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Report on the Vaping Epidemic in Indiana and Marion County

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Introduction

Over the past two decades, substantial progress has been made in reducing cigarette smoking in the United States (US). Current smoking prevalence rates among adults have nearly halved, declining from 23.2% in 2001 to 14.4% in 2021 (Centers for Disease Control and Prevention (CDC), 2023A). Even larger reductions in youth smoking occurred over this period. According to the Monitoring the Future Surveys, smoking among high school seniors declined from 29.5% in 2001 to 4.1% by 2021, equivalent to an 86.1% reduction (Monitoring the Future (MTF), 2023).

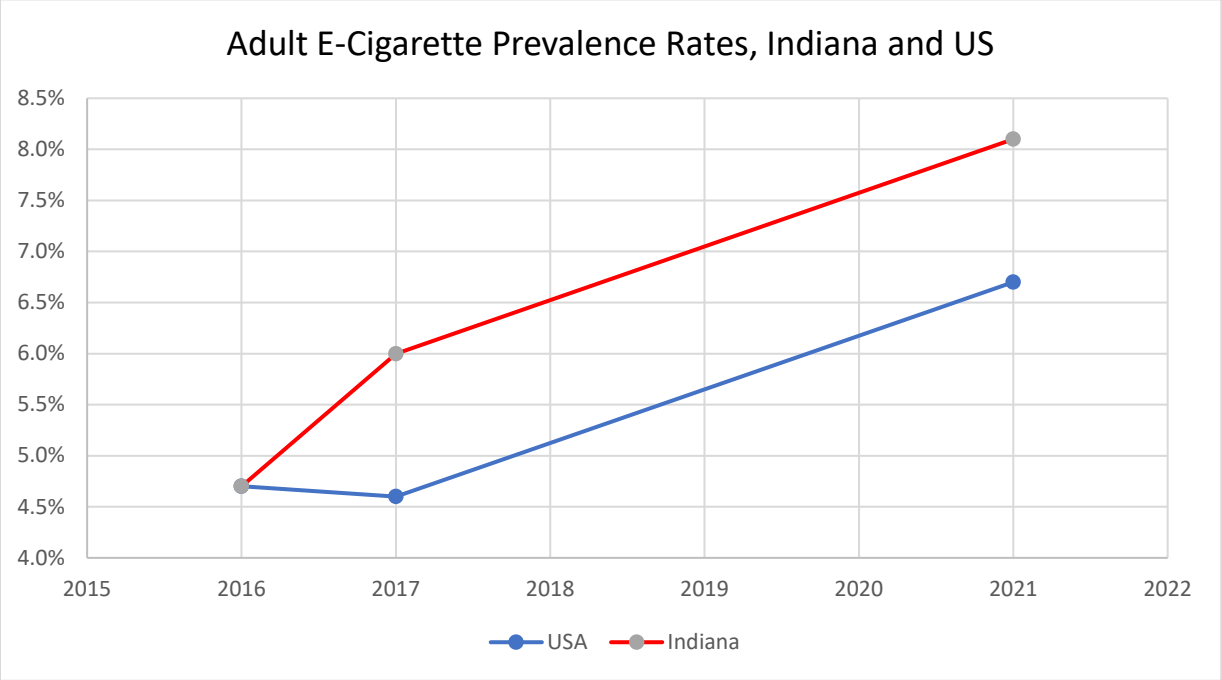
In 2007, the tobacco landscape changed as electronic cigarettes (e-cigarettes) entered the US marketplace. Many adolescents and adults in the US began vaping e-cigarettes and prevalence rates significantly increased. By 2014, e-cigarettes overtook cigarettes as the most commonly used tobacco product by youth in the US. From 2011 to 2019, current e-cigarette use by high school students increased 1,733%, from 1.5% to 27.5% before dropping to 14.1% by 2022 (CDC, 2013; Wang et al. 2019; Cooper et al, 2022). Increases in adult e-cigarette use were also observed over this time period. According to Behavioral Risk Factor Surveillance System (BRFSS) data, the prevalence of current e-cigarette use among American adults aged 18+ increased from 4.7% in 2016 to 6.7% in 2021 (CDC, 2023A).

Adult Use of Electronic Vapor Products in Indiana

In 2021, the prevalence of current e-cigarette use among Indiana adults aged 18+ was 8.1% (CDC, 2023A). This is significantly higher than the national average prevalence rate of 6.7% and makes Indiana the state with the seventh highest adult e-cigarette prevalence rate in the country. Only Arizona, Louisiana, Alabama, Tennessee, Kentucky, and Oklahoma have higher

prevalence rates. As can be seen in Figure 1, since 2016, the prevalence of e-cigarette use has been rising at a faster rate in Indiana than the US as a whole. From 2016 to 2021, the prevalence rate increased by 72.3% in Indiana as compared to 42.6% in the United States as a whole (CDC, 2023A).

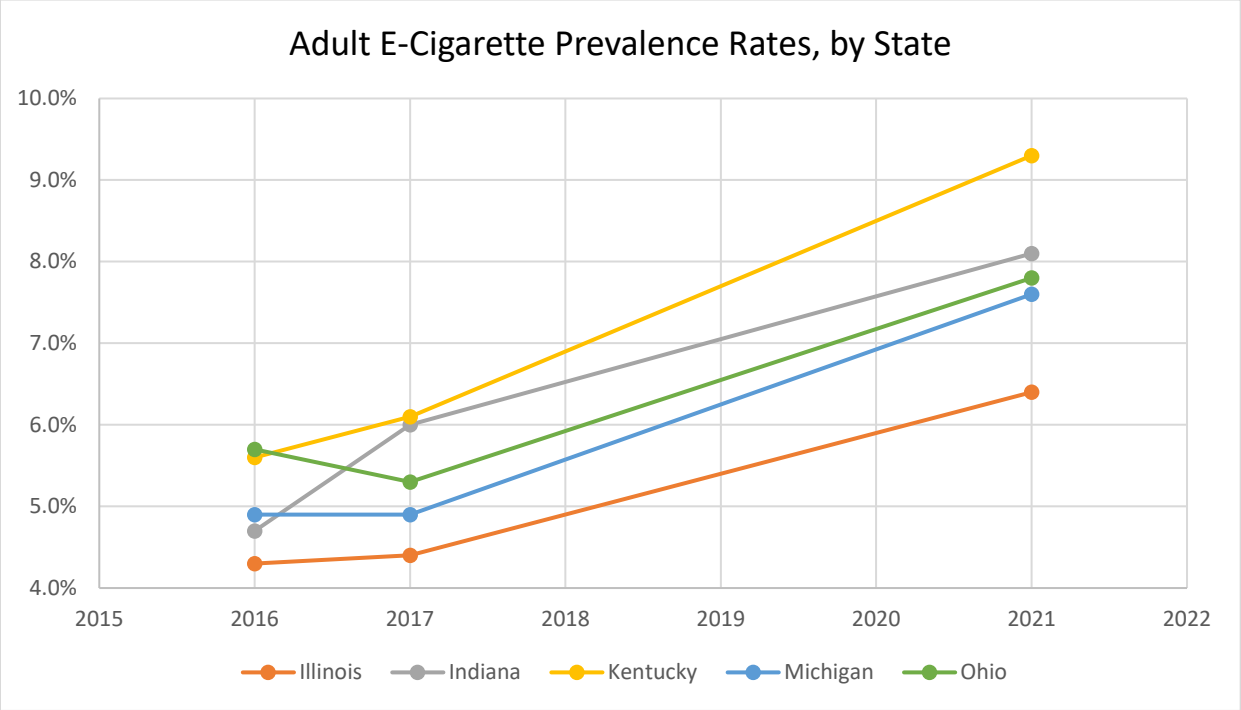
Figure 1



Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Division of Population Health. BRFSS Prevalence & Trends Data [online]. [accessed Mar 29, 2023]. URL: https://www.cdc.gov/brfss/brfssprevalence/.

