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# E-Cigarette Use Among Youth and Young Adults

A Report of the Surgeon General

## Executive Summary

U.S. Department of Health and Human Services

# E-Cigarette Use Among Youth and Young Adults

## A Report of the Surgeon General

# Executive Summary

2016

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
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# Message from Sylvia Burwell

*Secretary, U.S. Department of Health and Human Services*

The mission of the Department of Health and Human Services is to enhance and protect the health and well-being of all Americans. This report confirms that the use of electronic cigarettes (or e-cigarettes) is growing rapidly among American youth and young adults. While these products are novel, we know they contain harmful ingredients that are dangerous to youth. Important strides have been made over the past several decades in reducing conventional cigarette smoking among youth and young adults. We must make sure this progress is not compromised by the initiation and use of new tobacco products, such as e-cigarettes. That work is already underway.

To protect young people from initiating or continuing the use of e-cigarettes, actions must be taken at the federal, state, and local levels. At the federal level, the U.S. Food and Drug Administration (FDA)—under authority granted to it by Congress under the *Family Smoking Prevention and Tobacco Control Act of 2009*—took a historic step to protect America's youth from the harmful effects of using e-cigarettes by extending its regulatory authority over the manufacturing, distribution, and marketing of e-cigarettes. Through such action, FDA now requires minimum age restrictions to prevent sales to minors and prohibits sales through vending machines (in any facility that admits youth), and will require products to carry a nicotine warning.

We have more to do to help protect Americans from the dangers of tobacco and nicotine, especially our youth. As cigarette smoking among those under 18 has fallen, the use of other nicotine products, including e-cigarettes, has taken a drastic leap. All of this is creating a new generation of Americans who are at risk of nicotine addiction.

The findings from this report reinforce the need to support evidence-based programs to prevent youth and young adults from using tobacco in any form, including e-cigarettes. The health and well-being of our nation's young people depend on it.

# Foreword

Tobacco use among youth and young adults in any form, including e-cigarettes, is not safe. In recent years, e-cigarette use by youth and young adults has increased at an alarming rate. E-cigarettes are now the most commonly used tobacco product among youth in the United States. This timely report highlights the rapidly changing patterns of e-cigarette use among youth and young adults, assesses what we know about the health effects of using these products, and describes strategies that tobacco companies use to recruit our nation's youth and young adults to try and continue using e-cigarettes. The report also outlines interventions that can be adopted to minimize the harm these products cause to our nation's youth.

E-cigarettes are tobacco products that deliver nicotine. Nicotine is a highly addictive substance, and many of today's youth who are using e-cigarettes could become tomorrow's cigarette smokers. Nicotine exposure can also harm brain development in ways that may affect the health and mental health of our kids.

E-cigarette use among youth and young adults is associated with the use of other tobacco products, including conventional cigarettes. Because most tobacco use is established during adolescence, actions to prevent our nation's young people from the potential of a lifetime of nicotine addiction are critical.

E-cigarette companies appear to be using many of the advertising tactics the tobacco industry used to persuade a new generation of young people to use their products. Companies are promoting their products through television and radio advertisements that use celebrities, sexual content, and claims of independence to glamorize these addictive products and make them appealing to young people.

Comprehensive tobacco control and prevention strategies for youth and young adults should address all tobacco products, including e-cigarettes. Further reductions in tobacco use and initiation among youth and young adults are achievable by regulating the manufacturing, distribution, marketing, and sales of all tobacco products—including e-cigarettes, and particularly to children—and combining those approaches with other proven strategies. These strategies include funding tobacco control programs at levels recommended by the Centers for Disease Control and Prevention (CDC); increasing prices of tobacco products; implementing and enforcing comprehensive smokefree laws; and sustaining hard-hitting media campaigns, such as CDC's *Tips from Former Smokers* that encourages smokers to quit for good, and FDA's *Real Cost* that is aimed at preventing youth from trying tobacco and reducing the number of youth who move from experimenting to regular use. We can implement these cost-effective, evidence-based, life-saving strategies now. Together with additional effort and support, we can protect the health of our nation's young people.

Thomas R. Frieden, M.D., M.P.H.
Director
Centers for Disease Control and Prevention

# Preface

*from the Surgeon General*

E-cigarette use among U.S. youth and young adults is now a major public health concern. E-cigarette use has increased considerably in recent years, growing an astounding 900% among high school students from 2011 to 2015. These products are now the most commonly used form of tobacco among youth in the United States, surpassing conventional tobacco products, including cigarettes, cigars, chewing tobacco, and hookahs. Most e-cigarettes contain nicotine, which can cause addiction and can harm the developing adolescent brain.

Compared with older adults, the brain of youth and young adults is more vulnerable to the negative consequences of nicotine exposure. The effects include addiction, priming for use of other addictive substances, reduced impulse control, deficits in attention and cognition, and mood disorders. Furthermore, fetal exposure to nicotine during pregnancy can result in multiple adverse consequences, including sudden infant death syndrome, altered corpus callosum, auditory processing deficits, effects on behaviors and obesity, and deficits in attention and cognition. Ingestion of e-cigarette liquids containing nicotine can also cause acute toxicity and possibly death if the contents of refill cartridges or bottles containing nicotine are consumed.

This report highlights what we know and do not know about e-cigarettes. Gaps in scientific evidence do exist, and this report is being issued while these products and their patterns of use continue to change quickly. For example, the health effects and potentially harmful doses of heated and aerosolized constituents of e-cigarette liquids—including solvents, flavorants, and toxicants—are not completely understood. However, although e-cigarettes generally emit fewer toxicants than combustible tobacco products, we know that aerosol from e-cigarettes is not harmless.

Although we continue to learn more about e-cigarettes with each passing day, we currently know enough to take action to protect our nation's young people from being harmed by these products. Previous reports of the Surgeon General have established that nearly all habitual tobacco use begins during youth and young adulthood. To prevent and reduce the use of e-cigarettes by youth and young adults, we must work together as a society. We must implement proven prevention and education strategies. Health care providers, parents, teachers, and other caregivers should advise youth about the dangers of nicotine and discourage tobacco use in any form, including e-cigarettes. They can set a positive example by being tobacco-free and encouraging those who already use these products to quit. Free help is available at 1-800-QUIT-NOW or http://www.smokefree.gov. Preventing tobacco use in any form among youth and young adults is critical to ending the tobacco epidemic in the United States.

