An Update to E-Cigarettes: A Hazard or a Help?

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"E-Cigarettes: A Hazard or a Help?" by Sam Gutterman was published online in the *North American Actuarial Journal* on December 18, 2019, and in print in Volume 24, 2020–Issue 4. This essay is the author's update to the original paper; it has not been peer-reviewed. The essay is solely an expression of the views, opinions, and ideas of the essay author for applying the original research to actuarial work.

Introduction

Since electronic cigarettes (e-cigarettes) entered the U.S. marketplace in 2007, the tobacco landscape has evolved to include different product types of e-cigarette products (e.g., prefilled cartridges, disposable, and tank products) and flavored e-liquids (e.g., fruit, candy, mint, menthol, and tobacco flavors) that have contributed to increases in their use by youths. E-cigarettes have been the most commonly used tobacco product among U.S. youths since 2014; in 2019, 27.5% of high school students were reported to have used e-cigarettes (vaping).

The objective of this update is to supplement developments since Gutterman (2020, written in 2019) that discussed U.S. prevalence and health developments through 2019, which includes reported experience through 2019. This may have been the peak use of these products.

U.S. Vaping Prevalence

In the United States, e-cigarette use has been markedly higher among youths than adults. For example, in 2019, the current use of e-cigarettes was 27.5% among high school students, 10.5% among young adults aged 18–24 years, and 5.4% among all adults.

Since then, a significant decrease in vaping occurred by May 2020, which is the most recent data available when this update was prepared. This reduction was partly due to adverse health publicity in 2019 (especially associated with certain lung injuries) and regulatory actions by the Federal Drug Administration (FDA). For example, JUUL voluntarily removed mango, creme, fruit, and cucumber flavored cartridges from retail stores (November 2018) and online (October 2019) and removed mint-flavored cartridges from the market in November 2019. On January 2, 2020, the FDA prohibited the sale of prefilled cartridge e-cigarettes in a flavor other than tobacco or menthol. In December 2019, Congress passed legislation that set a federal minimum age of 21 for purchasing tobacco products, including e-cigarettes, although regulatory practice differs by state. However, enforcing such bans on sales to minors is difficult in retail locations and even more so online, with those underage often obtaining e-cigarettes from family members or friends.

Ali et al. (2020) reported sales of e-cigarettes (about half of the total e-cigarette market, excluding sales from the Internet and tobacco-specialty stores including vape shops) from September 14, 2014 through May 17, 2020. During August 2019–February 2020, sales decreased by 32.7%, from 22.0 million to 14.8 million units per 4-week period. No significant change in total sales occurred between February through May 2020.

The increase in e-cigarette sales between November 2016 and mid-2019 was driven by sales of prefilled cartridges, primarily from JUUL, which represented nearly 90% of the market by August 2019, with a total increase of 78% in e-cigarette sales among U.S. high school students and 48% among middle school students. Ali et al., categorizing e-cigarette products into prefilled cartridge devices, disposable devices, and e-liquid categories, found that prefilled cartridges decreased significantly beginning August 2019. Between August 2019 and May 2020, while mint sales declined from 47.6% to 0.3% of prefilled cartridge sales, the proportion of menthol sales increased from 10.7% to 61.8% and tobacco-flavored sales increased from 22.8% to 37.1%. Although prefilled cartridges remained the leading product type sold, disposable sales increased to 19.8% of total sales by May 2020. This shows that product mix can be quite fluid and can adjust to changes in product and market conditions.

YOUTH PREVALENCE

Wang et al. (2020) reported the findings of a Center for Disease Control and Prevention (CDC) and FDA analysis of nationally representative data from the 2020 National Youth Tobacco Survey, a survey of U.S. middle school (grades 6–8) and high school (grades 9–12) students conducted during January 16–March 16, 2020. 19.6% of high school students (3.02 million) and 4.7% of middle school students (550,000) reported current e-cigarette use. By comparison, in 2019, 27.5% of high school students and 10.5% of middle school students reported current e-cigarette use. Although this represents a considerable percentage decline, it means that 3.6 million U.S. youths used e-cigarettes in 2020. Some of them tried them once or a few times and did not use them further. But some were using them every day, likely still are, and are becoming addicted. Despite the decrease, e-cigarettes remain the most commonly used tobacco product among youths.