As can be seen in Figure 2, in 2021 Indiana had the second highest adult e-cigarette prevalence rate among all neighboring states; only Kentucky had a higher prevalence rate. Moreover, among all neighboring states, Indiana had the largest percent increase in adult e-cigarette use from 2016 to 2021 at 72.3% as compared to 66.1% in Kentucky, 55.1% in Michigan, 48.8% in Illinois, and 36.8% in Ohio (CDC, 2023A).

Figure 2



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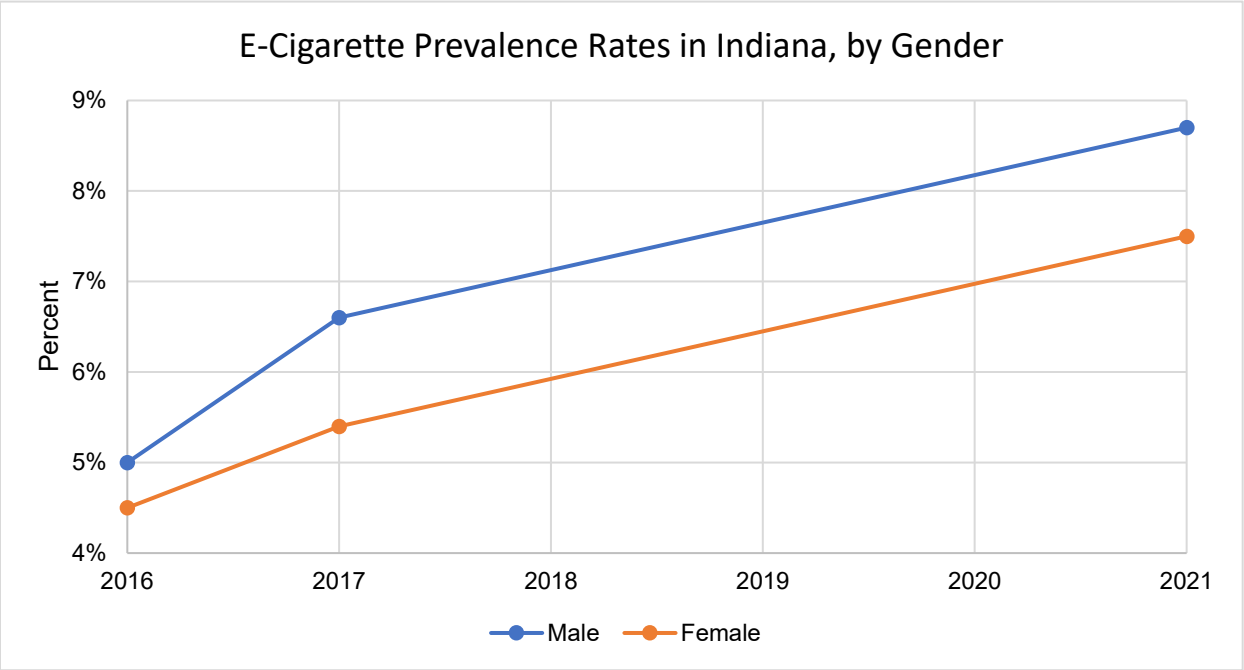
E-Cigarette Prevalence Rates by Adult Population Groups

While 8.1% of adults use e-cigarettes in Indiana, the prevalence rate is not uniform among different subgroups of the population. The disparities in e-cigarette use vary by gender, race, educational attainment, and household income level.

E-Cigarette Prevalence Rates by Gender

As can be seen in Figure 3, males have a higher prevalence rate of e-cigarette use than females. In 2021, 8.7% of Indiana males used e-cigarettes compared to 7.5% of females (CDC, 2023A).

Figure 3

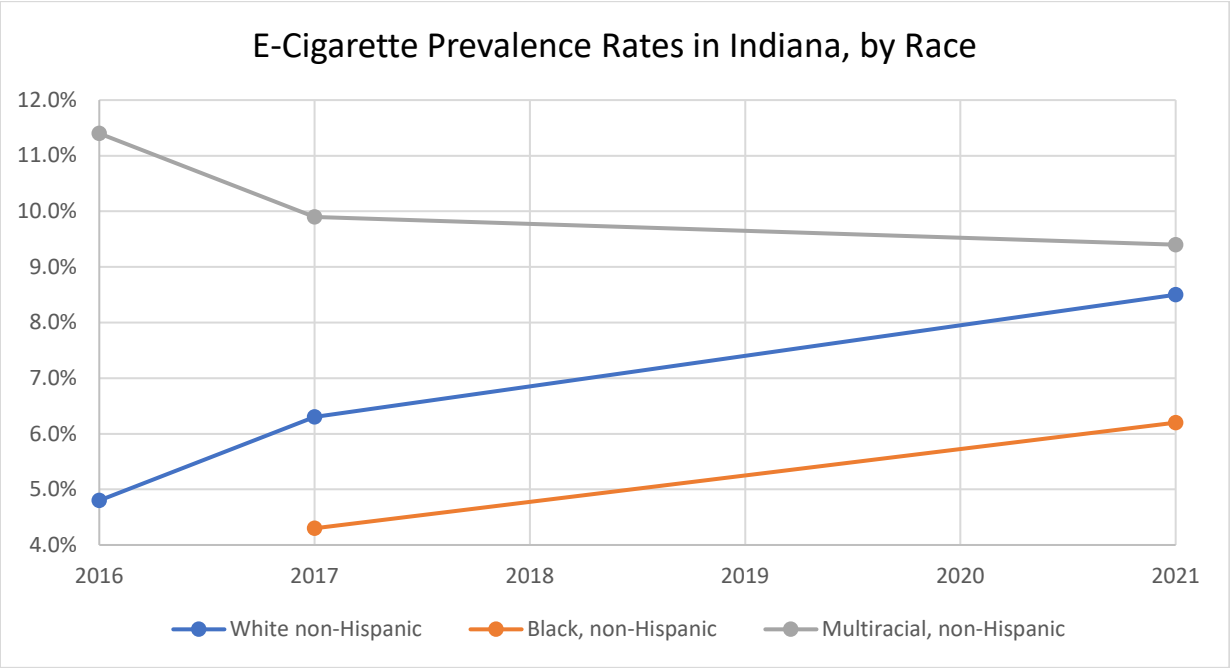


Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Division of Population Health. BRFSS Prevalence & Trends Data [online]. [accessed Mar 29, 2023]. URL: https://www.cdc.gov/brfss/brfssprevalence/.

E-Cigarette Prevalence Rates by Race

There are also racial differences in adult e-cigarette use in Indiana. As can be seen in Figure 4, non-Hispanic multiracial adults have the highest e-cigarette use rate at 9.4% in 2021, whereas non-Hispanic white adults and non-Hispanic Black adults have prevalence rates at 8.5% and 6.2%, respectively (CDC, 2023A). While multiracial adults have the highest e-cigarette prevalence rate, this rate has been trending downward since 2016, whereas the use rates among non-Hispanic white adults and non-Hispanic Black adults have been trending upward since 2016.