Vivek H. Murthy, M.D., M.B.A.
U.S. Surgeon General

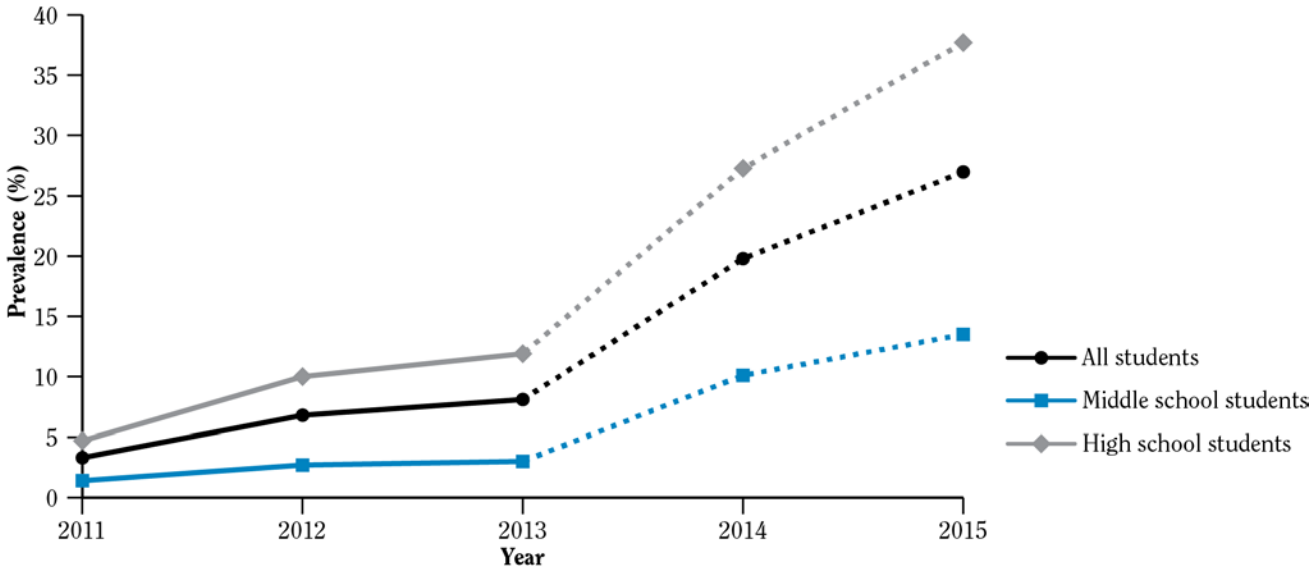
# Overview

Although conventional cigarette smoking has declined markedly over the past several decades among youth and young adults in the United States (U.S. Department of Health and Human Services [USDHHS] 2012), there have been substantial increases in the use of emerging tobacco products among these populations in recent years (Centers for Disease Control and Prevention [CDC] 2015, 2016). Among these increases there has been a dramatic rise in electronic cigarette (e-cigarette) use among youth and young adults (Figures 1, 2, and 3). It is crucial that the progress made in reducing conventional cigarette smoking among youth and young adults not be compromised by the initiation and use of e-cigarettes. This Surgeon General's report focuses on the history, epidemiology, and health effects of e-cigarette use among youth and young adults; the companies involved with marketing and promoting these products; and existing and proposed public health policies regarding the use of these products by youth and young adults.

E-cigarettes include a diverse group of devices that allow users to inhale an aerosol, which typically contains nicotine, flavorings, and other additives. E-cigarettes are tobacco products and are regulated as such under the *Federal Food, Drug, and Cosmetic Act,* as amended by the *Family Smoking Prevention and Tobacco Control Act of 2009.* E-cigarettes vary widely in design and appearance, but generally operate in a similar manner and are composed of similar components (Figure 4). A key challenge for surveillance of the products and understanding their patterns of use is the diverse and nonstandard nomenclature for the devices (Alexander et al. 2016). These devices are referred to, by the companies themselves, and by consumers, as "e-cigarettes," "e-cigs," "cigalikes," "e-hookahs," "mods," "vape pens," "vapes," and "tank systems." This report employs the term "e-cigarette" to represent all of the diverse products in this rapidly diversifying product category.

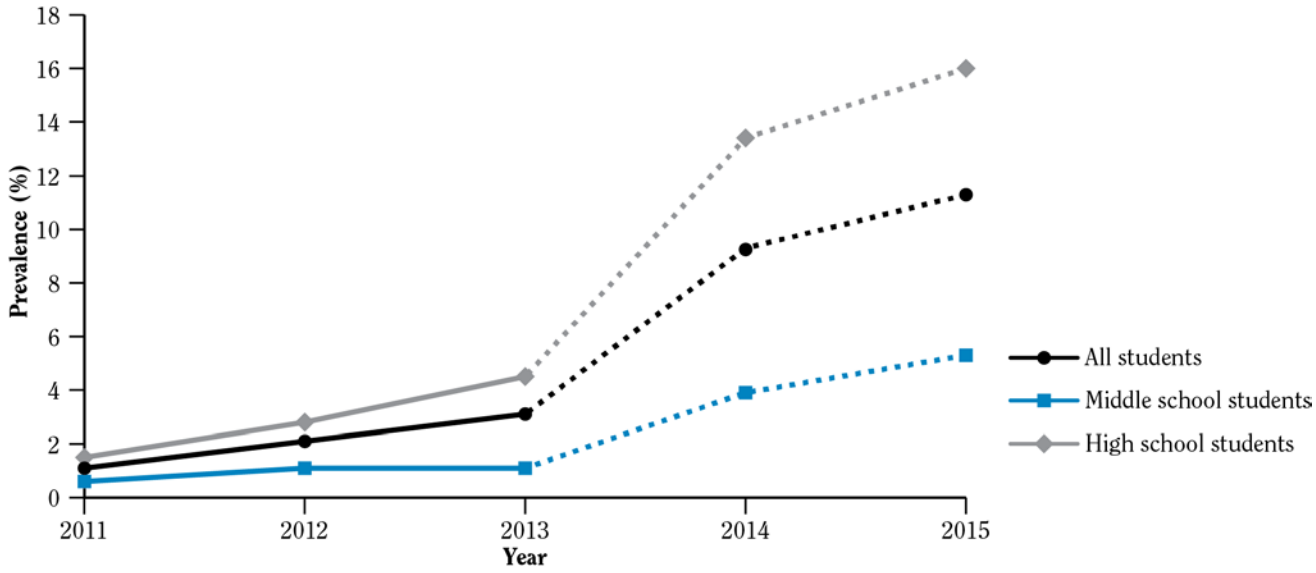
This report focuses on research conducted among youth and young adults because of the implications of e-cigarette use in these populations, particularly the potential for future public health problems. Understanding e-cigarette use among young people is critical because previous research suggests that about 9 in 10 adult smokers first try conventional cigarettes during adolescence (USDHHS 2012). Similarly, youth e-cigarette experimentation and use could also extend into adulthood; ongoing

