NICOTINE AND TOBACCO USE

Robin Mermelstein and Kristin Brikmanis

Tobacco use remains the leading preventable cause of death in the United States and worldwide, accounting for more than 7 million deaths globally in 2017 (World Health Organization, 2017). In the U.S., approximately 500,000 people die each year from tobacco-related diseases, and another 16 million live with a serious illness caused by smoking (Centers for Disease Control and Prevention, 2017). Despite these unacceptably high numbers, tremendous progress in tobacco control has been made. The prevalence of smoking today is less than half of what it was in 1964 when the first Surgeon General’s Report conclusively linked smoking to lung cancer in men. Although the smoking problem is not solved, the unprecedented and disruptive changes in the tobacco product landscape that are currently occurring present opportunities to decrease greatly the tremendous toll from tobacco use. Cigarette smoking may soon be seen as primarily a twentieth-century behavior, with alternative nicotine and tobacco products overtaking cigarettes as we move forward in the twenty-first century.

This chapter provides an overview of the current state of tobacco use in the U.S. and globally. Given the rapidly changing tobacco product landscape, this chapter focuses on recent trends and concepts helpful to understanding these changes, and does not review the more traditional behavioral interventions or theories of smoking cessation and relapse (see Baker et al., 2016 for a recent conceptual overview of the process of smoking cessation and methodological issues to move the field forward). Rather, this chapter describes the recent changes in patterns of tobacco use; considers how tobacco use develops across adolescents and young adults; provides conceptual frameworks for understanding the complexity of patterns of use with a focus on the role of emotions and mood in driving and maintaining smoking; discusses the role of nicotine dependence in understanding tobacco use; and provides an overview of how e-cigarette use may influence patterns of traditional, combustible cigarette smoking. Finally, we briefly discuss intervention approaches to further reduce the harm from tobacco use.

Epidemiology of Tobacco Use

We are in the midst of a revolution in the tobacco product landscape and tobacco use behavior, with new products, delivery systems, and alternatives to traditional combustible cigarettes being introduced rapidly and globally and having strong influences on tobacco use patterns. The term alternative nicotine delivery systems (ANDS) encompasses a broad class of noncombustible tobacco products or products that contain nicotine. The most common of these products is e-cigarettes, or the class of electronic nicotine delivery systems (ENDS). The more recent “heat not burn” tobacco products,
such as Phillip Morris International’s iQOS system, is also a noncombustible tobacco product that uses electronics to heat, not combust, tobacco to produce a nicotine-containing vapor. Heat not burn systems are marketed in several countries outside the U.S., but are not yet approved for sale in the U.S. Abrams and colleagues (Abrams et al., 2018) present a continuum of harm along which different tobacco products fall, from no harm at one end to extreme toxicity at the other. Products at the very low end of the harm continuum are nicotine replacement therapies, such as nicotine patches or nicotine gum or lozenges. These are followed by e-cigarettes. Combusted tobacco products (e.g., cigarettes, cigars, cigarillos, hookah) fall at the highest end of toxicity. Smokeless tobacco products, although less harmful than combusted products, have a range of harm levels, with typical U.S. smokeless tobacco products having higher levels of toxicity than Swedish-type snus with low nitrosamines, which are potent carcinogens.

Cigarettes are the most commonly used tobacco product in the U.S. (Jamal et al., 2018). In 2016, 15.5 percent of adults over age 18 in the U.S. smoked cigarettes. This represents a significant decline from the 2005 prevalence of 20.9 percent (Jamal et al., 2018) and an even more notable decline from 1965, when 42 percent of adults in the U.S. population smoked (U.S. Department of Health and Human Services, 2014). As smoking prevalence has declined, so has the intensity and frequency of smoking. Among current smokers, the proportion of daily smokers declined from 80.8 percent in 2005 to 76.1 percent in 2016, and over the same time period, the mean number of cigarettes smoked per day decreased from 16.7 to 14.1 (Jamal et al., 2018).

Smoking is not evenly distributed among the population. Smoking prevalence is higher among those with no more than a high school education; those who live below the poverty level; those who are uninsured or insured through Medicaid; those who are lesbian, gay, or bisexual compared to those who are heterosexual; and those who have serious psychological distress or a disability (Jamal et al., 2018). There are also geographic variations in smoking prevalence in the U.S.: Smoking is more common in the South and the Midwest than in other parts of the country.