Figure 4

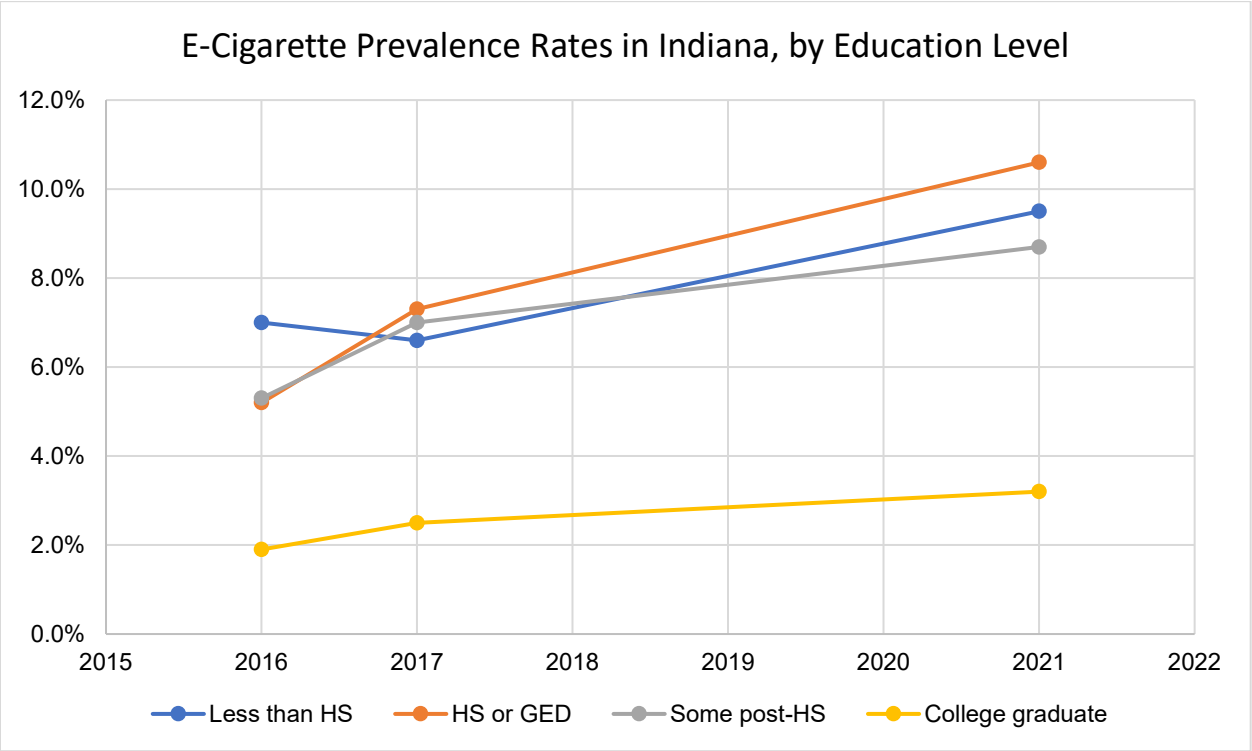


Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Division of Population Health. BRFSS Prevalence & Trends Data [online]. [accessed Mar 29, 2023]. URL: https://www.cdc.gov/brfss/brfssprevalence/.

E-Cigarette Prevalence Rates by Educational Attainment

Disparities in e-cigarette prevalence rates also exist by educational attainment. As can be seen in Figure 5, individuals with a college degree have much lower prevalence rates than individuals with less educational attainment. In particular, in 2021, individuals with some high school or less education, high school degree, and some post high school education have prevalence rates of 9.5%, 10.6%, and 8.7%, respectively (CDC, 2023A). This compares to a prevalence rate of 3.2% among adults with a college degree.

Figure 5

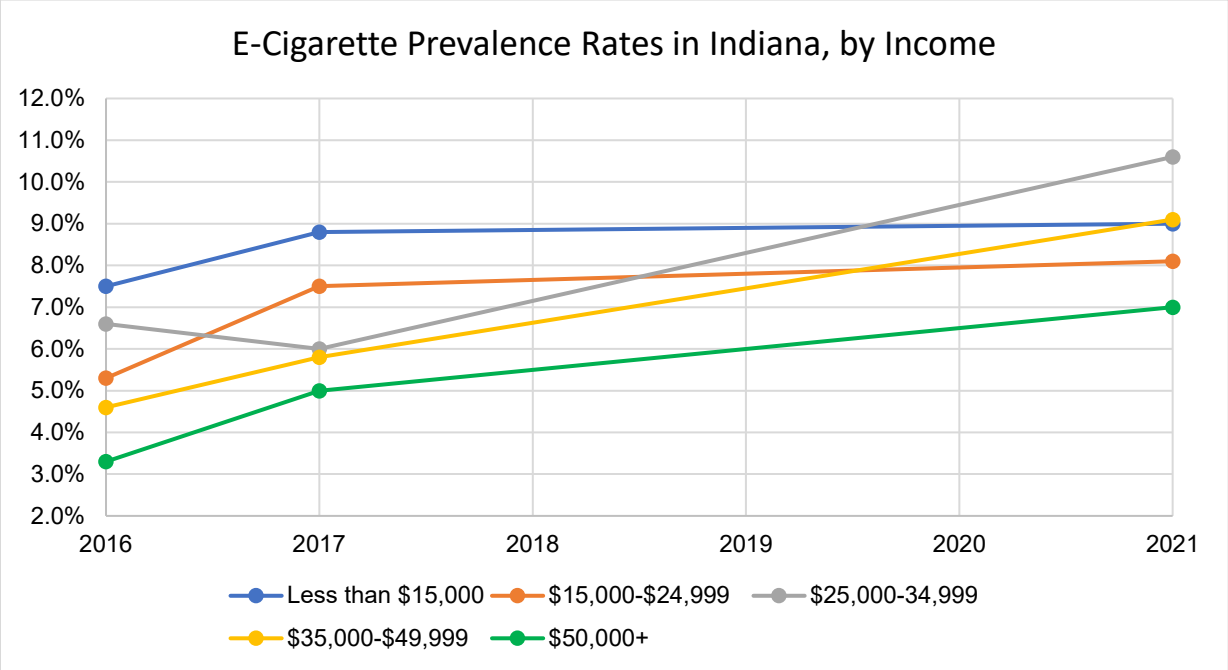


Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Division of Population Health. BRFSS Prevalence & Trends Data [online]. [accessed Mar 29, 2023]. URL: https://www.cdc.gov/brfss/brfssprevalence/ .

E-Cigarette Prevalence Rates by Household Income

There are also income differences in e-cigarette prevalence rates. As can be seen in Figure 6, individuals with the highest household income levels (greater than or equal to $50,000) have the lowest e-cigarette prevalence rates in each year. In 2021, individuals with incomes less than $15,000, $15,000- $24,999, $25,000-$34,999, $35,000 – $49,999, and $50,000+ had e-cigarette prevalence rates of 9.0%, 8.1%, 10.6%, 9.1%, and 7.0%, respectively (CDC, 2023A).

