. 2010. Infant morbidity and mortality attributable to prenatal smoking in the U.S. *American Journal of Preventive Medicine* 39(1):45–52.

Friend, K., and D. T. Levy. 2001. Smoking treatment interventions and policies to promote their use: A critical review. *Nicotine & Tobacco Research* 3(4):299–310.

———. 2002. Reductions in smoking prevalence and cigarette consumption associated with mass-media campaigns. *Health Education Research* 17(1):85–98.

Gilpin, E. A., J. P. Pierce, and A. J. Farkas. 1997. Duration of smoking abstinence and success in quitting. *Journal of the National Cancer Institute* 89(8):572–576.

Hammond, D., G. T. Fong, R. Borland, K. M. Cummings, A. McNeill, and P. Driezen. 2007. Text and graphic warnings on cigarette packages: Findings from the International Tobacco Control Four Country Study. *American Journal of Preventive Medicine* 32(3):202–209.

Hazelton, W. D., J. Jeon, R. Meza, and S. H. Moolgavkar. 2012. Chapter 8: The FHCRC lung cancer model. *Risk Analysis* 32(Suppl 1):S99–S116.

HHS (Department of Health and Human Services). 1990. *The health benefits of smoking cessation: A report of the Surgeon General*. Atlanta Georgia: U.S. Department of Health and Human Services, Public Health Service, Centers for Disease Control, Office on Smoking and Health.

———. 2004. *The health consequences of smoking: A report of the Surgeon General.* Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

———. 2014. *The health consequences of smoking—50 years of progress: A report of the Surgeon General.* Atlanta, GA: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health.

HHS, CDC, NCHS, and DVS (Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Health Statistics, and Department of Vital Statistics). 2014a. CDC WONDER: Linked birth/infant death records for 2011. http://wonder.cdc.gov/lbd.html (accessed February 25, 2015).

———. 2014b. CDC WONDER: Natality public-use data for 2012. http://wonder.cdc.gov/natality-current.html (accessed February 25, 2015).

Holford, T. R., and L. Clark. 2012. Chapter 4: Development of the counterfactual smoking histories used to assess the effects of tobacco control. *Risk Analysis* 32(Suppl 1):S39–S50.

Holford, T. R., D. T. Levy, L. A. McKay, L. Clarke, B. Racine, R. Meza, S. Land, J. Jeon, and E. J. Feuer. 2014a. Patterns of birth cohort-specific smoking histories, 1965–2009. *American Journal of Preventive Medicine* 46(2):e31–e37.

Holford, T. R., R. Meza, K. E. Warner, C. Meernik, J. Jeon, S. H. Moolgavkar, and D. T. Levy. 2014b. Tobacco control and the reduction in smoking-related premature deaths in the United States, 1964–2012. *JAMA* 311(2):164–171.

Huang, J., F. J. Chaloupka, and G. T. Fong. 2014. Cigarette graphic warning labels and smoking prevalence in Canada: A critical examination and reformulation of the FDA regulatory impact analysis. *Tobacco Control* 23(Suppl 1):i7–i12.

Hughes, J. R., E. N. Peters, and S. Naud. 2008. Relapse to smoking after 1 year of abstinence: A meta-analysis. *Addictive Behaviors* 33(12):1516–1520.

Jeon, J., R. Meza, M. Krapcho, L. D. Clarke, J. Byrne, and D. T. Levy. 2012. Chapter 5: Actual and counterfactual smoking prevalence rates in the U.S. population via microsimulation. *Risk Analysis* 32(Suppl 1):S51–S68.

Levin, M. 1953. The occurrence of lung cancer in man. *Acta Unio Internationalis Contra Cancrum* 9(3):531–541.

Levy, D. T., and K. B. Friend. 2000. A simulation model of tobacco youth access policies. *Journal of Health Politics, Policy and Law* 25(6):1023–1050.

———. 2001. A computer simulation model of mass media interventions directed at tobacco use. *Preventive Medicine* 32(3):284–294.

———. 2002a. Examining the effects of tobacco treatment policies on smoking rates and smoking related deaths using the SimSmoke computer simulation model. *Tobacco Control* 11(1):47–54.

———. 2002b. A simulation model of policies directed at treating tobacco use and dependence. *Medical Decision Making* 22(1):6–17.