Gender, race, and ethnicity all matter in examining patterns of tobacco use and tobacco-related health disparities in the U.S. Smoking continues to be more common among males than females (17.5 percent vs. 13.5 percent), and notable disparities in tobacco use remain across racial/ethnic groups (Jamal et al., 2018). Patterns of use of non-cigarette tobacco products also show sex differences, with smokeless tobacco and big cigar use more common among men than women (U.S. Department of Health and Human Services, 2014), but it is less clear how patterns of little cigars and e-cigarettes vary. Prevalence of use is a combination of both rates of initiation and rates of cessation. Although there have been fewer sex differences in rates of initiation in the recent past, there has been substantial debate about whether women have more difficulty in quitting smoking than do men. A recent review of gender differences in smoking cessation (Smith, Bessette, Weinberger, Sheffer, & McKee, 2016) found that women have more difficulty maintaining long-term abstinence than men in clinical efficacy trials, but data from prospective observational trials were more mixed, echoing other research that similarly concluded that there is not convincing evidence that men are more likely to quit smoking successfully than women (Jarvis, Cohen, Delnevo, & Giovino, 2013).

Tobacco use patterns and related health disparities also vary by race and ethnicity in the U.S. but in complex ways that may reflect interactions among race/ethnicity, social class, biological factors, and co-incident physical and mental disorders (National Cancer Institute, 2017). For example, although African-Americans smoke at lower intensities than do Whites, they have a higher incidence of smoking-related lung cancer. There is no clear consensus on an explanation for this disparity, but possible factors include greater use of menthol cigarettes by African-Americans, differences in nicotine metabolism that may affect inhalation and use patterns, and differences in genetic factors (National Cancer Institute, 2017). The highest prevalence rates of smoking occur with American Indian/Alaskan Native or multiracial adults in the U.S. (Jamal et al., 2018).
Researchers have debated whether the smoking population has fundamentally changed as the social acceptability and prevalence of smoking has declined. The hardening hypothesis suggests that as smoking becomes less prevalent, the remaining smokers will be either more deviance prone (Chassin, Presson, Morgan-Lopez, & Sherman, 2007), more nicotine dependent, or may have more trouble quitting (Hughes, 2011). In general, though, the data have not strongly supported the hardening hypothesis, but rather, as Warner and Burns (2003) suggest, hardening may be more usefully understood in the context of specific subgroups of smokers, such as those with mental illness or emotional disorders, who make up an increasing proportion of the remaining smoking population.

While the prevalence of cigarette smoking has decreased, the prevalence of other tobacco product use has increased over the past few years. In 2015, 20.1 percent of U.S. adults used any combustible tobacco product; 3.4 percent of adults used cigars or cigarillos, 1.2 percent used hookah, 2.3 percent used a smokeless tobacco product, and 3.5 percent used e-cigarettes. Dual or poly-tobacco product use is also becoming more common, with 3.9 percent of adults in 2015 reporting use of two or more products (Phillips et al., 2017). Multiple tobacco product use is most common among young adults (Richardson, Williams, Rath, Villanti, & Vallone, 2014), which may well be a harbinger of the future of tobacco use patterns. In sum, overall patterns of tobacco use are changing, with adults smoking cigarettes more intermittently and at lower levels of intensity, while the use of other tobacco products has been increasing.

Tobacco use is a global health issue, and patterns of tobacco product use vary substantially by world region. Smoking prevalence is declining in all world regions, with the exception of the African and Eastern Mediterranean regions (National Cancer Institute & World Health Organization, 2016). In many other countries, the prevalence of smoking among women is strikingly lower than that for men, primarily due to sociocultural and economic factors (National Cancer Institute & World Health Organization, 2016). For example, in the Eastern Mediterranean region, 36.2 percent of men smoke compared to 2.9 percent of women. Similarly, in the Western Pacific region, 48.5 percent of men smoke compared to 3.4 percent of women (World Health Organization, 2018). As in the U.S., a disproportionate burden of tobacco use and harm falls among disadvantaged groups, particularly within low and middle income countries. Perhaps one of the more remarkable changes in tobacco product use patterns has occurred in Norway. In 2017, for the first time, more people in Norway were using snus on a daily basis (12 percent) than were smoking cigarettes daily (11 percent; Statistics/Norway, The Norwegian Directorate of Health, 2018). Snus is a smokeless tobacco product that is manufactured in a way that reduces the harmful constituents found in other tobacco products and does not appear to cause cancers or respiratory disease (Foulds, Ramstrom, Burke, & Fagerstrom, 2003). The transition in Norway from smoking to snus is generally seen as an example of a public health harm reduction success.