**Figure 1 Trends in ever e-cigarette use[a] among U.S. middle and high school students; National Youth Tobacco Survey (NYTS) 2011–2015**



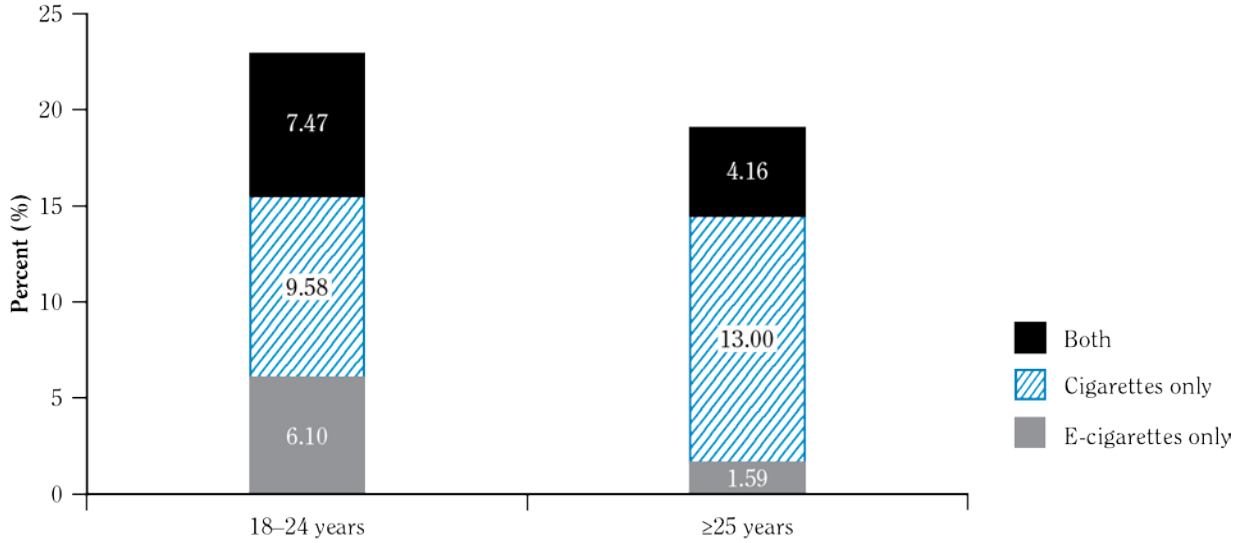

*Source:* Centers for Disease Control and Prevention 2013, 2014; unpublished data (data: NYTS 2015).
*Note:* In 2014, modifications were made to the e-cigarette measure to enhance its accuracy, which may limit the comparability of this estimate to those collected in previous years. The dotted lines from 2013 to 2015 represent these differences.
[a]Includes those who responded "yes" to the following question: "*Have you ever used an electronic cigarette or e-cigarette, even once or twice?*"

**Figure 2** **Trends in past-30-day e-cigarette use[a] among U.S. middle and high school students; National Youth Tobacco Survey (NYTS) 2011–2015**




*Source:* Centers for Disease Control and Prevention 2013, 2014; unpublished data (data: NYTS 2015).
*Note:* In 2014, modifications were made to the e-cigarette measure to enhance its accuracy, which may limit the comparability of this estimate to those collected in previous years. The dotted lines from 2013 to 2015 represent these differences.
[a]Includes those who selected "1 or more" for the following question: *"During the last 30 days, on how many days did you use electronic cigarettes or e-cigarettes?"*

**Figure 3** **Percentage of young adults who currently use e-cigarettes[a] and conventional cigarettes; National Adult Tobacco Survey (NATS) 2013–2014**




*Source:* Centers for Disease Control and Prevention, unpublished data (data: NATS 2013–2014).
[a]Current e-cigarette use was defined as those who reported they had heard of e-cigarettes and had tried e-cigarettes, and reported using e-cigarettes every day, some days, or rarely at the time of the interview.

**Figure 4 Diversity of e-cigarette products**

*Source:* Photo by Mandie Mills, CDC.

research should examine the long-term trajectories of e-cigarette use that begins in youth. The first Surgeon General's report on the health consequences of smoking was published in 1964; of the subsequent reports, those published in 1994 and 2012 focused solely on youth and young adults (USDHHS 1994, 2012). Most recently, the 2012 report documented the evidence regarding tobacco use among youth and young adults, concluding that declines in conventional cigarette smoking had slowed and that decreases in the use of smokeless tobacco had stalled. That report also found that the tobacco industry's advertising and promotional activities are causal to the onset of smoking in youth and young adults and the continuation of such use as adults (USDHHS 2012). However, that report was prepared before e-cigarettes were as widely promoted and used in the United States as they are now. Therefore, this 2016 report documents the scientific literature on these new products within the context of youth and young adults. This report also looks to the future by examining the potential impact of e-cigarette use among youth and young adults, while also summarizing the research on current use, health consequences, and marketing as it applies to youth and young adults.

Evidence for this report was gathered from scientific research that included one or more of three age groups. These age groups included young adolescents (11–13 years of age), adolescents (14–17 years of age), and young adults (18–24 years of age). Some studies refer to the younger groups more generally as *youth*. Despite important issues related to e-cigarette use in the general adult populations, clinical and otherwise (e.g., their potential for use in quitting conventional smoking), that literature is generally not included in this report unless it also discusses youth and young adults (Farsalinos and Polosa 2014; Franck et al. 2014; Grana et al. 2014a).

## Organization of the Report

Chapter 1 ("Introduction, Conclusions, and Historical Background Relative to E-Cigarettes") presents a brief introduction to the report and includes its major conclusions, followed by the conclusions of each chapter, the historical background of e-cigarettes, descriptions of the products, a review of the marketing and promotional activities of e-cigarette companies, and the current status of regulations from the U.S. Food and Drug Administration (FDA). Chapter 2 ("Patterns of E-Cigarette Use Among U.S. Youth and Young Adults") describes the epidemiology of e-cigarette use, including current (i.e., past 30 day) use; ever use; co-occurrence of using e-cigarettes with other tobacco products, like cigarettes; and psychosocial factors associated with using e-cigarettes. This chapter relies on data from the most recent nationally representative studies available at the time this report was prepared. Chapter 3 ("Health Effects of E-Cigarette Use Among U.S. Youth and Young Adults") documents potential adverse health effects caused by direct exposure to aerosolized nicotine, flavorants, chemicals, and other particulates of e-cigarettes, secondhand environmental exposure to e-cigarette aerosol, and exposure to the surface-deposited aerosol contaminants. Literature regarding harmful consequences of close contact with malfunctioning e-cigarette devices and ingestion of the nicotine-containing liquids are also explored. Chapter 4 ("Activities of the E-Cigarette Companies") describes e-cigarette companies' influences on e-cigarette use and considers manufacturing and price; the impact of price on sales and use; the rapid changes in the industry, particularly the e-cigarette companies; and the marketing and promotion of e-cigarettes. Chapter 5 ("E-Cigarette Policy and Practice Implications") discusses the implications for policy and practice at the national, state, and local levels. The report ends with a Call to Action to stakeholders—including policymakers, public health practitioners and clinicians, researchers, and the public—to work to prevent harms from e-cigarette use and secondhand aerosol exposure among youth and young adults.