Figure 6

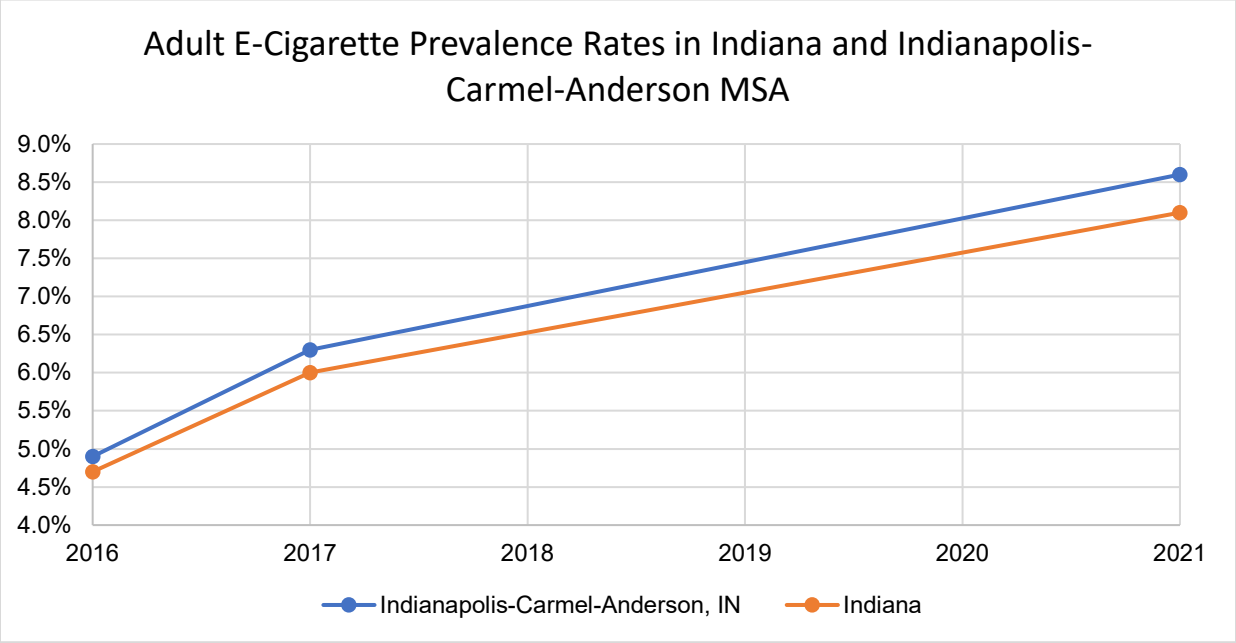


Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Division of Population Health. BRFSS Prevalence & Trends Data [online]. [accessed Mar 29, 2023]. URL: https://www.cdc.gov/brfss/brfssprevalence/. In 2016 and 2017 the highest income category was greater than or equal to $50,000. In 2021, there are two income categories $50,00-$99,999 and $100,000-$199,999. A simple average of these two categories is used for the $50,000+ category for 2021.

E-Cigarette Use by Adults in the Indianapolis-Carmel-Anderson Metropolitan Statistical Area

The electronic cigarette prevalence rates among adults in the Indianapolis-Carmel-Anderson metropolitan statistical area (MSA) have been rising over the past five years. Indeed, the e-cigarette prevalence rate has increased by 75.5% between 2016 and 2021 in the Indianapolis-Carmel-Anderson MSA (CDC, 2023A). In 2021, the adult electronic cigarette prevalence rate in the Indianapolis-Carmel-Anderson MSA was 8.6% (CDC, 2023A). As can be seen in Figure 7, the adult e-cigarette prevalence rate in the Indianapolis-Carmel-Anderson MSA has been higher than the average for the state of Indiana as a whole in each of the BRFSS estimates since 2016.

Figure 7



Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Division of Population Health. BRFSS Prevalence & Trends Data [online]. [accessed Mar 29, 2023]. URL: https://www.cdc.gov/brfss/brfssprevalence/.

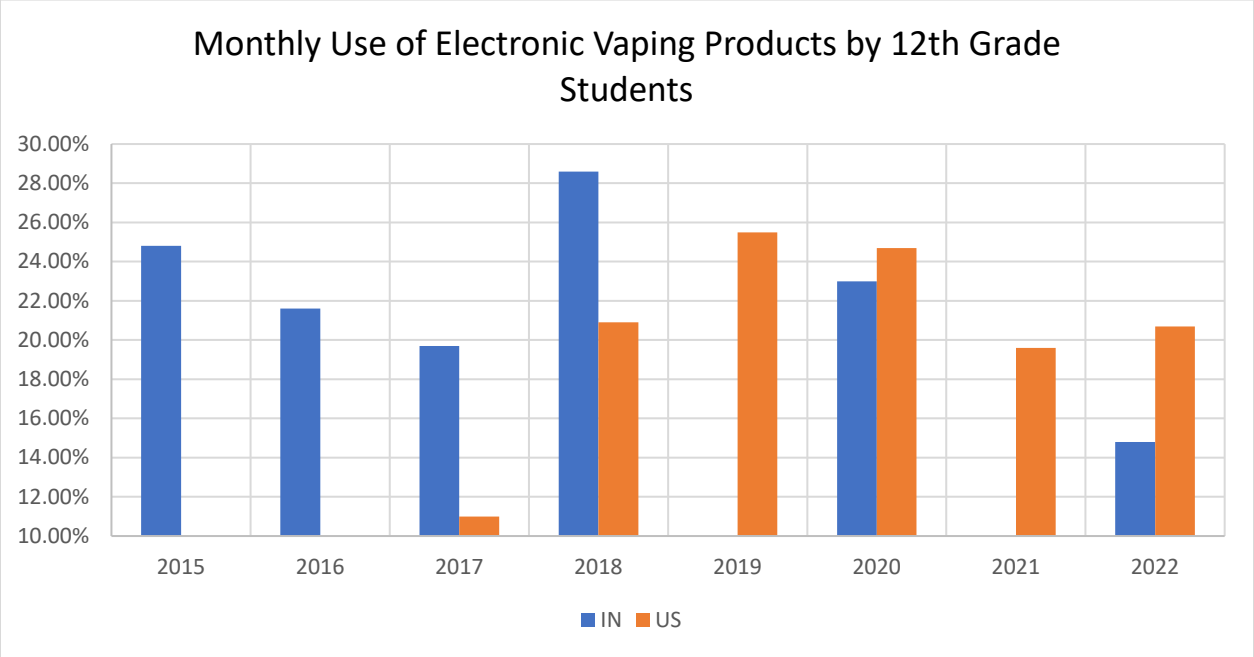
Youth Use of Electronic Vapor Products in Indiana

According to the Indiana Youth Survey (INYS), the prevalence of current e-cigarette use among 12th graders in Indiana was 14.8% in 2022[1] (Jun, et al., 2022). This is lower than the national average prevalence rate of 20.7% (MTF, 2023). As can be seen in Figure 8, e-cigarette use by 12th graders in Indiana was significantly higher than the national average through 2018, But by 2020 the prevalence of e-cigarette use among high school seniors in Indiana dropped below the national average.[2]

[1] The Indiana Youth Survey (INYS) uses a nonrandom convenience sampling procedure. This implies that the results of the survey may not be generalizable to students who did not complete the survey. The INYS results reported in this section should be interpreted with this consideration in mind. Moreover, since 2018, the INYS has been administered in even years only.

[2] The 2020 INYS was disrupted by COVID 19. The administration of the 2020 survey was unexpectedly cut short due to the pandemic. By order of the governor of Indiana, schools moved to online-only education effective March 19, 2020 and the 2020 INYS data collection was terminated on March 20, 2020. The 2020 INYS results reported in this section should be interpreted with this consideration in mind.