Adolescent and Young Adult Tobacco Use

Most tobacco use starts during adolescence or during the young adult years. Until very recently, the majority of all cigarette users smoked their first cigarette by age 18 (Institute of Medicine, 2015). Following the 1998 Master Settlement Agreement, which placed restrictions on marketing tobacco products to youth, the tobacco industry focused its marketing efforts on young adults (Biener & Albers, 2004) and, in the past few years, more young adults than adolescents have been initiating smoking (Thompson, Mowery, Tebes, & McKee, 2017). However, almost no initiation occurs after age 26 (Institute of Medicine, 2015). Thus, tracking both adolescent and young adult tobacco use patterns is critical to understanding and curbing the tobacco epidemic.

Unlike surveys of adults older than age 18, which define current smoking as lifetime use of at least 100 cigarettes and at least some of every day smoking, surveys of youth under age 18 define current use as any tobacco product use in the past 30 days—a much lower threshold for defining a user. The
prevalence of cigarette smoking among youth has dropped markedly over the past few decades. Past month smoking among 12th graders peaked in 1976 at 39 percent, declined for a few years, and rose steadily again until about 1997, when prevalence rates once again approached 40 percent (Johnston et al., 2018). With the implementation of a variety of strong policy and tobacco control interventions, adolescent smoking prevalence started a substantial decline, and current cigarette smoking among youth in the U.S. is now at the lowest levels in decades. In 2017, only 9.7 percent of 12th graders reported any cigarette use in the past 30 days (Johnston et al., 2018). As with adults, however, adolescents are also using a variety of other tobacco products; 4.9 percent of 12th graders reported current use of smokeless tobacco, 5.6 percent reported use of big cigars, 10.1 percent reported use of flavored little cigars, 6.6 percent of regular little cigars, and 5.0 percent reported current use of hookah. Polyproduct use is common among adolescents; among high school students reporting any past 30-day tobacco use, 47.2 percent were poly-users (Jamal et al., 2017).

Among adolescents, vaping is now the most common method for using tobacco. Vaping involves the use of a battery-powered device to heat a liquid that releases chemicals in an aerosol that is inhaled. Vaping devices include e-cigarettes, mods, e-pens, e-hookah, and Juuls, which look like a USB device. Vaping liquids can contain a wide variety of flavors, ranging from traditional tobacco flavor to menthol, mint, fruit, alcohol, dessert, spice, or other flavors, and may contain nicotine or the active ingredients in marijuana. Because of the variety of substances that may be used in vaping, the most recent 2017 version of the Monitoring the Future survey of U.S. adolescent drug, alcohol, and tobacco use included questions that distinguished among the different types of vaping ingredients. In 2017, data from the Monitoring the Future survey showed that 16.6 percent of 12th graders reported any vaping in the past month; 11.0 percent reported vaping nicotine; 9.7 percent reported vaping just flavors; 5.0 percent reported vaping hookah; and 4.9 percent reported vaping marijuana (Johnston et al., 2018). Although there are some concerns about the reliability and accuracy of adolescents’ self-reports and knowledge of what is in the e-liquids, these data are striking, as the rates of vaping nicotine are now higher than the rates of traditional, combustible cigarette use.

The Development of Tobacco Use: A Conceptual Framework

Tobacco use evolves over multiple phases, as individuals transition across the continuum from never using to initial use of a product, to occasional use, and to more regular use and dependence. Tobacco use is a multi-determined behavior, resulting from the complex and dynamic interplay of converging genetic, social, psychological, and environmental factors, many of which are developmentally related, and each of which may have differential importance at varying stages along the use continuum (Baker, Brandon, & Chassin, 2004). For example, social, environmental, and psychological factors are central in the transition from never use to initial experimentation, but biological, genetic, and mood factors may assume greater importance in the transition from initial use to more regular use and dependence. Researchers have devoted tremendous effort over the past several decades to identifying a vast array of factors that predict smoking initiation, escalation, and cessation. This research has been invaluable in helping to understand vulnerabilities to tobacco use at different stages along the continuum of smoking and has led researchers to emphasize that tobacco use is the result of an intricate interplay of numerous intrapersonal and contextual variables. As such, no single theory can adequately and parsimoniously explain tobacco use. Rather, researchers have focused on more complex conceptual frameworks that help to organize multilevel (biological, environmental, societal, family, intrapersonal, social) factors.