Because of the recency of research related to e-cigarettes (particularly in contrast with decades of research on conventional cigarette smoking) and since this report focuses on a vulnerable population for tobacco use (youth and young adults), the "precautionary principle" is employed to guide actions to address e-cigarette use among youth and young adults. This principle supports intervention to avoid possible health risks when the potential risks remain uncertain and have been, as yet, partially undefined (Bialous and Sarma 2014; Saitta et al. 2014; Hagopian et al. 2015).

The following is a brief summary of the report's Major Conclusions, each chapter, and their subsequent chapter conclusions.

## Major Conclusions

1. E-cigarettes are a rapidly emerging and diversified product class. These devices typically deliver nicotine, flavorings, and other additives to users via an inhaled aerosol. These devices are referred to by a variety of names, including "e-cigs," "e-hookahs," "mods," "vape pens," "vapes," and "tank systems."

2. E-cigarette use among youth and young adults has become a public health concern. In 2014, current use of e-cigarettes by young adults 18–24 years of age surpassed that of adults 25 years of age and older.

3. E-cigarettes are now the most commonly used tobacco product among youth, surpassing conventional cigarettes in 2014. E-cigarette use is strongly associated with the use of other tobacco products among youth and young adults, including combustible tobacco products.

4. The use of products containing nicotine poses dangers to youth, pregnant women, and fetuses. The use of products containing nicotine in any form among youth, including in e-cigarettes, is unsafe.

5. E-cigarette aerosol is not harmless. It can contain harmful and potentially harmful constituents, including nicotine. Nicotine exposure during adolescence can cause addiction and can harm the developing adolescent brain.

6. E-cigarettes are marketed by promoting flavors and using a wide variety of media channels and approaches that have been used in the past for marketing conventional tobacco products to youth and young adults.

7. Action can be taken at the national, state, local, tribal, and territorial levels to address e-cigarette use among youth and young adults. Actions could include incorporating e-cigarettes into smokefree policies, preventing access to e-cigarettes by youth, price and tax policies, retail licensure, regulation of e-cigarette marketing likely to attract youth, and educational initiatives targeting youth and young adults.

# Chapter 1. Introduction, Conclusions, and Historical Background Relative to E-Cigarettes

Chapter 1 presents the major conclusions of this Surgeon General's report and the conclusions of each chapter. E-cigarettes are presented within their historical context, with an overview of the components of these devices and the types of products. In May 2016, FDA published its final rule deeming e-cigarettes, among other products, to be subject to regulation under the *Federal Food, Drug, and Cosmetic Act,* as amended by the *Family Smoking Prevention and Tobacco Control Act* (*Federal Register* 2016). Chapter 1 outlines the current status of federal regulation of e-cigarettes, particularly as they relate to youth and young adults. The need to protect this population from initiating or continuing the use of tobacco products forms a strong basis for the need to regulate e-cigarettes at the local, state, and national levels, both now and in the future.

## Conclusions

1. E-cigarettes are devices that typically deliver nicotine, flavorings, and other additives to users via an inhaled aerosol. These devices are referred to by a variety of names, including "e-cigs," "e-hookahs," "mods," "vape pens," "vapes," and "tank systems."

2. E-cigarettes represent an evolution in a long history of tobacco products in the United States, including conventional cigarettes.

3. In May 2016, the Food and Drug Administration issued the deeming rule, exercising its regulatory authority over e-cigarettes as a tobacco product.

# Chapter 2. Patterns of E-Cigarette Use Among U.S. Youth and Young Adults

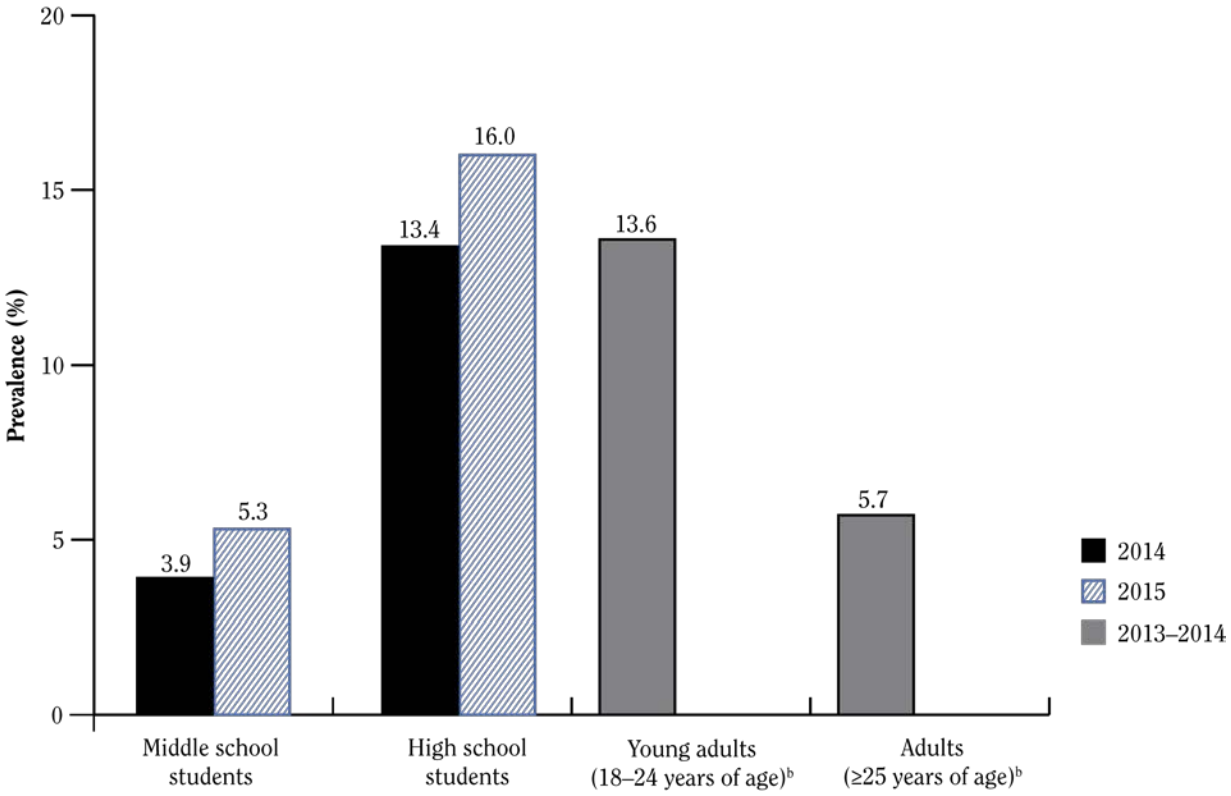
Among youth and young adults, rates of ever and past-30-day use of e-cigarettes have increased since the earliest e-cigarette surveillance efforts in 2011. According to the National Youth Tobacco Survey (NYTS), both ever use and past-30-day use of e-cigarettes have increased greatly among youth from 2011 to 2015 (Figures 1 and 2) (CDC 2013; Ambrose et al. 2014; Lippert 2015). Among young adults (18–24 years of age), the prevalence of ever use more than doubled from 2013 to 2014 (Figure 3; National Adult Tobacco Survey [NATS], 2013–2014, unpublished data). Figures 5 and 6 compare the prevalence of ever and current e-cigarette use among middle school students, high school students, young adults (18–24 years of age), and adults (≥25 years of age). Data for 2015 were not available for young adults and adults at the time this report was prepared; however, these trends are alarming and warrant continued surveillance.