Levy, D. T., K. M. Cummings, and A. Hyland. 2000a. Increasing taxes as a strategy to reduce cigarette use and deaths: Results of a simulation model. *Preventive Medicine* 31(3):279–286.

———. 2000b. A simulation of the effects of youth initiation policies on overall cigarette use. *American Journal of Public Health* 90(8):1311–1314.

Levy, D. T., K. B. Friend, H. Holder, and M. Carmona. 2001a. Effect of policies directed at youth access to smoking: Results from the SimSmoke computer simulation model. *Tobacco Control* 10(2):108–116.

Levy, D. T., K. B. Friend, and E. Polishchuk. 2001b. Effect of clean indoor air laws on smokers: The clean air module of the SimSmoke computer simulation model. *Tobacco Control* 10(4):345–351.

Levy, D. T., F. Chaloupka, and J. G. Gitchell. 2004. The effects of tobacco control policies on smoking rates: A tobacco control scorecard. *Journal of Public Health Management and Practice* 10(4):338–353.

Levy, D. T., N. Nikolayev, and E. A. Mumford. 2005. Recent trends in smoking and the role of public policies: Results from the SimSmoke tobacco control policy simulation model. *Addiction* 10(10):1526–1537.

Levy, D. T., A. Hyland, C. Higbee, L. Remer, and C. Compton. 2007. The role of public policies in reducing smoking prevalence in California: Results from the California tobacco policy simulation model. *Health Policy* 82(2):167–185.

Levy, D. T., C. Tworek, E. J. Hahn, and R. E. Davis. 2008. The Kentucky SimSmoke tobacco policy simulation model: Reaching Healthy People 2010 goals through policy change. *Southern Medical Journal* 101(5):503–507.

Levy, D. T., S. I. Cho, Y. M. Kim, S. Park, M. K. Suh, and S. Kam. 2010a. SimSmoke model evaluation of the effect of tobacco control policies in Korea: The unknown success story. *American Journal of Public Health* 100(7):1267–1273.

Levy, D. T., A. L. Graham, P. L. Mabry, D. B. Abrams, and C. T. Orleans. 2010b. Modeling the impact of smoking cessation treatment policies on quit rates. *American Journal of Preventive Medicine* 38(3S):S364–S372.

Levy, D., L. M. de Almeida, and A. Szklo. 2012a. The Brazil SimSmoke policy simulation model: The effect of strong tobacco control policies on smoking prevalence and smoking-attributable deaths in a middle income nation. *PLoS Medicine* 9(11): e1001336.

Levy, D. T., R. G. Boyle, and D. B. Abrams. 2012b. The role of public policies in reducing smoking: The Minnesota SimSmoke tobacco policy model. *American Journal of Preventive Medicine* 43(5 Suppl 3):S179–S186.

Levy, D. T., K. Blackman, L. M. Currie, and U. Mons. 2013a. Germany SimSmoke: The effect of tobacco control policies on future smoking prevalence and smoking-attributable deaths in Germany. *Nicotine & Tobacco Research* 15(2):465–473.

Levy, D. T., L. Currie, and L. Clancy. 2013b. Tobacco control policy in the UK: Blueprint for the rest of Europe? *European Journal of Public Health* 23(2):201–206.

Levy, D., R. L. Rodriguez-Buno, T. W. Hu, and A. E. Moran. 2014. The potential effects of tobacco control in China: Projections from the China SimSmoke simulation model. *BMJ* 348:g1134.

Levy, D., K. Blackman, G. T. Fong, and F. Chaloupka (eds.). In press. The role of tobacco control policies in reducing smoking and deaths in the eighteen heavy burden nations: Results from the MPOWER SimSmoke tobacco control policy model. In National Cancer Institute monograph *Tobacco control policies in low and middle income nations*, edited by G. Fong, F. Chaloupka, and A. Yurekli. Rockville, MD: National Cancer Institute.

Lewit, E. M., D. Coate, and M. Grossman. 1981. The effects of government regulation on teenage smoking. *Journal of Law and Economics* 24(3):545–569.

Lilienfeld, A. M. 1980. Advances in quantitative methods in epidemiology. *Public Health Reports* 95(5):462–469.

Matthews, T. J., and M. F. MacDorman. 2013. Infant mortality statistics from the 2010 period linked birth/infant death data set. *National Vital Statistics Reports* 62(8):1–26.