Broad conceptual frameworks such as Social Cognitive Theory (Bandura, 2001), the Social Ecological Model (Bronfenbrenner, 1979), and the Theory of Triadic Influence (Flay, 1999) help to
understand the dynamic influences of personal factors and contextual factors on tobacco use behavior and to capture the reciprocal determinism of interactions among personal factors, biology, environmental influences, and tobacco use behavior. Factors across these levels work together to create curiosity and an openness to try tobacco. Contexts of tobacco use provide insights into the functional value and motivation for using these products; understanding these influences can shed light on the factors that predict use patterns. Proximal contexts include both social contexts (with whom, social pressures and norms) and emotional contexts (mood in the moment).

Macro-environmental influences may be especially powerful factors in increasing adolescents’ and young adults’ susceptibility to using tobacco. There is significant empirical literature linking exposure to cigarette marketing, including through movies and television, and subsequent smoking (e.g., Hanewinkel, Isensee, Sargent, & Morgenstern, 2011). Theories of media exposure effects, such as the “super peer” theory (Brown, Halpern, & L’Engle, 2005), suggest that the media influences adolescents’ perceptions of what is normative and acceptable, and may even have a stronger influence than parents or peers (Scull, Kupersmidt, Parker, Elmore, & Benson, 2010; Ward, Day, & Epstein, 2006). Interpersonal, social level influences have been well studied at each phase of the smoking continuum from initiation to relapse, with consistent deleterious effects found for the presence of other smokers on an individual’s susceptibility to use and relapse following cessation (Baker, Brandon, & Chassin, 2004). Potential mechanisms include modeling, access to cigarettes, cue reactivity, and direct messages supporting use. Other individual level differences include substantial evidence for genetic vulnerabilities, socioeconomic status, knowledge and attitudes about tobacco products, motives for use, psychological symptoms, and comorbid substance use, among others (Baker et al., 2004). Of note is that although most smokers are aware of the major health consequences of smoking, smokers tend to underestimate the magnitude of the risks and tend not to personalize these risks (Institute of Medicine, 2015). Adolescents and young adults are especially likely to underestimate the health risks, making them even more likely to be susceptible to environmental level marketing and advertising influences (Institute of Medicine, 2015).

One of the more useful models for understanding patterns of tobacco use is the traditional epidemiologic model of agent, host, vector, and environment (Orleans & Slade, 1993). This model is especially timely with its inclusion of the agent, given that the agent (cigarettes and other tobacco products) has changed considerably over the past several decades, as tobacco companies had manipulated the level of nicotine in products to promote addiction or enhanced flavorings and taste options (Glantz, 1996), or more recently, as potentially reduced harm exposure products are being developed. Features of the agent may make the product more addictive, more appealing, or more attractive. The host is the individual user. Multiple host factors can influence use, including motivation to start, switch products, or to stop using; genetic susceptibility to nicotine dependence; comorbidities; misperceptions and cognitive biases; personality and temperament factors; and socioeconomic factors (U.S. Department of Health and Human Services, 2014). Host factors can also include subjective experiences with tobacco products, which may help explain why some individuals experiment with tobacco and stop, whereas others experiment and escalate to dependence (Pomerleau, Collins, Shiffman, & Pomerleau, 1993). The vector is the entity that carries the agent to susceptible individuals. Tobacco companies produce and market their products in ways to maximize their appeal, especially to vulnerable populations, for example, young adults (Cummings, 2004). Environmental influences include traditional influences across levels of culture, family, and peer influences as well as strong media influences, which include the powerful effects of both tobacco use in traditional and social media channels (Charlesworth & Glantz, 2005; Freeman, 2012). Environmental influences also include smoke- and tobacco-free policies, access and age restrictions to tobacco products, smoking cessation promotions, and advice to quit from health professionals.
Influence of Mood and Emotions on Tobacco Use