Among youth, e-cigarette use increases with age and is highest among Hispanics and Whites (Tables 2.1a, 2.1b).[1] Among young adults, e-cigarette use is higher among males than females and lowest among Blacks and those with a college education (Table 2.4a). Continued research is necessary to monitor patterns of e-cigarette use across population groups by gender, age, race/ethnicity, and education, as well as sociodemographic characteristics for which disparities in tobacco use have previously been noted, including geography (e.g., subnational data at the state or local levels), sexual orientation and gender identity (e.g., lesbian, gay, bisexual, and transgender), disability/limitation, and socioeconomic status (e.g., household income, poverty status) (CDC 2014; Johnson et al. 2016).

According to data from the Monitoring the Future (MTF) study, in 2015, among youth, past-30-day exclusive use of e-cigarettes (6.7%, 10.4%, and 10.4% in 8th, 10th, and 12th grades, respectively) is more common than exclusive use of conventional cigarettes (1.4%, 2.2%, and 5.3% in those grades) or dual use of e-cigarettes and

[1]All tables that are cross-referenced in this Executive Summary can be found in the full report

**Figure 5 Percentage of middle school students, high school students, young adults (18–24 years of age), and adults (≥25 years of age) who currently[a] use e-cigarettes**



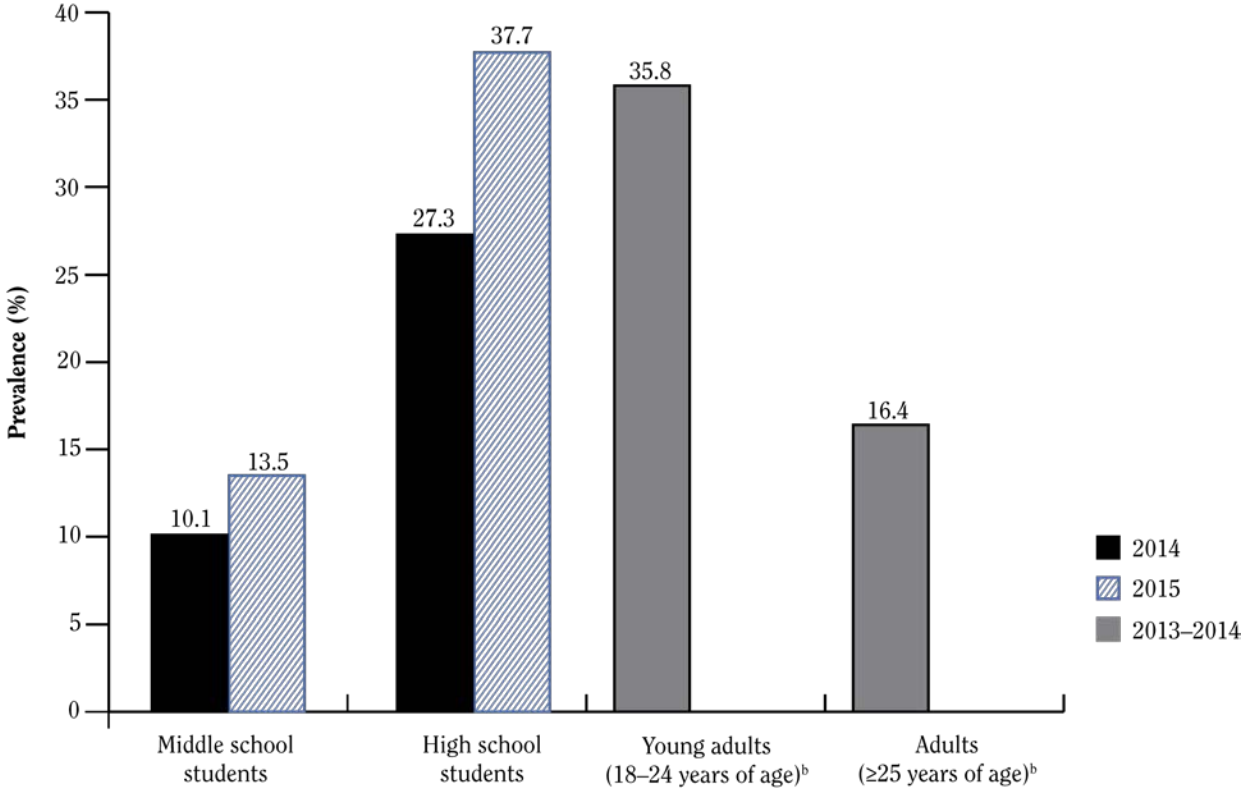

*Source:* Centers for Disease Control and Prevention, unpublished data (NYTS 2014, 2015; data: NATS 2013–2014).
[a]For middle school and high school students (NYTS 2014, 2015), current use included those who reported using e-cigarettes on 1 or more days in the past 30 days. For young adults and adults (NATS 2013–2014), current use included those who reported they had heard of, tried, and used e-cigarettes every day, some days, or rarely at the time of the interview.
[b]2013–2014 NATS data for young adults and adults were the latest data available when this Surgeon General's report was prepared.

conventional cigarettes (2.4%, 3.5%, and 5.8%) (Figure 7). However, among young adults 18–24 years of age, exclusive use of conventional cigarettes surpasses exclusive use of e-cigarettes and dual use of both products, according to data from the NATS (Figure 3; Table 2.8b). In 2013–2014, 9.6% of young adults were exclusive past-30-day conventional cigarette smokers, compared to 6.1% who were exclusive past-30-day e-cigarette users, and 7.5% who were past-30-day dual users.