McMahon, P. M., R. Meza, S. K. Plevritis, W. C. Black, C. M. Tammemagi, A. Erdogan, K. ten Haaf, W. Hazelton, T. R. Holford, J. Jeon, L. Clarke, C. Y. Kong, S. E. Choi, V. N. Munshi, S. S. Han, J. van Rosmalen, P. F. Pinsky, S. Moolgavkar, H. J. de Koning, and E. J. Feuer. 2014. Comparing benefits from many possible computed tomography lung cancer screening programs: Extrapolating from the National Lung Screening Trial using comparative modeling. *PLoS ONE* 9(6):e99978.

Melvin, C. L., E. K. Adams, and V. Miller. 2000. Costs of smoking during pregnancy: Development of the Maternal and Child Health Smoking Attributable Mortality, Morbidity and Economic Costs (MCHSAMMEC) software. *Tobacco Control* 9(Suppl 3):iii12–iii15.

Meza, R., W. D. Hazelton, G. A. Colditz, and S. H. Moolgavkar. 2008. Analysis of lung cancer incidence in the Nurses' Health and the Health Professionals' Follow-Up Studies using a multistage carcinogenesis model. *Cancer Causes and Control* 19(3):317–328.

Meza, R., K. ten Haaf, C. Y. Kong, A. Erdogan, W. C. Black, M. C. Tammemagi, S. E. Choi, J. Jeon, S. S. Han, V. Munshi, J. van Rosmalen, P. Pinsky, P. M. McMahon, H. J. de Koning, E. J. Feuer, W. D. Hazelton, and S. K. Plevritis. 2014. Comparative analysis of 5 lung cancer natural history and screening models that reproduce outcomes of the NLST and PLCO trials. *Cancer* 120(11):1713–1724.

Moolgavkar, S. H., T. R. Holford, D. T. Levy, C. Y. Kong, M. Foy, L. Clarke, J. Jeon, W. D. Hazelton, R. Meza, F. Schultz, W. McCarthy, R. Boer, O. Gorlova, G. S. Gazelle, M. Kimmel, P. M. McMahon, H. J. de Koning, and E. J. Feuer. 2012. Impact of reduced tobacco smoking on lung cancer mortality in the United States during 1975–2000. *Journal of the National Cancer Institute* 104(7):541–548.

Orzechowski, W., and R. C. Walker. 2012. *The tax burden on tobacco: Historical compilation,* Vol. 47, 2012. Arlington, VA: Orzechowski and Walker. http://www.taxadmin.org/fta/tobacco/papers/tax_burden_2012.pdf (accessed February 23, 2015).

———. 2013. *The tax burden on tobacco: Historical compilation*, Vol. 48, 2013. Arlington, VA: Orzechowski and Walker. http://www.taxadmin.org/fta/tobacco/papers/tax_burden_2013.pdf (accessed March 20, 2015).

Rosenberg, M. A., E. J. Feuer, B. Yu, J. Sun, S. J. Henley, T. G. Shanks, C. M. Anderson, P. M. McMahon, M. J. Thun, and D. M. Burns. 2012. Chapter 3: Cohort life tables by smoking status, removing lung cancer as a cause of death. *Risk Analysis* 32 (Suppl 1):S25–538.

Sprague, W. W. 2009. LCFIT: The Lee–Carter fitter (Web-based software for estimating the Lee–Carter method for modeling and forecasting mortality). http://lcfit.demog.berkeley.edu (accessed January 16, 2015).

Steyn, K., T. De Wet, Y. Saloojee, H. Nel, and D. Yach. 2006. The influence of maternal cigarette smoking, snuff use and passive smoking on pregnancy outcomes: The Birth to Ten Study. *Paediatric and Perinatal Epidemiology* 20(2):90–99.

Tong, V. T., P. M. Dietz, S. L. Farr, D. V. D'Angelo, and L. J. England. 2013. Estimates of smoking before and during pregnancy, and smoking cessation during pregnancy: Comparing two population-based data sources. *Public Health Reports* 128(3):179–188.

USCB (U.S. Census Bureau). 2013a. Annual estimates of the resident population by single year of age and sex for the United States, states, and Puerto Rico commonwealth: April 1, 2010 to July 1, 2012. http://factfinder.census.gov/faces/tableservices/jsf/pages/productview.xhtml?src=bkmk (accessed November 26, 2014).