Although no one theory can comprehensively incorporate the multitude of factors that drive initiation, escalation, and cessation of tobacco use, researchers have highlighted the importance of an individual’s in-the-moment experience and immediate context of using tobacco as an important proximal driver of whether tobacco use continues, escalates, or discontinues. There is strong evidence, for example, that adolescents and young adults derive immediate affective benefits from smoking (enhanced positive mood and decreased negative mood) and that these changes predict escalation (Mermelstein, Hedeker, & Weinstein, 2009; Piatecki, Trela, Hedeker, & Mermelstein, 2014; Weinstein & Mermelstein, 2013a, 2013b; Weinstein, Mermelstein, & Shiffman, 2008). Researchers often assess whether mood-related processes account for the acquisition and progression of smoking or tobacco use. In an authoritative review, Kassel, Stroud, and Paronis (2003) highlighted the importance of considering the stage of smoking with focused, developmentally specific questions to improve our understanding of the relationship between mood and smoking, and noted the importance of considering both mood-enhancing and negative affect reduction effects as important drivers of smoking at all stages. They also pointed out the importance of considering within-person changes in mood that influence tobacco use and recommend using research designs that capture within-person variability, and not only between-person differences in mood.

The transdiagnostic emotional vulnerability model (TEVM; Leventhal & Zvolensky, 2015) is a recent, integrative conceptualization for understanding the mood-smoking link. The TEVM emphasizes a core set of common biobehavioral traits that underpin the range of emotional symptoms and disorders often associated with smoking. Anhedonia (i.e., diminished pleasure/interest in response to awards) is emphasized as a factor that amplifies smoking’s anticipated and actual affect-enhancing properties, thereby contributing to progression across the smoking continuum, including escalation from experimentation. Both anhedonia (Audrain-McGovern, Rodriguez, Leventhal, et al., 2012) and negative mood (Weinstein et al., 2008; Weinstein & Mermelstein, 2013a) predict escalation during later teen years. Further support comes from recent research by Ameringer and colleagues (Ameringer, Chou, Sussman, Unger, & Leventhal, 2015) who used confirmatory factor analysis to compare different models of relationships among nine measures of affective and behavioral symptoms implicated in smoking (e.g., depression, anxiety, anhedonia, ADHD, happiness, and alcohol use disorder symptoms). A three-factor model that separated the latent dimensions of deficient positive affect, negative affect, and disinhibition was the best fit for the relationship between experimentation and lifetime smoking, but they noted that low positive and high negative affect factors were associated most strongly with the number of cigarettes smoked each day. Thus, these recent conceptualizations suggest that latent shared factors may be the most parsimonious explanation of how multiple manifestations of psychological dysfunction play a role in smoking and escalation, and emphasize the importance of the broad domains of positive/negative affect and boredom/anhedonia.

The Development of Nicotine Dependence

Nicotine is the primary driving force behind continued cigarette smoking and tobacco use dependence. Abrams et al. (2018) provide one of the most useful definitions of nicotine dependence that conveys the complexity and multidimensional features of the phenomenon:

Dependence refers to the potential for the product to provide satisfaction and, relatedly, its potential to induce addiction, which is a function of both its pharmacological and its subjective rewarding and sensory properties. Dependence can also reflect a response to negative consequences of stopping smoking (withdrawal) and to wanting the positive
and desirable effects that nicotine can have for some users (e.g., the satisfaction related to improved alertness, attention, concentration, memory, or mood).

(p. 14.7)

Although nicotine itself is not the cause of the diseases that result from smoking, the Federal Drug Administration (FDA) has recently announced a comprehensive plan for nicotine regulation that accommodates the notion that nicotine may be delivered in lowered harm products (Gottlieb & Zeller, 2017). Nicotine dependence still does matter; high nicotine dependence consistently and robustly predicts a failure to stop smoking (U.S. Department of Health and Human Services, 2014). If we understand more about the development of dependence, we then have the potential to interrupt progression from early use to dependence, and to prevent the accumulated harms from smoking.