Five longitudinal studies to date (Leventhal et al. 2015; Primack et al. 2015; Wills et al. 2016; Barrington-Trimis et al. 2016; Unger et al. 2016) suggest that e-cigarette use is related to the onset of other tobacco product use among youth and young adults, including cigarette smoking and other combustible tobacco product use (e.g., cigar and hookah use). However, these studies are limited in their ability to distinguish experimental conventional cigarette smokers from regular conventional cigarette smokers at follow-up. Therefore, more studies are needed to elucidate the nature of any true causal relationship between e-cigarette and combustible tobacco product use. Additionally, investigation of whether e-cigarette use is related to other types of substance use (e.g., marijuana, alcohol) might help distinguish the extent to which e-cigarette use may precede or follow other forms of substance use in the context of the common liability/vulnerability model (Vanyukov et al. 2012).

The most commonly cited reasons that youth and young adults report using e-cigarettes include curiosity (Schmidt et al. 2014; Biener and Hargraves 2015; Biener et al. 2015; Kong et al. 2015; McDonald and Ling 2015; Suris et al. 2015; Sutfin et al. 2015), flavorings/taste (Ambrose et al. 2015; University of Michigan 2015), use as a less harmful/less toxic alternative to conventional cigarettes

**Figure 6 Percentage of middle school students, high school students, young adults (18–24 years of age), and adults (≥25 years of age) who have ever[a] used e-cigarettes**




*Source:* Centers for Disease Control and Prevention, unpublished data (NYTS 2014, 2015; data: NATS 2013–2014).
[a]For middle school and high school students (NYTS 2014, 2015), ever use included those who reported using an e-cigarette, even once or twice. For young adults and adults (NATS 2013–2014), ever use included those who reported they had heard of and tried e-cigarettes.
[b]2013–2014 NATS data for young adults and adults were the latest data available when this Surgeon General's report was prepared.

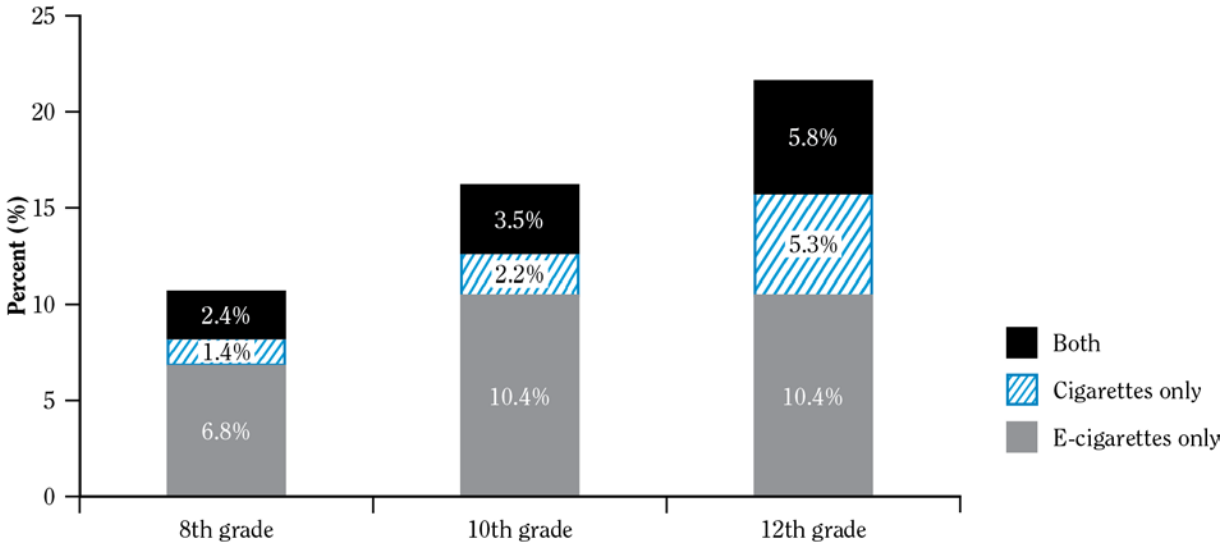
(Peters et al. 2013; Tucker et al. 2014; Ambrose et al. 2015; Kong et al. 2015; McDonald and Ling 2015; Sutfin et al. 2015), and avoidance of indoor smoking restrictions or disturbing people with secondhand smoke from conventional cigarettes (Tucker et al. 2014; Ambrose et al. 2015; Kong et al. 2015; McDonald and Ling 2015; Suris et al. 2015; Sutfin et al. 2015). Using e-cigarettes as an aid to conventional cigarette smoking reduction/cessation (Li et al. 2013; Schmidt et al. 2014; Tucker et al. 2014) does not appear to be a primary reason for use among youth and young adults. Youth and young adult smokers cite lack of satisfaction (Kong et al. 2015), poor taste (Pepper et al. 2014; Kong et al. 2015), and cost (Pepper et al. 2014; Kong et al. 2015) as reasons for discontinuing e-cigarette use. Additional research is needed to examine how reasons for use, including the appeal of flavored e-cigarettes, are causally related to the onset and progression of e-cigarette use among youth and young adults.

## Conclusions

1. Among middle and high school students, both ever and past-30-day e-cigarette use have more than tripled since 2011. Among young adults 18–24 years of age, ever e-cigarette use more than doubled from 2013 to 2014 following a period of relative stability from 2011 to 2013.

2. The most recent data available show that the prevalence of past-30-day use of e-cigarettes was similar among high school students (16% in 2015, 13.4% in 2014) and young adults 18–24 years of age (13.6%

**Figure 7** **Percentage of students in grades 8, 10, and 12 who used e-cigarettes and cigarettes in the past 30 days; Monitoring the Future (MTF) 2015**




*Source:* University of Michigan, Institute for Social Research, unpublished data (data: MTF 2015).
*Note:* Questions on e-cigarette use were asked on four of six questionnaire forms. Data presented here are based on those four forms only.

in 2013–2014) compared to middle school students (5.3% in 2015, 3.9% in 2014) and adults 25 years of age and older (5.7% in 2013–2014).