Among current e-cigarette users, 38.9% of high school students and 20.0% of middle school students reported using e-cigarettes on 20 or more of the past 30 days; 22.5% of high school users and 9.4% of middle school users reported daily use. Among current e-cigarette users, 82.9% used flavored e-cigarettes, including 84.7% of high school users and 73.9% of middle school users.

During 2019–2020, the most commonly used device among current e-cigarette users was prefilled pods or cartridges (48.5%), followed by disposables (26.5%), and tanks (14.8%). Among current e-cigarette users in middle school, the most commonly used device was prefilled pods or cartridges (41.3%), followed by tanks (21.5%), and disposables (15.2%).

National policy now prohibits the sale of prefilled pod- or cartridge-based e-cigarettes in any flavor other than tobacco or menthol, while several states and communities have restricted all flavored e-cigarette sales, including menthol.

Gaiha et al. (2020) examined the association of the COVID-19 pandemic with patterns of vaping, based on a national sample of 4,351 participants aged 13 to 24 years during May 2020 (after the results of Wang et al. 2020). Key findings included that 56.4% of participants reported a change in their e-cigarette use since the beginning of the COVID-19 pandemic. Among those who changed their use, 32.8% of youth participants quit vaping, 35.3% reduced their use of e-cigarettes, with others either increasing their nicotine intake (17.6%), increased marijuana (cannabis) use (7.8%), or switched to another nicotine or cannabis product (6.9%).

Major reasons for decreased use included a fear that their parents would find out about their vaping habits (15.2%), inaccessibility of products (19.5%), and a belief that e-cigarettes may weaken their lungs. Reasons for continuing to vape through the pandemic included boredom, stress, and the need for a distraction. Gaiha et al. found that those who continued their vaping habit had higher nicotine dependence and more frequent e-cigarette use. About 20% of youth e-cigarette users changed their point of purchase from retail stores to online sources; poor online age verification did not seem to present major problems in obtaining e-cigarettes.

The reductions in 2020 do not appear greater for youths than for those aged 21 years and older, despite greater restrictions on use by underage youth.

Vaping, however, does not seem to represent a fad. Vaping dependency, in a study of 3,168 twelfth-grade students, 11.7% reported experiencing at least one e-cigarette dependence symptom (reflecting a loss of control over use, craving or urge, or withdrawal while abstinent). While less common and severe than combustible cigarette dependence, e-cigarette dependence had a similar symptom profile and was associated with vaping continuation, frequency, and intensity 6 months later. This e-cigarette dependence may be an expression of tobacco use disorder associated with an escalation of future use.

Using data from the Monitoring the Future survey of smoking and vaping by U.S. teenagers, Meza et al. (2020) analyzed trends in past 30-day and daily cigarette and smokeless tobacco use from 1991 to 2019 among those in the 8th, 10th, and 12th grades. Decreases in overall smoking prevalence slowed in the mid-2000s, but then accelerated considerably, reaching rates of decline of as much as 16% or more per year since 2012. In particular, for 12th graders between 2012 and 2019, smoking during the past 30 days decreased from 19.3% to 6.9% for boys and from 14.5% to 4.0% for girls. Daily smoking, a stronger indicator of long-term combustible cigarette use, decreased during the same period from 10.9% to 2.8% for boys and from 7.3% to 1.6% for girls, both record low rates. This decrease occurred at the same time that vaping and the use of Juul and similar vaping products accelerated.