Adolescence and young adulthood are the key periods of vulnerability to tobacco use and to the progression to nicotine dependence (Jamner et al., 2003). The adolescent brain may be especially primed to be receptive to the rewarding effects of nicotine (Institute of Medicine, 2015; Jamner et al., 2003). The young adult years (ages 18–25) present even further vulnerabilities as young adults are a prime target for marketing and advertising by the tobacco industry (Ling & Glantz, 2002; Ling, Lee, Hong, et al., 2014). The young adult years are also the period of greatest escalation and entrenchment of smoking (Richardson et al., 2014); significant initiation of tobacco use still occurs after age 18 (Johnston, O’Malley, Bachman, Schulenberg, & Miech, 2014). Tobacco use in the young adult years is further complicated by its strong association with escalation of other risk behaviors, including marijuana and problem alcohol use, both of which may act synergistically with nicotine to increase tobacco dependency (Agrawal, Budney, & Lynskey, 2012).

Longitudinal studies are needed to establish the latency from first tobacco use to dependence. Results of the relatively small number of such longitudinal studies vary, in large part, because of differing definitions and measures of dependence. Measures may range from questionnaires that assess dependence along a continuum, and that ask about perceptions of desire for cigarettes, behavioral patterning, and motivational factors (e.g., the Fagerstrom Test for Nicotine Dependence; Heatherton, Kozlowski, Frecker, & Fagerstrom, 1991; the Wisconsin Inventory of Smoking Dependence Motives, Piper et al., 2008) to checklists that cover specific symptoms, such as in the Diagnostic and Statistical Manual of the American Psychiatric Association. The most recent DSM-V includes criteria for tobacco use disorder which mimic criteria for other substance use disorders, and includes a newly added symptom of craving or strong desire to use tobacco (American Psychiatric Association, 2013). Overall evidence suggests that symptoms of nicotine dependence develop relatively early in the process of trying and continued use. DiFranza and colleagues (DiFranza et al., 2002) found that 50 percent of youths experienced their first symptom of dependence about 486 days after their first cigarette, and about 54 days after the onset of monthly smoking. Gervais, O’Loughlin, Meshefedjian, Bancej, and Tremblay (2006) found that 25 percent of adolescent smokers experienced selected symptoms within 11 months, and full nicotine dependence, as measured by the ICD-10, within 41 months. Kandel, Hu, Griesler, and Schaffran (2007) used survival analysis to estimate latency to individual DSM-IV nicotine dependence criteria as well as to the full DSM-IV syndrome. They found that 25 percent of adolescents experienced the syndrome within 23 months of first using cigarettes.

More recent longitudinal evidence also supports the notion that a substantial number of adolescents experience nicotine dependence symptoms prior to smoking 100 cigarettes (an accepted criteria for marking progression to regular smoking), with endorsement of individual symptoms ranging from 9 to 59 percent (Zhan, Dierker, Rose, Selya, & Mermelstein, 2012). Dierker and colleagues (Dierker, Hedeker, Rose, Selya, & Mermelstein, 2015) found that even low levels of endorsement of nicotine dependence symptoms among adolescents who had smoked fewer than 100 cigarettes in their lifetime predicted daily smoking four years later in young adulthood. These findings thus add to accumulating evidence that early emerging nicotine dependence symptoms reported at low levels of
smoking exposure signal a greater propensity for continued smoking and escalation to daily smoking levels. We have little data to date, though, on how nicotine dependence develops or varies with the use of non-cigarette tobacco products.

### E-Cigarettes and Transitions Into and Out of Smoking

Given the increasing use of e-cigarettes along with dual and poly-product use among youth and young adults, it is critical to understand how the use of one product, particularly e-cigarettes, affects patterns of combustible cigarette smoking. Substantial evidence supports the conclusion that e-cigarettes are less harmful than combustible cigarettes (NAS, 2018). In general, researchers and public health advocates acknowledge the potential for significant risk reduction if adult smokers who are unable or unwilling to stop smoking switched completely from combustibles to e-cigarettes.

To date, there is not sufficient evidence from randomized controlled trials to evaluate whether e-cigarettes are effective as cessation aids (NAS, 2018), in part because of regulatory challenges of conducting these trials in the U.S. There is suggestive evidence, though, from observational trials that more frequent use of e-cigarettes is associated with an increased likelihood of cessation (NAS, 2018).