———. 2013b. National estimates by age, sex, race: 1900–1979. https://www.census.gov/popest/data/national/asrh/pre-1980/PE-11.html (accessed November 26, 2014).

———. 2014. Methodology, assumptions, and inputs for the 2014 national projections. http://www.census.gov/population/projections/files/methodology/methodstatement14.pdf (accessed February 23, 2015).

van den Berg, G., M. van Eijsden, F. Galindo-Garre, T. G. Vrijkotte, and R. J. Gemke. 2013. Smoking overrules many other risk factors for small for gestational age birth in less educated mothers. *Early Human Development* 89(7):497–501.

Warner, K. 1989. Effects of the antismoking campaign: An update. *American Journal of Public Health* 79(2):144–151.

Warner, K. E., and H. A. Murt. 1983. Premature deaths avoided by the antismoking campaign. *American Journal of Public Health* 73(6):672–677.

WHO (World Health Organization). 2008. *WHO report on the global tobacco epidemic, 2008: The MPOWER package.* Geneva: World Health Organization.

———. 2013. *WHO report on the global tobacco epidemic, 2013: Enforcing bans on tobacco advertising, promotion and sponsorship*. Geneva: World Health Organization.

Zhang, K., and X. Wang. 2013. Maternal smoking and increased risk of sudden infant death syndrome: A meta-analysis. *Legal Medicine* 15(3):115–121.

Appendix E

Open Meeting Agendas

MEETING ONE

Tuesday, February 4, 2014
National Academy of Sciences, Board Room
2101 Constitution Avenue, NW
Washington, DC

10:30 a.m. **Convene Open Session**

Introductions
Richard Bonnie

Presentation of the Charge to the Committee and Discussion
Eric Lindblom
Director of the Office of Policy
Center for Tobacco Products, Food and Drug Administration

11:30 a.m. *State and Local Efforts in Raising the Minimum Purchase Age*
Peter H. Fisher
Vice President, State Issues
Campaign for Tobacco-Free Kids

12:30 p.m. **Adjourn Open Session**

MEETING TWO

Thursday, April 10, 2014
Keck Center, Room 100
500 Fifth Street, NW
Washington, DC

OPEN SESSION

8:30 a.m. *Adolescent and Young Adult Brain Development*
Jay Giedd, M.D.
Chief, Brain Imaging Section
Child Psychiatry Branch, National Institute of Mental Health

9:30 a.m. *Adolescent and Young Adult Cognitive and Psychosocial Development and Decision Making*
Laurence Steinberg, Ph.D.
Professor, Department of Psychology
Temple University

10:30 a.m. **Break**

10:45 a.m. *Effect of Nicotine on the Developing Brain*
Neal Benowitz, M.D.
Professor, Department of Medicine
University of California, San Francisco, School of Medicine

11:45 a.m. *Emerging and Alternative Nicotine and Tobacco Products*
David Abrams, Ph.D.
Executive Director, Schroeder Institute for Tobacco Research and Policy Studies
Legacy for Health

12:45 p.m. **Lunch**

Advertising, Marketing, and Messaging Strategies for Adolescents and Young Adults

1:45 p.m. *Tobacco Industry Messaging Strategies*
Pam Ling, M.D., M.P.H.
Associate Professor, Department of Medicine
University of California, San Francisco

2:45 p.m. ***The Role of Media Channels and Messages in Shaping U.S. Tobacco Use Patterns***
Donna Vallone, Ph.D., M.P.H.
Senior Vice President, Research and Evaluation
Legacy for Health

3:45 p.m. ***Reflections: Clinical Pediatric Perspective***
Jonathan Winickoff, M.D., M.P.H.
Associate Professor of Pediatrics
Massachusetts General Hospital for Children

4:15 p.m. **Public Comment**

Closing Comments
Richard Bonnie, Committee Chair
(When no additional public comments, adjourn open session.)