There has been considerable public health controversy involving vaping, often involving the question of whether vaping acts as a gateway to smoking, possibly through dual-use or displacement of smoking. Although Meza et al. did not indicate that e-cigarettes cannot act as a gateway to smoking for some individuals, they indicated that a reversal in the decrease in smoking has not occurred at the population level, at least through 2019. In sum, the increase in vaping has not appeared to have slowed the decrease in smoking prevalence among youth.

Kavousi et al. (2020), in a position paper of the European Association of Preventive Cardiology (EAPC), concluded that public health action should be undertaken to minimize e-cigarette use in the young. In particular, they stated that prevention should be encouraged to decrease vaping, an 'epidemic of youth use'. They recommended strict regulation of e-cigarette marketing and advertising to youth in the same manner as for tobacco. In particular, they urged that strong age verification procedures be used to prevent adolescents from accessing tobacco and e-cigarette websites.

At least through 2019, trajectories of nicotine vaping and cannabis vaping were similar (Lanza et al. 2020). Patrick et al. (2020) found that through 2018 about a quarter of teenagers who used cannabis did so through vaping, with most being dual users of vaping and smoking cannabis. The increase in cannabis vaping about offset the decrease in smoking cannabis since 2015. More than a quarter of those who cannabis-vaped do so daily.

ADULT PREVALENCE

Obisesan et al. (2020) found that, according to the Behavioral Risk Factor Surveillance System (BRFSS), a large annual nationally representative survey, about 5.4% of the U.S. adult population currently vaped in 2018, compared

with 4.4% in the corresponding 2017 BRFSS (and 4.5% in the2016 BRFSS). 6.9% for males in 2018 compared with 5.4% in 2017 and 4.1% for females in 2018 compared with 3.4% in 2017. The 2018 increase occurred at the same time as youth prevalence did. If the trends continue to be consistent, at least 2019 will see an increase.

Obisesan et al. also reported that, according to the 2018 BRFSS results, the age groups with the largest annual increase in vaping in 2018 were the 19–24 age category, whose vaping increased from 10.0% to 15.0%, and for those aged 25–29 with an increase from 7.2% to 9.7%. A shift to more daily e-cigarette use between 2016 to 2018 was observed. In 2018, 14.7% of current smokers also vaped, while 6.9% of former smokers and 2.3% of never-before smokers vaped. In 2018, of current cannabis users, 21.3% vaped cannabis e-cigarettes, while of those who were not cannabis users, 3.7% vaped. Corresponding percentages of those who were also heavy drinkers were 11.5% and those who were not, 4.9%. On an age-standardized basis, of those suffering from COPD were 11.7% and those not, 5.9%, while those suffering from depression were 10.2% and those not, 5.2%.

Mayer et al. (2020), based on the 2018–2019 Tobacco Use Supplement to the Current Population Survey, reported that 39.1% of current adult vapers also smoked combustible cigarettes (were dual users), 37.9% were former smokers, and 23.1% were never-smokers. Of those in the latter category, 63.4% were aged 18–24 and 23.8% were 25–34. Of those who were current dual users, 69.3% first used e-cigarettes to help quit smoking and 80.7% of former smokers used e-cigarettes to help quit smoking.

SMOKING CESSATION

There has been some promising evidence that vaping can contribute to cigarette smoking cessation in the general adult population. However, according to Pearson et al. (2020)'s analysis of 3 years of data from the Population Assessment of Tobacco and Health Study, a cohort study of 1,096 young adults, there is no conclusive evidence that vaping leads to increased or reduced cigarette smoking among young adult smokers. The authors concluded that vaping was not associated with an increase or decrease in cigarette smoking among young adult ever-smokers.

In a nationally representative longitudinal U.S. study of former smokers, Everard et al. (2020) found that the use of e-cigarettes was found to be associated with significant increases in combustible cigarette smoking relapse for both recent former cigarette smokers (odds ratio of 1.63 for those less than 1 year) and long-term former cigarette smokers (odds ratio of 3.79 for long-term former smokers of more than 1 year).