The controversies surrounding e-cigarettes are more heated, however, when considering youth use. The concern is whether e-cigarettes may act as a “gateway” to combustible cigarette use, serving as a first step along a trajectory to long-term smoking and addiction. Three possible mechanisms may explain ways in which e-cigarettes may affect smoking trajectories among youth and young adults (NAS, 2018). The first, the common liability hypothesis (Etter, 2017; Kozlowski & Warner, 2017), proposes that e-cigarettes and smoking may be linked because of a shared vulnerability for youth to experiment with substances. With the common liability hypothesis, one would expect to see e-cigarette use among the youth who show commonly found risk factors for smoking (e.g., sensation seeking). Youth who are prone to experimentation may briefly try smoking or vaping, but may not necessarily progress to regular smoking. For these youth, e-cigarette use may not increase risk for combustible cigarette smoking progression.

A second mechanism is the diversion hypothesis (NAS, 2018), which proposes that e-cigarettes may reduce smoking among high risk youth who would be likely to initiate smoking in the absence of e-cigarettes by providing an alternative. In contrast, the third potential mechanism is the catalyst hypothesis, which maintains that e-cigarette use increases smoking among low risk youth who would have been unlikely to initiate smoking without the presence of e-cigarettes (Schneider & Diehl, 2016). The premise of the catalyst hypothesis is that youth who vape may habituate more easily to the aversive pharmacological effects of nicotine, may become sensitized to the more addictive and pleasurable aspects of nicotine (Schneider & Diehl, 2016), and that the act of vaping and self-administration may make it easier to adapt to smoking and to escalate smoking frequency and intensity more rapidly (Wills, Sargent, Gibbons, Pagano, & Schweitzer, 2016).

Understanding the patterns of transitions between different products as well as between no use of tobacco products to use of any products requires longitudinal studies that include youth who have never used a tobacco product. A recent evidence review and consensus report on e-cigarettes (NAS, 2018) concluded that there is substantial evidence that e-cigarette use increases the risk of ever using combustible cigarettes among youth and young adults. There is moderate evidence that e-cigarettes increase the frequency and intensity of subsequent smoking but limited evidence that e-cigarette use increases the duration of subsequent cigarette smoking. In sum, we do not yet have studies that have followed individuals long enough to know whether e-cigarette use among adolescents and young adults is long lasting and leads to continued cigarette smoking, or whether it may just be experimental, transitory use.

A recent study using data from a nationally representative sample provides perhaps the best evaluation of transitions into and out of different tobacco products among youth and young adults (Hair
et al., 2018). Most prior studies had considered transitions into a single product (e.g., e-cigarettes to combustible cigarettes) and had limited periods of follow-up. Hair et al. (2018) considered a broader range of product transitions across a period of 2.5 years. Current patterns of use predicted future patterns over time intervals of less than one year, but had only weak associations with future patterns at longer intervals. The most striking findings were that adolescents and young adults had frequent changes in tobacco use states and that there was considerable instability in use patterns over periods less than a year. Adolescents frequently moved between using e-cigarettes and combustibles, and the ability to predict future use patterns declined substantially after one year. This study highlights a need for caution in interpreting product transitions among youth and young adults, and more importantly, the need to consider longer follow-ups with multiple transitions modeled over time.

**Intervention Approaches for the Future**

Eliminating combustible tobacco use will require a comprehensive set of interventions, including both enhancing current well-proven efforts and expanding into new directions. Evidence to date strongly supports the need for intervention approaches at multiple levels—policy, media, education, and treatment.

From a policy perspective, one of our most powerful tools is adjusting the price of cigarettes via tobacco excise taxes. When tobacco prices rise, primarily from taxation, smoking declines (National Cancer Institute & World Health Organization, 2016). Increasing the federal excise tax on cigarettes will greatly encourage cessation and reduce youth initiation (Chaloupka & Warner, 2000). Moreover, those most vulnerable to smoking—the poor and youth—are the most likely to stop smoking, or not to start to smoke, when prices rise. Chaloupka, Swenon, and Wärner (2015) have persuasively argued for a differential taxation strategy for nicotine and tobacco products based on level of risk and harm in order to create incentives for smokers to switch from the most harmful products to the least harmful ones. Raising the minimum age of legal access to tobacco products to 21 would lead to substantial reductions in smoking initiation, smoking prevalence, and smoking-related mortality and morbidity (Institute of Medicine, 2015). Several local municipalities have done this and have seen meaningful reductions in youth smoking (Schneider, Buka, Dash, Winickoff, & O’Donnell, 2016).