Figure 8

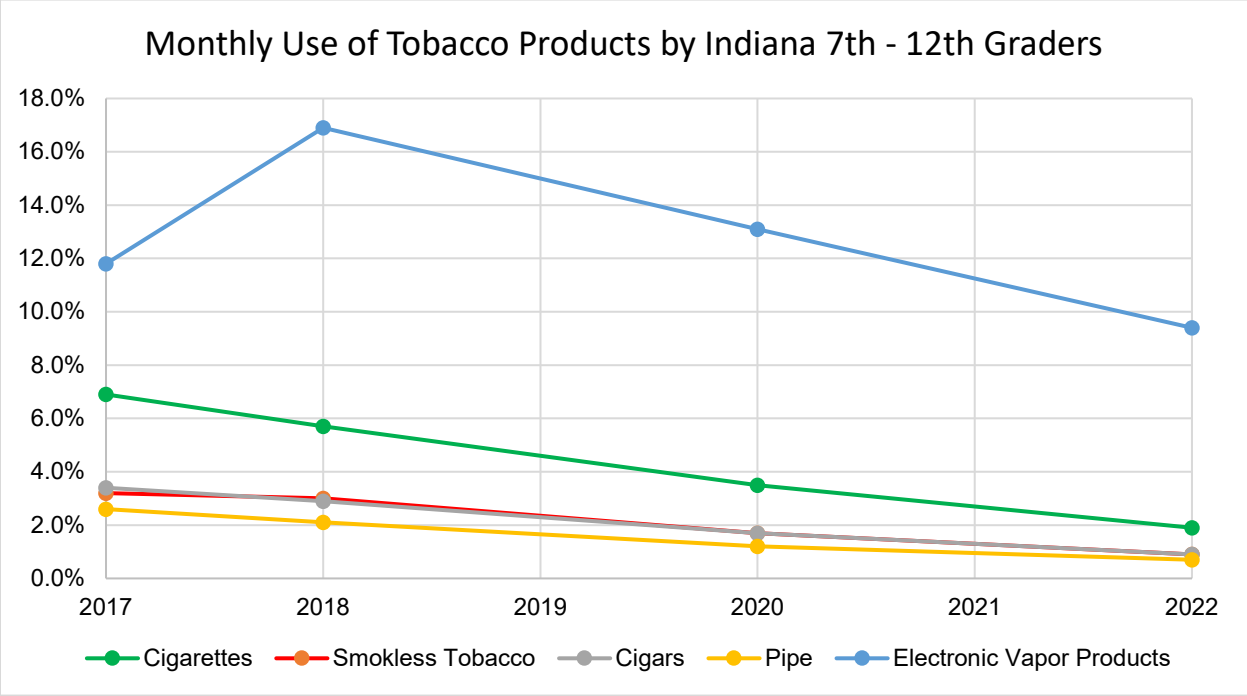


Data for Indiana were extracted from the Indiana Youth Survey. Data for the US were extracted from the Monitoring the Future Surveys. The figure shows the percentage of youth who reported vaping at least once in the previous 30 days.

Prevalence of Nicotine-related Products by Indiana Youth

Electronic vapor products are by far the most prevalent nicotine-related product used by Indiana youth, at 9.4% prevalence for all grades combined (grades 7-12). The next highest prevalence rate was 1.9% for cigarettes (Jun, et al., 2022). See Figure 9 for a comparison of nicotine-related product prevalence in Indiana.

Figure 9



Data were extracted from the Indiana Youth Survey. The figure shows the percentage of youth who reported vaping at least once in the previous 30 days.

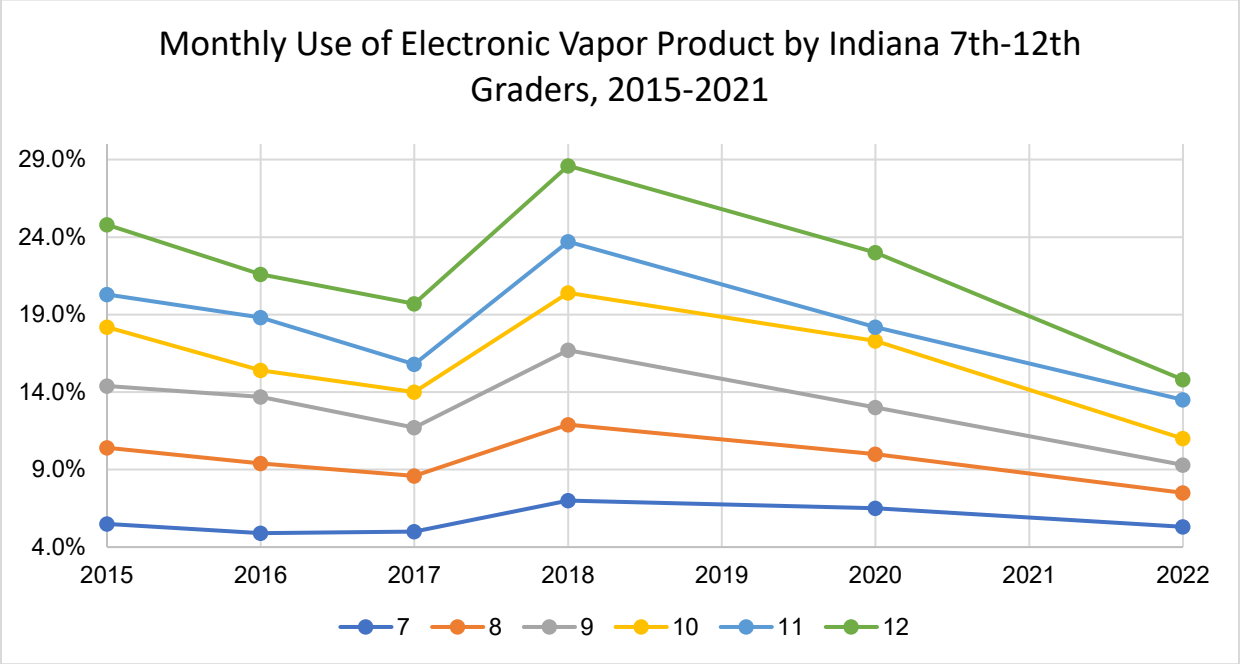
E-Cigarette Prevalence Rates by Youth Population Groups

E-cigarette prevalence rates are not uniform among different subgroups of the youth population in Indiana. There are considerable differences in the prevalence of vapor product use by grade level, gender, and race and ethnicity.

E-Cigarette Prevalence Rates by Grade

As can be seen in Figure 10, there is a strong positive relationship between e-cigarette prevalence rates and grade level with 12th graders having nearly a three times higher prevalence rate (14.8%) as compared to 7th graders (5.3%) in Indiana in 2022 (Jun, et al,. 2022). A similar pattern of declining vapor product prevalence was observed among all the grades in Indiana after 2018. Trends by grade level can be found in Figure 10.

Figure 10

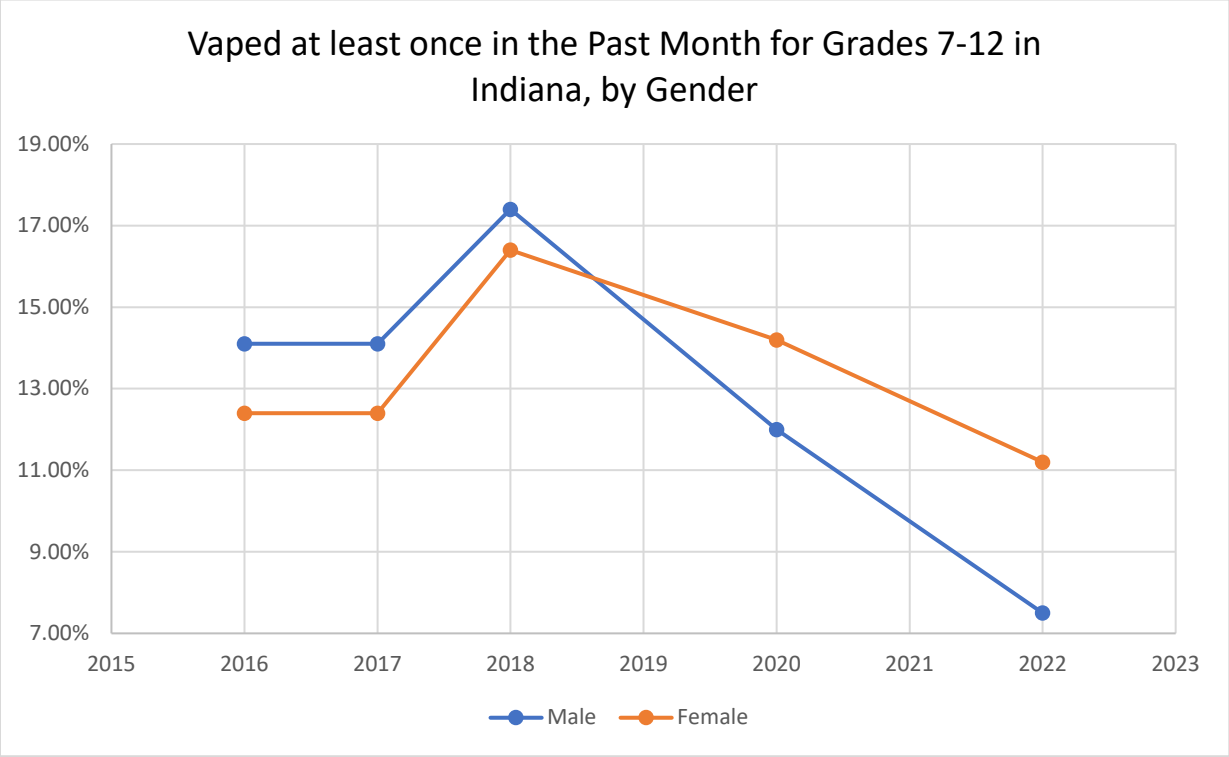


Data were extracted from the Indiana Youth Survey. The figure shows the percentage of youth who reported vaping at least once in the previous 30 days.