The contribution of e-cigarette use to reduce smoking and achieve smoking cessation is complex. Kavousi et al. (2020) concluded that the impact of e-cigarette use on long-term cessation lacks sufficient evidence. As it is important to minimize risk from the adverse effects of potential nicotine addiction, they recommended that health professionals be cautious in recommending the use of e-cigarettes to their patients and the general public to help contain smoking because (1) mounting evidence suggests that e-cigarettes are harmful to health, including to the heart, (2) smokers might end up vaping as a supplement to smoking without cutting back their tobacco consumption, and (3) there is a lack of robust evidence that the use of e-cigarettes is effective as a smoking cessation tool, especially since in many cases e-cigarettes are used instead of evidence-based smoking cessation products and programs.

Health consequences

There remains a great deal yet unknown concerning possible health consequences of vaping, especially regarding its long-term health effects. Because e-cigarettes in their current form have been around for a limited time, there is as of yet a dearth of longitudinal studies of their health risks. However, the results of several recent cross-sectional studies have become available, with some recently published results follow.

Yet even with this relative dearth of definitive information, the CDC has indicated that neither youths nor pregnant women should use e-cigarettes, as deleterious effects on the fetus have been observed. Also, others are taking on health risks when vaping, including its cardiovascular and respiratory effects.

As Gutterman (2020) pointed out, just because vaping is less harmful to one's health than smoking is not reassuring, as smoking remains the single greatest adverse behavioral risk factor to health. I recommend, along with almost all other observers, that studies of the effects of the most recent version of e-cigarette products be tested using long-term longitudinal studies. In the meantime, public health authorities need to consider how to effectively regulate their use, marketing, as well as actuaries who should consider these findings, or in some cases, lack of definitive findings, in their practice.

CARDIOVASCULAR

Due to their unique properties, the impact of e-cigarettes on cardiovascular physiology is not fully known. Data supporting the conclusion that vaping is not a harm-free alternative to smoking have primarily been derived from short-term studies. For example, Buchanan et al. (2020) concluded that there is growing evidence that e-cigarettes and their aerosol constituents, including nicotine, carbonyl compounds, particulate matter, metals, and flavorings, can adversely affect the cardiovascular system. Recent studies have suggested that vaping is associated with inflammation, oxidative stress, and hemodynamic imbalance, leading to increased cardiovascular disease risk.

The health effects of vaping depend on such factors as the propylene glycol-to-glycerin ratio, its manufacturer, the type of e-cigarette, temperature, airflow rate, nicotine content, and any added flavorings, as well as the frequency of vaping and the intensity of each puff. The WHO has pointed out that e-cigarette vapor contains an aggregation of chemicals, which may have an additive or synergistic effect that could contribute to a greater risk of developing atherosclerosis than the individual chemicals separately.

In May 2020, the WHO (2020) indicated that there is insufficient data to understand the full breadth of the impact of vaping on human health, especially its long-term effects. The American Heart Association, while encouraging further research, has also indicated that it is known that nicotine affects blood pressure, heart rate, and myocardial contractility. Some added flavors have potentially adverse effects on, among other things, endothelial cells and platelets. The WHO has indicated that the youth and pregnant women should not vape at all and is concerned that vaping could create addiction in a generation of young people.

While the currently limited literature suggests that vaping may lead to fewer negative cardiovascular effects than combustible cigarettes, Buchanan et al. (2020) indicated that there is still insufficient data to confirm the extent of these effects. Kavousi et al. (2020), in presenting the current evidence regarding the cardiovascular effects of vaping, pointed out that e-cigarettes contain potential toxicants and exert a variety of biological effects, such that adverse health-related sequelae linked to exposure to nicotine and components in e-cigarette vapor. They emphasized that, even though the long-term direct cardiovascular effects of e-cigarettes remain largely uncertain, existing evidence suggests that e-cigarettes should not be regarded as a cardiovascular-safe product.