Smokers continue to smoke in large part because they are addicted to nicotine. Evidence now exists that smokers are more likely to quit when they smoke cigarettes with very low nicotine levels (Donny et al., 2015). If the FDA asserted its legislative authority to require tobacco companies to reduce the nicotine content in all combustible tobacco products to non-addictive levels, more smokers might quit or switch to less harmful products. Powerful anti-smoking media campaigns, such as the Center for Disease Control’s (CDC) “Tips From Former Smokers” (TIPS), the FDA’s “The Real Cost” campaign, and the Truth Initiative’s campaign clearly work, increasing calls to the national Tobacco Quit Line, encouraging quit attempts, and reducing youth smoking (Farrelly, Nonnemaker, Davis, & Husser, 2009; McAfee, Davis, Alexander, Pechacek, & Bunnell, 2013). Many of these campaigns work by denormalizing tobacco use and were designed to counter the tobacco industry’s attempts to influence social norms about smoking (National Cancer Institute, 2008). These campaigns help to increase awareness, change social norms, and encourage smokers to seek help with stopping. Fortunately, we also have a strong set of evidence-based pharmacological and behavioral treatments to help smokers who are motivated to quit (e.g., Fiore et al., 2008; Schlam & Baker, 2013), but much more work needs to be done to develop approaches to engage and motivate smokers who are not yet ready to quit.

These approaches provide a strong foundation of evidence-based strategies that will continue to reduce smoking. However, eliminating combustible tobacco use will require that we go further and consider new approaches. One approach is to focus more effort on the young adult years, which are the period of greatest escalation and entrenchment of smoking (Thompson et al., 2017). Current tobacco control efforts may be missing the mark when one considers the complexity of patterns of
young adult tobacco use, including the rates of initiation after age 18 and the use of diverse products. The young adult years may be the “missing link” between youth prevention and adult cessation (Rath, Villanti, Abrams, & Vallone, 2012). For the most part, interventions for youth have focused on preventing initiation, and interventions for adults have focused on smoking cessation, thus often neglecting the needs and tobacco use patterns of young adults.

Villanti, Niura, Abrams, and Mermelstein (2018) have introduced the concept of prevescalation to describe a key time for intervention between youth prevention and adult cessation. Prevescalation proposes that we think differently about this unique developmental period and the intervention approaches that may gain traction in populations who are on a pathway of escalating tobacco use. The concept focuses on understanding and interrupting transitions between experimentation with tobacco products and established tobacco use that largely occur during young adulthood.

More profound changes may be needed in our approach to reducing combustible tobacco use, however, and the field is moving towards greater acceptance of a harm minimization perspective within tobacco control. As Abrams et al. (2018) suggest, a primary goal of harm minimization is both to prevent the use of nicotine- and tobacco-containing products among nonusers (e.g., youth), while acknowledging that less harmful noncombusted products, such as e-cigarettes or snus, can significantly reduce risk compared to conventional combustible tobacco products. A harm minimization approach allows for the possibility that nicotine use, including nicotine dependence, may be acceptable if it helps to speed the reduction of tobacco-caused disease and death. Strong science is needed, however, to help navigate the changes in societal, professional, and regulatory attitudes and approaches to make best use of a harm minimization approach.

Summary

Dramatic changes in the tobacco product landscape have led to several important behavioral changes in tobacco use over the past few years, both in the U.S. and globally. These changes include the clear and consistent declines in cigarette smoking prevalence paired with the increasing use of alternative nicotine delivery systems, and the use of two or more products among both adolescents and adults (Jamal et al., 2017; Villanti et al., 2017). Tobacco use is a complex, multi-layered and multi-determined behavior, driven by an intersection of environmental, social, psychological, and biological presses and responses to product use. With the changing product landscape, we have also seen a reconsideration of the role of nicotine and a greater consideration of decoupling nicotine from the harms of combusted and inhaled tobacco smoke (e.g., Gottlieb & Zeller, 2017). As we move forward, researchers will to continue to provide a strong evidence-base to help influence timely policy changes and treatment approaches.

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Nicotine and Tobacco Use


Nicotine and Tobacco Use


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