Appendix F

Committee Biographical Sketches

RICHARD J. BONNIE, L.L.B. (*Chair*), is the director of the Institute of Law, Psychiatry, and Public Policy at the University of Virginia. He is also a charter fellow of the College on the Problems of Drug Dependence, where he has served twice on the board of directors. In addition to these positions, Bonnie is the Harrison Foundation Professor of Medicine and Law in the School of Law and a professor of psychiatry and neurobehavioral sciences in the School of Medicine at the University of Virginia. His research focuses on criminal law, bioethics, and public policies relating to mental health, substance abuse, aging, and public health. Mr. Bonnie received his law degree from the University of Virginia. He has been a major contributor to the Institute of Medicine (IOM) and the National Research Council (NRC), where he has served on multiple committees, including the Workshop for Understanding the Demand for Illegal Drugs (2010); the Committee on Reducing Tobacco Use: Strategies, Barriers and Consequences (chair, 2007); the Committee on Developing a Strategy to Prevent and Reduce Underage Drinking (chair, 2004); the Committee on Data and Research for Policy on Illegal Drugs (2001); and the Committee on Preventing Nicotine Dependence in Children and Adolescents (vice chair, 1994). He is currently the chair of the Committee on Improving the Health, Safety and Well-Being of Young Adults (2013–2015). Mr. Bonnie was elected to the IOM in 1991.

ANTHONY J. ALBERG, Ph.D., M.P.H., is the Blatt Ness Endowed Chair in Oncology and a professor of public health sciences and currently serves as the interim director of cancer control of the Hollings Cancer Center at the Medical University of South Carolina. He is an epidemiologist whose research focuses on non-melanoma skin cancer, cigarette smoking, health effects of secondhand smoke, etiology of tobacco-associated malignancies, and tobacco prevention and control. Dr. Alberg is a member of the editorial board for cancer screening and prevention of the National Cancer Institute's Physician Data Query (PDQ), editor for the epidemiology section of the American College of Chest Physician's *Lung Cancer Guidelines III*, and associate editor of the *American Journal of Epidemiology.* He was a standing member of the National Institutes of Health's epidemiology of cancer study section, and he has been a contributing author to two U.S. Surgeon General's reports on the health consequences of smoking. He is a member of South Carolina's Cancer Control Advisory Committee (CCAC) and chair of the CCAC's Cancer Surveillance Committee. Dr. Alberg received his M.P.H. from the Yale School of Medicine and his Ph.D. from the Johns Hopkins Bloomberg School of Public Health.

REGINA BENJAMIN, M.D., M.B.A., is the NOLA.com/Times Picayune Endowed Chair of Public Health Sciences at Xavier University of Louisiana and from 2009 to 2013 served as the 18th Surgeon General of the United States. She specializes in prevention policies and health promotion among both individuals and large populations, especially concerning obesity, childhood obesity, and children's health. She has special interests in rural health care, health disparities among socioeconomic groups, suicide, violence, and mental health. Prior to her role as Surgeon General, Dr. Benjamin founded and directed a rural primary care health clinic in Bayou La Batre, Alabama, where she administered health care to residents without easy access to doctors. Dr. Benjamin attended Morehouse School of Medicine, and she received her M.D. from the University of Alabama, Birmingham, and her M.B.A. from Tulane University. She has served on several IOM and NRC committees, including the Committee on Health Threats and Workforce Resilience (2009); the Committee on a Comprehensive Review of the DHHS Office of Family Planning Title X Program (2007–2009); the Committee on Cancer Survivorship: Improving Care and Quality of Life (2004–2005); the Committee on Crossing the Quality Chasm-Next Steps Summit (2003–2004); and the Committee on Cancer Research Among Minorities and the Medically Underserved (1997–1999). She was elected to the IOM in 1997. She became a MacArthur Fellow in 2008.

JONATHAN CAULKINS, Ph.D., is the H. Guyford Stever Professor of Operations Research at Carnegie Mellon University's Heinz College of Public Policy and Management. Dr. Caulkins was also the founding director of the Pittsburgh branch of RAND, a corporation designed to improve decision making and to implement better policy worldwide. His main research methods are focused on mathematical problem solving and model development related to social policy and interventions. His interests are focused on drugs, crime, delinquency, and prevention. He received his M.S. in systems science and mathematics from Washington University and his S.M. in electrical engineering and computer science from the Massachusetts Institute of Technology (MIT). He holds a Ph.D. in operations research, also from MIT. For the IOM and the NRC, he has served on the Committee on Reducing Tobacco Use: Strategies, Barriers, and Consequences (2007); the Committee on Immunotherapies and Sustained-Release Formulations for Treating Drug Addiction (2004); and the Committee on Estimating Costs to the Department of Justice of Increased Border Security Enforcement by the Department of Homeland Security (2010–2011), and, since 2013, the Committee on Modernizing the Nation's Crime Statistics.