3. Exclusive, past-30-day use of e-cigarettes among 8th-, 10th-, and 12th-grade students (6.8%, 10.4%, and 10.4%, respectively) exceeded exclusive, past-30-day use of conventional cigarettes in 2015 (1.4%, 2.2%, and 5.3%, respectively). In contrast—in 2013–2014 among young adults 18–24 years of age—exclusive, past-30-day use of conventional cigarettes (9.6%) exceeded exclusive, past-30-day use of e-cigarettes (6.1%). For both age groups, dual use of these products is common.

4. E-cigarette use is strongly associated with the use of other tobacco products among youth and young adults, particularly the use of combustible tobacco products. For example, in 2015, 58.8% of high school students who were current users of combustible tobacco products were also current users of e-cigarettes.

5. Among youth—older students, Hispanics, and Whites are more likely to use e-cigarettes than younger students and Blacks. Among young adults—males, Hispanics, Whites, and those with lower levels of education are more likely to use e-cigarettes than females, Blacks, and those with higher levels of education.

6. The most commonly cited reasons for using e-cigarettes among both youth and young adults are curiosity, flavoring/taste, and low perceived harm compared to other tobacco products. The use of e-cigarettes as an aid to quit conventional cigarettes is not reported as a primary reason for use among youth and young adults.

7. Flavored e-cigarette use among young adult current users (18–24 years of age) exceeds that of older adult current users (25 years of age and older). Moreover, among youth who have ever tried an e-cigarette, a majority used a flavored product the first time they tried an e-cigarette.

8. E-cigarette products can be used as a delivery system for cannabinoids and potentially for other illicit drugs. More specific surveillance measures are needed to assess the use of drugs other than nicotine in e-cigarettes.

# Chapter 3. Health Effects of E-Cigarette Use Among U.S. Youth and Young Adults

There is little doubt that the use of e-cigarettes by youth and young adults represents self-administration of the drug nicotine, and this self-administration of nicotine puts youth at risk for addiction and many related harmful consequences. Animal research indicates adolescent brains are particularly sensitive to nicotine's effects, such that subsequent self-administration is more likely, and that same literature indicates that this age group is at risk for a constellation of nicotine-induced neural and behavioral alterations (Table A3.1-4 in Appendix 3.1). Studies of the effects of maternal smoking of conventional cigarettes during pregnancy, coupled with preclinical literature (e.g., animal studies) examining the effects of administration of nicotine during pregnancy, suggest that e-cigarette use by mothers during pregnancy could present a wide variety of risks to fetal, infant, and child brain development.

Users of e-cigarettes risk respiratory exposure to a variety of aerosolized chemicals, including solvents and flavorants added intentionally to e-liquids, adulterants added unintentionally, and other toxicants produced during the heating/aerosolization process (see the section on "Effects of the Inhalation of Aerosol Constituents Other than Nicotine" in Chapter 3). The health impacts of frequent exposure to the toxicants in e-cigarette aerosol are not well understood, though several are known carcinogens. The detection and level of these carcinogens depend on several factors, including the concentration of the e-liquid and the strength of the heating device. Although adults report using e-cigarettes as a cessation device, the evidence supporting the effectiveness of e-cigarettes as an aid for quitting conventional cigarettes remains unproven (Bullen et al. 2013; Caponnetto et al. 2013; Grana et al. 2014b) and nonexistent among youth (Bullen et al. 2013; Caponnetto et al. 2013; Grana et al. 2014b).

Further research is warranted to focus on the characteristics of e-cigarette devices, the constituents of e-liquids, and the user behaviors that can influence the yield of nicotine and other toxicants (Shihadeh and Eissenberg 2015). This close focus includes providing details of devices (e.g., voltage of the power supply, heating element resistance) and components of e-liquids (e.g., propylene glycol, vegetable glycerin, other additives), and measuring user puff topography. Standardization of procedures for producing and delivering the aerosol is likely a necessary component of at least some in vivo and in vitro work. Preclinical work examining the effects of e-cigarette aerosols is a clear research need and, again, the standardization of procedures for production and delivery of the aerosol is necessary. To enhance relevance, the parameters of aerosol production should span the range of those seen with humans (Shihadeh and Eissenberg 2011).

The huge variety of products of different origin and design, the rapid appearance of new products, and the varied ways in which consumers use these products make the development of standard measurement conditions challenging (Famele et al. 2015). Accordingly, more research is needed to understand how different design features relate to potential toxicity—for example, how various compounds in e-cigarettes are affected by heating, changes in chemical composition, or pH; to what extent these compounds are absorbed into the bloodstream; and how additives to the e-liquid affect the bioavailability of these compounds, among other considerations. Research is also needed to understand whether potential health risks may be ameliorated by changes in product engineering.

## Conclusions

1. Nicotine exposure during adolescence can cause addiction and can harm the developing adolescent brain.

2. Nicotine can cross the placenta and has known effects on fetal and postnatal development. Therefore, nicotine delivered by e-cigarettes during pregnancy can result in multiple adverse consequences, including sudden infant death syndrome, and could result in altered corpus callosum, deficits in auditory processing, and obesity.

3. E-cigarettes can expose users to several chemicals, including nicotine, carbonyl compounds, and volatile organic compounds, known to have adverse health effects. The health effects and potentially harmful doses of heated and aerosolized constituents of e-cigarette liquids, including solvents, flavorants, and toxicants, are not completely understood.

4. E-cigarette aerosol is not harmless "water vapor," although it generally contains fewer toxicants than combustible tobacco products.

5. Ingestion of e-cigarette liquids containing nicotine can cause acute toxicity and possibly death if the contents of refill cartridges or bottles containing nicotine are consumed.

# Chapter 4. Activities of the E-Cigarette Companies

Although the e-cigarette marketplace is complicated by the differences in brands that are owned by tobacco companies versus independent brands, e-cigarette companies continue to change and influence the manufacturing, price, marketing and promotion, and distribution of e-cigarette products and accessories. The e-cigarette market continues to grow, with projected sales of $3.5 billion in 2015. Consolidation of e-cigarette companies has been rapid, with the first major merger taking place in 2012. These mergers and acquisitions are likely to continue, but the rate of consolidation may slow down as sales of "cigalikes" (products that resemble cigarettes) have recently decelerated, and "vape shops" could have the potential to influence the e-cigarette marketplace based on the current structure of the marketplace and regulatory landscape. Chapter 4 shows that many of the marketing techniques used by e-cigarette companies are similar to those used by the tobacco industry for conventional cigarettes, and that awareness by youth and young adults of this marketing, and their levels of exposure to it, is high. Further, tracking marketing expenditures and product sales is difficult because of the rapidly changing venues, including "vape shops," use of social media and online advertising, and limited regulation of marketing.