E-Cigarette Prevalence Rates by Gender

The disparities in e-cigarette use among Indiana youth also vary by gender. As can be seen in Figure 11, males had a higher prevalence rate of e-cigarette use than females from 2016-2018, but the pattern reversed and in 2020 and 2022, females had a higher prevalence rate than males (Jun, et al., 2022). In 2022, 11.2% of females used e-cigarettes compared to 7.5% of males (Jun, et al., 2022).

Figure 11

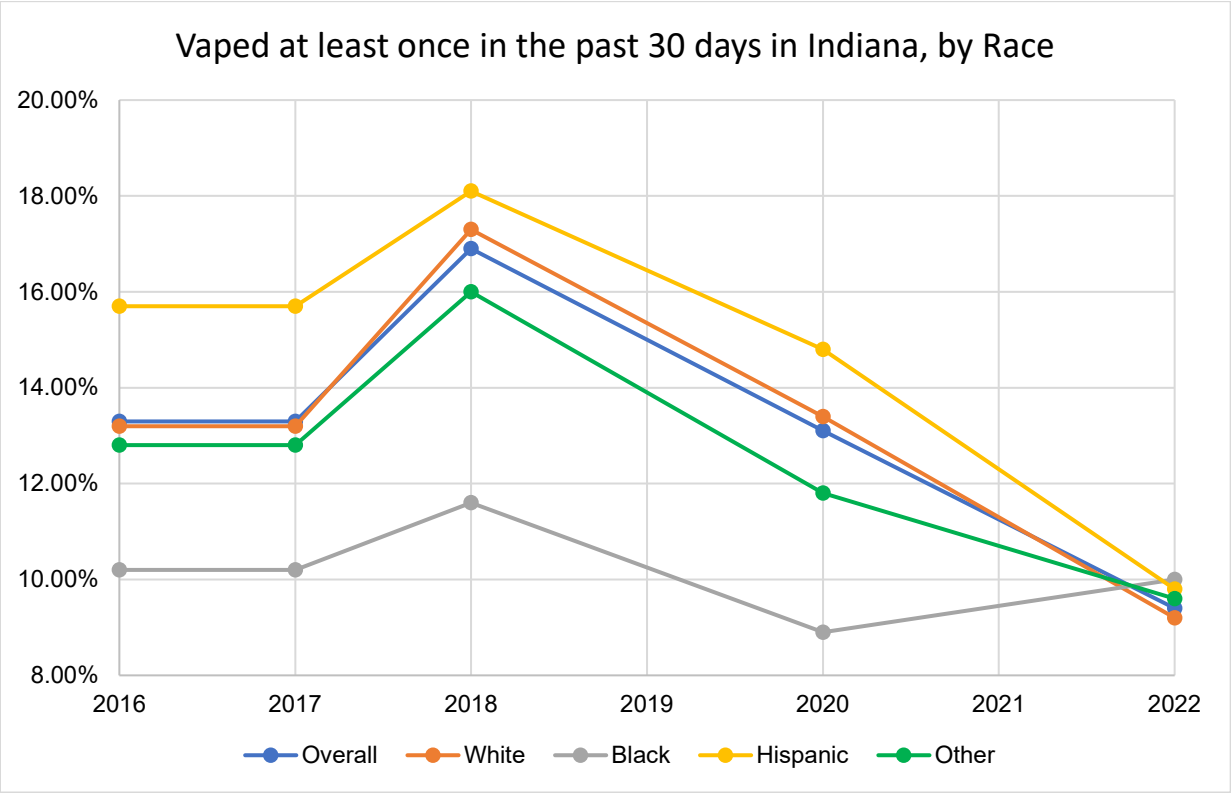


Data were extracted from the Indiana Youth Survey. The figure shows the percentage of youth who reported vaping at least once in the previous 30 days.

E-Cigarette Prevalence Rates by Race and Ethnicity

Racial and ethnic differences in youth vaping exist in Indiana. As can be seen in Figure 12, between 2016 and 2020 among youth in grades 7-12, Hispanics had the highest vaping prevalence rates followed by non-Hispanic whites, non-Hispanic other races, and non-Hispanic Black youth. In 2022, the pattern changed with non-Hispanic Black youth having the highest vaping prevalence rate (10.0%), followed by Hispanics (9.8%), non-Hispanic other race (9.6%), and non-Hispanic white (9.2%) having the lowest prevalence rate (Jun, et al., 2022). Patterns of use by race/ethnicity can be seen in Figure 12.

Figure 12

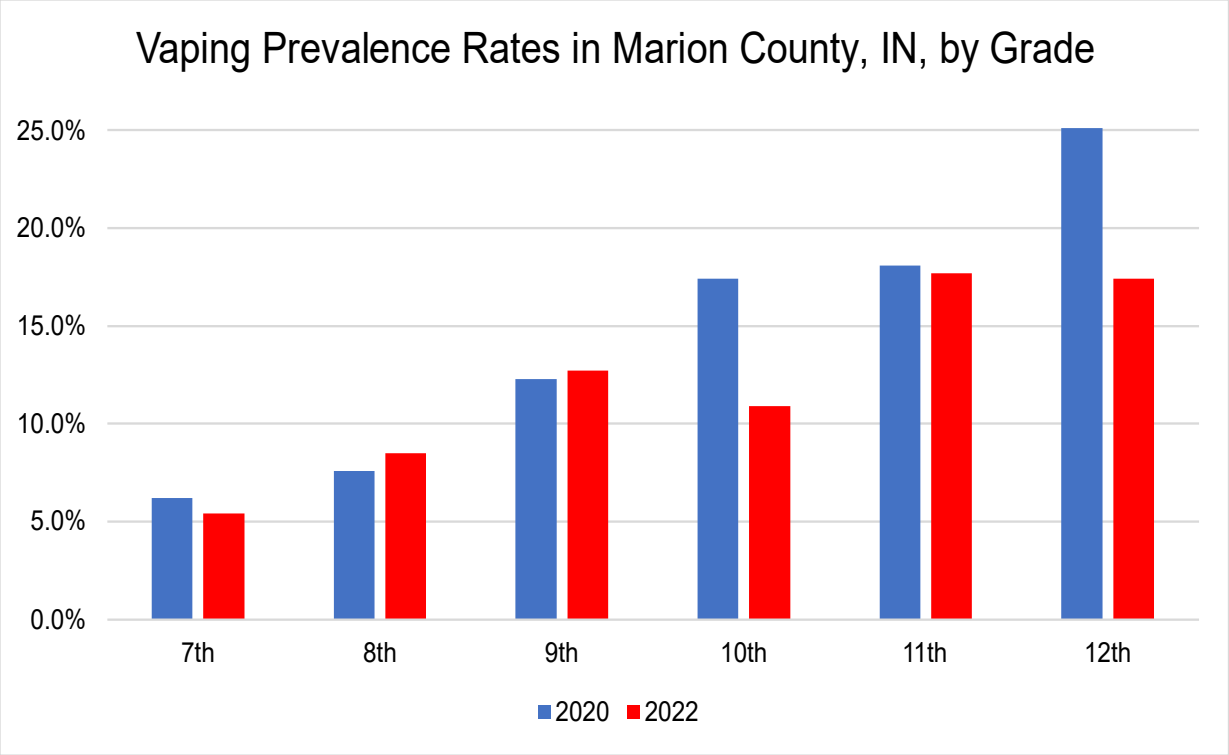


Data were extracted from the Indiana Youth Survey. The figure shows the percentage of youth who reported vaping at least once in the previous 30 days.