RESPIRATORY

Xie et al. (2020) reported the results of a nationally representative cohort of 21,618 US adults from four waves of the Population Assessment of Tobacco and Health study (2013 to 2018). Individuals aged 18 years and older at baseline with no prevalent respiratory conditions were included in the study. Former and current use of e-cigarettes was associated with an increased risk of developing an adverse respiratory condition compared with no prior use of e-cigarettes, independent of other tobacco product use. Regarding respiratory diseases among current e-cigarette users, the incidence rate ratio (IRR) was 1.33 for chronic bronchitis, 1.69 for emphysema, 1.57 for COPD, and 1.31

for asthma. Adjusted for smoking use, demographic characteristics, and chronic health conditions, there was an increased risk of respiratory disease among former e-cigarette users with an IRR of 1.28 and current e-cigarette users an IRR of 1.31.

In a 2018–2019 study of 2,553 young adult vapers, Braymiller et al. (2020) studied pulmonary symptoms. They compared those who had never vaped cannabis with those who vaped cannabis in their lifetime but not in the past 5 years (adjusted odds ratio of 1.83), in the past six months but not in the last 30 days (1.58), 1–2 days in the past 30 days (2.83), and three or more days in the past 30 days (2.14) had significantly higher odds of chronic bronchitic symptoms after adjusting for nicotine-vaping, cigarette-smoking, cannabis-smoking, and sociodemographic characteristics. Cannabis vaping 3 or more times in the last 30 days was also associated with increased odds of wheeze (2.27). This implies an independent association between any level of cannabis vaping and persistent symptoms of bronchitis. However, there were no statistically significant associations of cannabis vaping with shortness of breath and nicotine-vaping with any respiratory health outcome in fully adjusted models.

CANCER

The evidence is clear that the aerosols of the majority of e-cigarettes contain toxic chemicals, including nicotine and other substances that can cause cancer. However, because it generally takes quite some time to develop applicable studies, there have only been limited results tying them definitively. Nevertheless, e-cigarettes on their own are generally associated with an increased risk of lung disorders and adverse effects on the development of the fetus during pregnancy.

Adults who vape for only a few months have an increased risk of developing cancer or gum disease, according to Ganesan et al. (2020). In their study of 123 subjects, participants' oral bacteria composition resembled that of people with periodontitis, which is a risk factor for heart and lung diseases. It did find that the risk-for-harm from e-cigarettes is different from, but not less than, combustible cigarettes.

DEPRESSION

Obisesen et al. (2019), using a cross-sectional study of the 2016–2017 BFRSS database, former e-cigarette users had 1.6-fold higher odds of reporting a history of clinical diagnosis of depression than never-users, while current e-cigarette users had 2.1 times higher odds. Higher odds of reporting depression were also associated with increased frequency of use among current vapers compared with never users (daily use: odds ratio of 2.39; occasional use: odds ratio of 1.96). Similar results were seen in subgroup analyses by sex, race/ethnicity, smoking status, and student status. This study found a significant cross-sectional association between e-cigarette use and depression, which highlights the need for prospective studies analyzing the longitudinal risk of mental health with e-cigarette use.

E-CIGARETTE OR VAPING USE ASSOCIATED LUNG INJURY (EVALI)

In 2019, an illness affecting mostly young people who developed acute respiratory failure caused by vaping product use–associated lung injury (EVALI) that was referred to in Gutterman (2020). This was a multistate outbreak associated with about 2,500 cases and more than 50 deaths. The CDC determined that most patients with EVALI had a history of inhaling modified vaping products that incorporated tetrahydrocannabinol (THC) and cannabidiol in diluents, including oil-like substances such as vitamin E acetate. The association of the EVALI outbreak with the presence of vitamin E acetate in THC-containing vaping products and the bronchial fluid of EVALI patients implicated this compound as the trigger of lung injury. Most of these products were purchased through the Internet or street markets. There has been limited reporting of EVALI situations in 2020. Although this public health threat appears to have subsided, the risk of such a situation remains, especially where there is no effective oversight.

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