## Conclusions

1. The e-cigarette market has grown and changed rapidly, with notable increases in total sales of e-cigarette products, types of products, consolidation of companies, marketing expenses, and sales channels.

2. Prices of e-cigarette products are inversely related to sales volume: as prices have declined, sales have sharply increased.

3. E-cigarette products are marketed in a wide variety of channels that have broad reach among youth and young adults, including television, point-of-sale, magazines, promotional activities, radio, and the Internet.

4. Themes in e-cigarette marketing, including sexual content and customer satisfaction, are parallel to themes and techniques that have been found to be appealing to youth and young adults in conventional cigarette advertising and promotion.

# Chapter 5. E-Cigarette Policy and Practice Implications

Chapters 1–4 document the particular challenges posed by the rapid emergence and dynamic nature of e-cigarette use among youth and young adults. The principles and strategies articulated in the 2014 Surgeon General's report and prior reports are also relevant to e-cigarettes. The 2014 report was written not long after the use of e-cigarettes began to surge dramatically; that report emphasized the need for rapid elimination of conventional cigarettes and other combustible tobacco products, but did not discuss strategies to minimize adverse effects among youth and young adults (USDHHS 2014). Building on this foundation, Chapter 5 sets out an evidence-based strategy for the future. It describes recommendations related to e-cigarettes that can be taken at the state and local levels to address e-cigarette use among youth and young adults, such as:

- Incorporating e-cigarettes into smokefree policies;
- Preventing access to e-cigarettes by youth;
- Significant increases in tax and price;
- Retail licensure;
- Regulation of e-cigarette marketing that is likely to attract youth and young adults, to the extent feasible under the law; and
- Educational initiatives targeting this population.

## Conclusions

1. The dynamic nature of the e-cigarette landscape calls for expansion and enhancement of tobacco-related surveillance to include (a) tracking patterns of use in priority populations; (b) monitoring the characteristics of the retail market; (c) examining policies at the national, state, local, tribal, and territorial levels; (d) examining the channels and messaging for marketing e-cigarettes in order to more

fully understand the impact future regulations could have; and (e) searching for sentinel health events in youth and young adult e-cigarette users, while longer-term health consequences are tracked.

2. Strategic, comprehensive research is critical to identify and characterize the potential health risks from e-cigarette use, particularly among youth and young adults.

3. The adoption of public health strategies that are precautionary to protect youth and young adults from adverse effects related to e-cigarettes is justified.

4. A broad program of behavioral, communications, and educational research is crucial to assess how youth perceive e-cigarettes and associated marketing messages, and to determine what kinds of tobacco control communication strategies and channels are most effective.

5. Health professionals represent an important channel for education about e-cigarettes, particularly for youth and young adults.

6. Diverse actions, modeled after evidence-based tobacco control strategies, can be taken at the state, local, tribal, and territorial levels to address e-cigarette use among youth and young adults, including incorporating e-cigarettes into smoke-free policies; preventing the access of youth to e-cigarettes; price and tax policies; retail licensure; regulation of e-cigarette marketing that is likely to attract youth and young adults, to the extent feasible under the law; and educational initiatives targeting youth and young adults. Among others, research focused on policy, economics, and the e-cigarette industry will aid in the development and implementation of evidence-based strategies and best practices.

# The Call to Action

Finally, the Call to Action is issued to accelerate policies and approaches that can reduce the public health threat posed by e-cigarette use among young people. It offers a list of goals and evidence-based strategies designed to reduce the public health threat posed by e-cigarette use among youth and young adults.

## Goal 1. First, Do No Harm

- ***Strategy 1A.*** Implement a comprehensive strategy to address e-cigarettes that will avoid adverse consequences and give careful consideration to the risks for youth and young adults. This can be done by including e-cigarettes in policies and programs related to conventional cigarette smoking at the national, state, local, tribal, and territorial levels.

- ***Strategy 1B.*** Provide consistent and evidence-based messages about the health risks of e-cigarette use and exposure to secondhand aerosol from e-cigarettes.

## Goal 2. Provide Information About the Dangers of E-Cigarette Use Among Youth and Young Adults

- ***Strategy 2A.*** Educate parents, teachers, coaches, and other influencers of youth about the risks of e-cigarette use among youth and young adults.

- ***Strategy 2B.*** Educate health professionals about the risks of e-cigarette use among youth and young adults.

## Goal 3. Continue to Regulate E-Cigarettes at the Federal Level to Protect Public Health

- ***Strategy 3A.*** Implement FDA regulatory authority over the manufacturing, marketing, and distribution of e-cigarettes.

- ***Strategy 3B.*** Reinforce other federal agencies as they implement programs and policies to address e-cigarettes.

## Goal 4. Promote Programs and Policies at the State and Local Levels to Prevent E-Cigarette Use Among Youth and Young Adults

- ***Strategy 4A.*** State, local, tribal, and territorial governments should implement population-level strategies to reduce e-cigarette use among youth and young adults, such as including e-cigarettes in smokefree indoor air policies, restricting youth access to e-cigarettes in retail settings, licensing retailers, and establishing specific package requirements.

- ***Strategy 4B.*** Coordinate, evaluate, and share best practices from state and local entities that have implemented programs and policies to address e-cigarette use among youth and young adults.

## Goal 5. Curb Advertising and Marketing that Encourages Youth and Young Adults to Use E-Cigarettes

- ***Strategy 5A.*** Curb e-cigarette advertising and marketing that are likely to attract youth and young adults.

- ***Strategy 5B.*** Urge the e-cigarette companies to stop advertising and marketing that encourages and glamorizes e-cigarette use among youth and young adults.

## Goal 6. Expand Surveillance, Research, and Evaluation Related to E-Cigarettes

- ***Strategy 6A.*** Improve the quality, timeliness, and scope of e-cigarette surveillance, research, and evaluation.

- ***Strategy 6B.*** Address surveillance, research, and evaluation gaps related to e-cigarettes.

# Summary

We know a great deal about what works to effectively prevent tobacco use among young people (USDHHS 2012). Now we must apply these strategies to e-cigarettes—and continue to apply them to other tobacco products. To achieve success, we must work together, aligning and coordinating efforts across a wide range of stakeholders, including individuals and families; public health professionals and clinicians; federal, state, local, tribal, and territorial governments; public health agencies; and researchers. We must protect our nation's young people from a lifetime of nicotine addiction and associated problems by immediately addressing e-cigarettes as an urgent public health problem. Now is the time to take action.

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