E-Cigarette Use by Youth in Marion County

According to the 2022 Indiana Youth Survey, the prevalence of vaping within the previous 30 days among 7th, 8th, 9th, 10th, 11th, and 12th graders in Marion County Indiana was 5.4%, 8.5%, 12.7%, 10.9%, 17.7%, and 17.4%, respectively. As can be seen in Figure 13, 10th and 12th grade students in Marion County experienced significant declines in vaping between 2020 and 2022. Substantial declines were not observed in other grades in Marion County between 2020 and 2022.

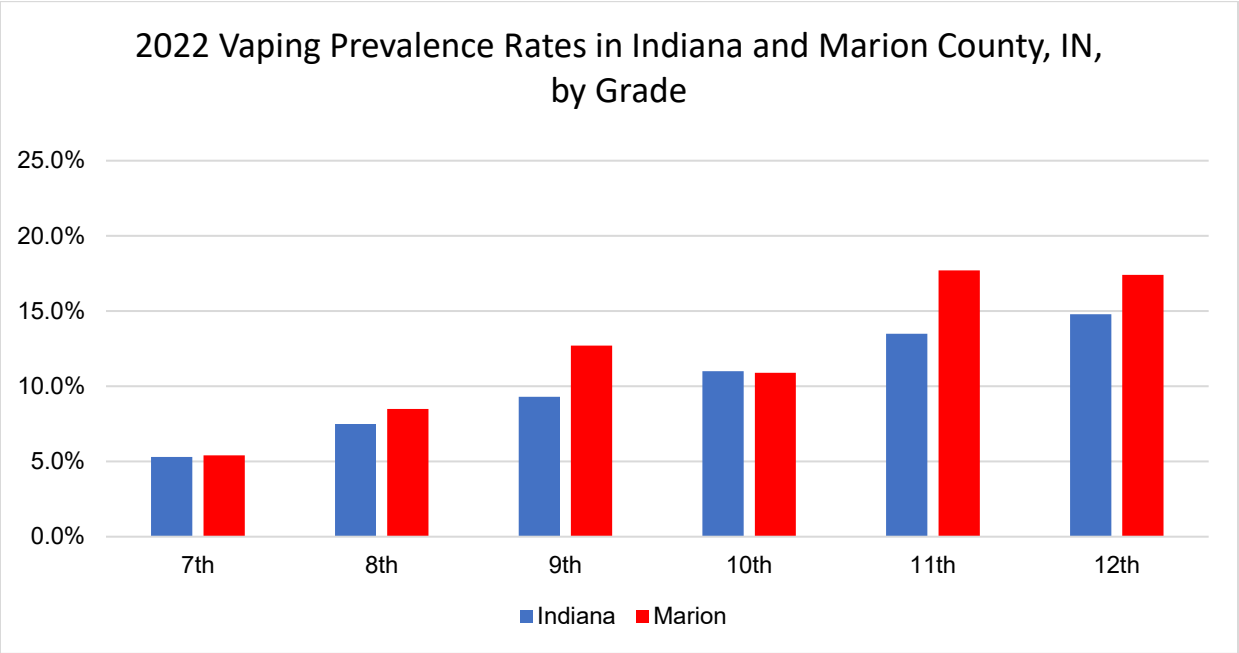
Figure 13



Data were extracted from the Indiana Youth Survey. The figure shows the percentage of youth who reported vaping at least once in the previous 30 days.

With the exception of 10th grade students, youth vaping prevalence rates in Marion County are higher than the state of Indiana averages. As can be seen in Figure 14, the largest differences are observed in 9th, 11th, and 12th grade students. In particular, vaping in Marion County is 3.4, 4.2, and 2.6 percentage points higher among 9th, 11th, and 12th grade students, respectively, than in the state of Indiana as a whole.

Figure 14



Data were extracted from the Indiana Youth Survey. The figure shows the percentage of youth who reported vaping at least once in the previous 30 days.

Health Effects of E-Cigarette Use

It is generally believed that e-cigarettes are safer than combustible cigarettes. A 2018 report published by the National Academies of Sciences, Engineering, and Medicine stated, "In contrast to combustible cigarettes, e-cigarettes do not 'burn,' and do not contain most of the estimated 7,000 chemical constituents present in tobacco smoke. Thus, it is generally believed that e-cigarettes are 'safer' than combustible tobacco cigarettes." The report highlighted that while e-cigarettes are likely safer than combustible cigarettes, they are not harmless. In fact, the report highlighted that many chemicals and several hazardous compounds have been found in liquids and in the heated aerosol produced by e-cigarettes, including formaldehyde, acetaldehyde, and acrolein, which are known carcinogenic toxicants. Moreover, the report emphasized that there is substantial evidence that e-cigarette aerosol contains metals, and

these metals are highly toxic for multiple organs and systems through inhalation. In short, the ingredients in e-cigarettes have been found to cause health problems for humans.

There are still many unknowns about how e-cigarettes affect human health over the long run and there is still some uncertainty as to exactly what chemicals make up the aerosol that is inhaled. The health effects of e-cigarette use are still being studied and an ever-growing literature on the health effects of e-cigarettes is emerging. The ingredients in e-cigarette liquid are typically nicotine, propylene glycol, flavorings, and other chemicals. Additional transformational chemical compounds and metals enter the human body once the liquid has been aerosolized. The inhaled nicotine, chemical compounds, and metals cause significant human health effects.

Health Effects of Nicotine Consumption

Nicotine is a highly addictive substance found in most e-cigarettes and is readily absorbed through the airway, mucous membranes, gastrointestinal tract, and even skin (Callahan-Lyon, 2015). The amount of nicotine consumed by e-cigarette users can vary considerably. The nicotine delivered by e-cigarettes varies by brand, type of product, device characteristics, concentration and form of nicotine in e-cigarette liquids, other e-liquid constituents, and user puffing behavior. E-cigarettes have the potential to deliver equal or more nicotine compared to a traditional cigarette and some vapers may end up consuming more nicotine as a result.

Effects of Nicotine on Brain Development

E-cigarette use by youth is particularly concerning due to the impact of high doses of nicotine on the developing brain. The human brain continues to develop until approximately the

age of 25 (Arain et al., 2013). Using nicotine in adolescence, while the brain is developing, can harm the parts of the brain that control attention, learning, mood, and impulse control. Specifically, the prefrontal cortex, an area of the brain responsible for executive functioning, attention, and impulse control, is undergoing maturation during adolescence. Nicotine exposure in adolescents adversely impacts the prefrontal cortex causing behavioral issues and long-term effects on cognitive ability and mental health (Goriounova, 2012; SAMSHA, 2020).