BONNIE HALPERN-FELSHER, Ph.D., is a professor of pediatrics, the director of research, and the associate director of the Adolescent Medicine Fellowship Program in the Division of Adolescent Medicine, Department of Pediatrics at Stanford University. Prior to holding these positions, she was the co-director of research for the Adolescent Medicine Fellowship, co-director of the General Pediatric Fellowship, and a professor in the Division of Adolescent Medicine, Department of Pediatrics at the University of California. She was a faculty member in the following programs: the Psychology and Medicine Postdoctoral Program at the University of California, San Francisco (UCSF), the Center for Health and Community, the Center for Tobacco Control Research and Education, and the UCSF Heller Diller Family Comprehensive Cancer Center. Dr. Halpern-Felsher's main research areas are child, adolescent, and emerging adult development; adolescent and young adult health; risk behavior and risk perceptions; decision making; risk communication; tobacco control among adolescents and young adults; and tobacco prevention. Dr. Halpern-Felsher received her M.A. in psychology and her Ph.D. in developmental psychology from the University of California, Riverside. She has contributed her knowledge and time to several IOM and NRC studies, including the following committees: the Committee on Scientific Standards for Studies on Modified Risk Tobacco Products (2011); the Committee on Contributions for the Behavioral and Social Sciences in Reducing and Preventing Teen Motor Vehicle Crashes (2007); the Committee on Reducing Tobacco Use: Strategies, Barriers and Consequences (2007); and the Committee on Developing a Strategy to Prevent and Reduce Underage Drinking (2004).

SWANNIE JETT, Dr.P.H., is the executive director of the Seminole County Department of Health in Florida. Dr. Jett has been influential in improving county health efforts by strengthening infrastructure through funding improvements, increasing workforce competencies, and creating strong partnerships that are aimed at improving overall population health outcomes. With more than 18 years of public health experience, he has worked to promote health awareness and public health policy, mainly concerning health disparities and air pollution. He was previously the public health director for Bullitt County Health Department in Kentucky, the manager of clinical operations for the Louisville Metro Department of Public Health and Wellness, and the public health officer for the U.S. Air Force National Guard. Dr. Jett received his M.S. in biosystems engineering and environmental science from the University of Tennessee and his doctorate in public health with a preventative medicine/environmental health emphasis from the University of Kentucky.

HARLAN JUSTER, Ph.D., is the director of the New York State Department of Health's Bureau of Tobacco Control. The bureau administers the statewide tobacco control program, which uses a population-oriented, policy, and systems change approach to altering the tobacco environment in New York. The program relies on evidence-based and promising interventions to reduce youth initiation, promote adult cessation, and eliminate exposure to secondhand smoke. Prior to his role as director, he served as manager of the tobacco surveillance, evaluation, and research team for the same program. In that role he was responsible for program evaluation, local and statewide surveillance, and contributing to the science of tobacco control. Dr. Juster earned his Ph.D. in psychology from the University at Albany and is a licensed psychologist in New York State.

JONATHAN D. KLEIN, M.D., M.P.H., is the associate executive director of the American Academy of Pediatrics and the director of the academy's Julius B. Richmond Center of Excellence for Children. He is also a professor of adolescent medicine in the Department of Pediatrics at the University of Rochester in New York, where he previously served as the associate chair of the Department of Pediatrics. Dr. Klein's research at the Richmond Center is focused on secondhand smoke exposure, health systems and behavior change for adolescent tobacco cessation, and education to engage pediatricians and other clinicians in helping eliminate childhood exposure to tobacco. Dr. Klein's other research areas are in the access, quality, and effectiveness of child and adolescent preventive services and in related survey methods. He joined the academy in 2009, and his oversight responsibilities there include research, tobacco control, membership and strategic planning, and international health. Dr. Klein received his M.P.H. in health policy and management from the Harvard School of Public Health and his M.D. from the University of Medicine and Dentistry of New Jersey.

PAULA M. LANTZ, Ph.D., is a professor and the chair of the Department of Health Policy and Management at George Washington University as well as a professor of public health policy and public administration. Her research interests are focused on the role of public health in health care reform; clinical preventive services; and health disparities as a result of social inequalities. Prior to her role as chair and professor, she was a professor at the University of Michigan's School of Public Health and Gerald R. Ford School of Public Policy, and she served as chair of the Department of Health Management and Policy. Her published research on tobacco includes Radon, Smoking and Lung Cancer: The Need to Refocus Radon Control Policy (2012). Dr. Lantz received her M.S. in preventive medicine epidemiology and her Ph.D. in sociology, both from the University of Wisconsin–Madison. She was elected to the IOM in 2012 and since 2013 has served on the IOM Roundtable on Population Health Improvement.

ROBIN MERMELSTEIN, Ph.D., is the director of the Institute of Health Research and Policy. She is also a professor of psychology and a clinical professor of community health sciences at the University of Illinois at Chicago. Dr. Mermelstein has more than 25 years of tobacco-based research experience ranging from longitudinal studies of the etiology of youth smoking to cessation interventions for adult smokers. She is nationally recognized for her research approaches to studying contextual factors related to the development of nicotine addiction and the development of clinical intervention methods for adolescent and adult smokers. Dr. Mermelstein received her Ph.D. in clinical and community psychology from the University of Oregon.

RAFAEL MEZA, Ph.D., is an assistant professor of epidemiology at the University of Michigan School of Public Health. His research focuses lie in cancer risk assessment and cancer epidemiology data analysis, using mathematically based models to assess disease dynamics. Dr. Meza's current research centers on developing models that will be used to evaluate the public health impact of screening strategies for lung, colon, and esophagus cancer risk. Some of his recently published peer-reviewed studies concerning tobacco usage are "Lung Cancer in Never Smokers: Epidemiology and Risk Prediction Models" (2012) and "Impact of the Reduction in Tobacco Smoking on Lung Cancer Mortality in the U.S. During the Period 1975–2000" (2012). In addition to his duties as a professor, Dr. Meza is a member of the Cancer Intervention and Surveillance Modeling Network (CISNET) and the Cancer Prevention and Control Program at the University of Michigan's Comprehensive Cancer Center. Dr. Meza attended the University of Washington, where he received his Ph.D. in applied mathematics.

PATRICK O'MALLEY, Ph.D., is a research professor at the Survey Research Center of the Institute for Social Research at the University of Michigan. He specializes in the epidemiology of drug use, with a special focus on tobacco usage in youth populations. He is a co–principal investigator of Monitoring the Future: A Continuing Study of the Lifestyles and Values of American Youth, funded by the National Institute on Drug Abuse. The study focuses on substance abuse, including tobacco abuse, and related behaviors among secondary school students, college students, and young adults. He is also a co–principal investigator on the Youth, Education, and Society study, funded by the Robert Wood Johnson Foundation. Dr. O'Malley received his Ph.D. from the University of Michigan. He has served on committees for the NRC, including the Committee on Opportunities in Drug Abuse Research (1995) and the Committee on Drug Abuse Prevention Research (1992).

KIMBERLY THOMPSON, Sc.D., is the president of Kid Risk, Inc., and a professor of preventive medicine and global health at the University of Central Florida's College of Medicine. She previously served on the faculty of the Harvard School of Public Health in the departments of health policy and management and maternal and child health, as well as at the Children's Hospital Boston in adolescent medicine. She founded and directed the Harvard Kids Risk Project, which she later developed into a nonprofit organization called Kid Risk, Inc. Her research interests and teaching focus on developing and applying economic, dynamic, risk, decision, and integrated mathematical models to examine and connect the benefits of preventive medicine interventions and global health policies. She leads global health research related to managing infectious diseases, including polio, measles, rubella, and cholera. Her research on policy development and implementation assesses the effects of methodological choices on modeling decisions and economics (including cost-effectiveness, benefit–cost, decision, value-of-information, and risk analysis) and how a consideration of uncertainty, variability, and time affect policy outcomes. Dr. Thompson received her M.S. in chemical engineering from MIT and her Sc.D. in environmental health from Harvard University. She has served on several IOM and NRC committees, including the Committee on Ranking FDA Product Categories Based on Health Consequences (2009).