Effects of Nicotine on Addiction

Exposure to nicotine among youth is also dangerous since it affects key brain receptors making adolescents more susceptible to nicotine addiction (USDHHS, 2014). In addition to making youth more prone to nicotine addiction, nicotine may induce epigenetic changes that sensitize the brain to other drugs and prepare it for future substance abuse (Yuan et al., 2015; Kandel, 2014). Several meta-analyses have examined the association between electronic cigarette use and future cigarette smoking initiation in adolescents, commonly referred to as the "gateway effect" (O'Brien et al., 2021; Soneji et al., 2017; Khouja et al., 2021; and Aladeokin and Haighton, 2019). These meta-analyses have all concluded that there is evidence to support the "gateway effect." However, the gateway effect is a subject of much debate and there are other studies that find no evidence of a gateway effect (Beard, et al., 2022) or argue that the relationship between e-cigarette consumption and future smoking is not causal, but rather is due to common liability (Chan et al., 2021). That is, vaping and smoking share a common liability that increases the risk of using both products.

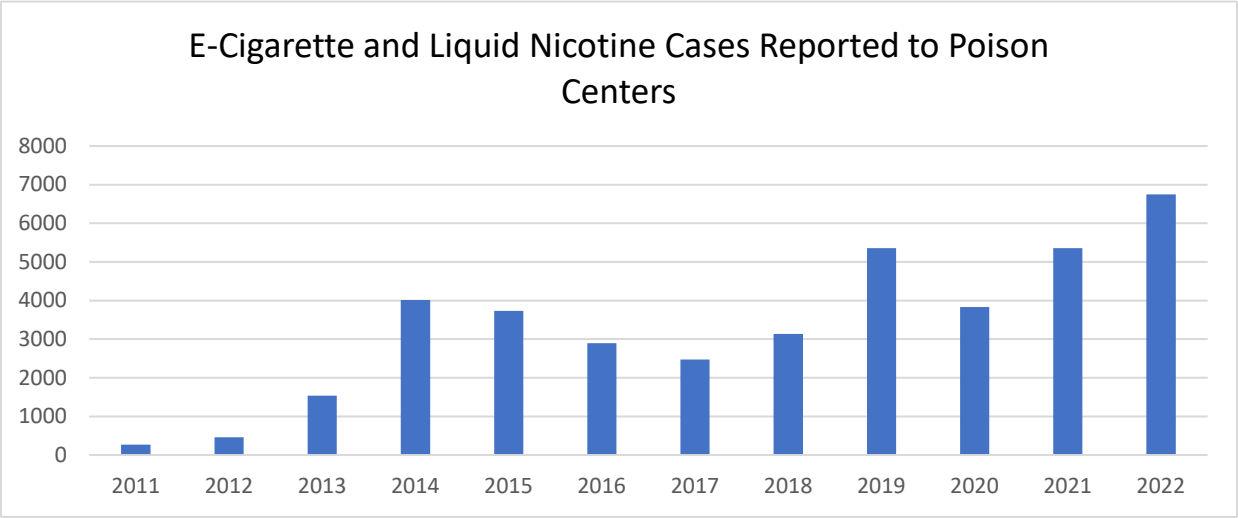
Effects of Nicotine on Pregnancy

Nicotine consumption during pregnancy is very dangerous as nicotine can cross the placenta and has known effects on fetal and postnatal development. According to the 2016 Surgeon General's report, "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" (USDHHS, 2016).

Effects of Nicotine on Acute Toxicity

Ingestion of nicotine can cause acute toxicity and possibly death if the contents of refill cartridges or bottles containing nicotine are consumed. Acute toxicity can occur from inhaling the aerosol from e-cigarettes or ingesting e-cigarette liquids through swallowing or absorbing through the skin or eyes. E-cigarettes pose a higher risk of nicotine toxicity as compared to smoking due to the availability of high nicotine concentrations in the e-cigarette liquids (Ordonez et al., 2013). According to Ordonez and colleagues (2013), "Acute nicotine poisoning has an early clinical phase characterized by nausea, vomiting, abdominal pain, salivation, bronchorrhea, tachypnea, hypertension, tachycardia, miosis, tremor, muscle fasciculations, and seizures. The delayed phase consists of respiratory depression, dyspnea, bradycardia, hypotension, shock, mydriasis, weakness, muscle paralysis, and coma." Poison centers began receiving calls about e-cigarettes and liquid nicotine products in 2011 and poison centers across the US have managed more than 40,000 exposure cases about e-cigarette devices and liquid nicotine since 2011. Figure 15 shows the yearly cases of e-cigarettes and liquid nicotine exposures reported to the poison centers between January 2011 and December 2022.

Figure 15



National Poison Data System, America's Poison Centers. Located at https://www.aapcc.org/track/ecigarettes-liquid-nicotine.

Cardiovascular Health Effects of E-cigarette Use

The use of e-cigarettes causes significant short-term elevations in heart rate, blood pressure, sympathetic nerve activity, and arterial stiffness which predisposes users to increased cardiovascular risk (Buchanan, 2020). The acute increases in sympathetic nerve activity, blood pressure, and heart rate are attributed to the vasoactivity of nicotine (Buchanan, 2020). Additional cardiovascular risk is attributed to reactive aldehydes such as acrolein, formaldehyde, and acetaldehyde which are found in e-cigarette generated aerosol (Fetterman et al, 2020).

A recent review of literature on the effects of e-cigarette use on cardiovascular health concluded that e-cigarettes increase cardiovascular mortality and morbidity and are not a safe alternative to combustible cigarettes for cardiovascular health (Raja et al., 2021). The review provides evidence of e-cigarettes causing inflammation of the pulmonary system and producing oxidative stress which leads to atherosclerosis and major vascular disease. The review also

highlights that e-cigarettes have been found to cause aggregation of platelets which can result in cardiovascular disease.

Respiratory Health Effects of E-cigarette Use

A review of the literature on the respiratory effects of e-cigarettes concluded that e-cigarettes disrupt normal pulmonary homeostasis which involves both physiological and immune-mediated processes (Miyashita and Foley, 2020). The report provides evidence that e-cigarette use disturbs gas exchange, reduces lung function, increases airway inflammation and oxidative stress, suppresses immune cell function, and increases the risk of respiratory infection. Another review of the literature by Gotts and colleagues (2019) found that e-cigarettes emit volatile carbonyls, reactive oxygen species, furans, and metals, many of which are toxic to the lung. The study further added that e-cigarette use is associated with increased odds of chronic cough, phlegm and bronchitis, and asthma diagnoses (Gotts et al., 2019). The report by Gotts and colleagues concluded that the current knowledge is insufficient to determine whether the respiratory health effects of e-cigarettes are less than those of combustible tobacco products. It will be decades before we see the effects of e-cigarette use on lung cancer, chronic obstructive pulmonary disease, and other respiratory diseases (Gotts et al, 2019).

Finally, during the summer of 2019, cases of e-cigarette or vaping use-associated lung injury (EVALI) increased sharply. By February 2020, nearly 3,000 hospitalized cases of EVALI had been reported to the CDC with 68 cases resulting in death. A 2019 study by the Mayo Clinic found that these lung injuries resembled “exposure to toxic chemical fumes, poisonous gases and toxic agents” (Mayo Clinic, 2019). The CDC believes that an additive in e-cigarette liquid, vitamin E acetate, was responsible for the outbreak and deaths.

Other Health Effects of E-cigarette Use

Individuals who do not use e-cigarettes may be exposed to aerosols emitted by e-cigarette users. These aerosols may contain nicotine, toxicants, and carcinogens and may be harmful to humans, particularly among vulnerable populations such as pregnant women and children. Moreover, explosions from poorly manufactured or defective e-cigarettes have caused injuries. A report by the US Fire Administration (USFA) concluded that between January 2009 and December 31, 2016, 195 separate incidents of explosion and fire involving an electronic cigarette were reported by the US media and these incidents resulted in 133 acute injuries (USFA, 2017). Of these explosion injuries, 38 (29%) were severe. Finally, the Food and Drug Administration has been investigating the relationship between e-cigarette usage and seizures since April of 2019. As of March 1, 2021, more than 250 reports of e-cigarette associated seizures have been submitted to the FDA, with approximately two thirds of cases occurring in youth or young adults (Liu-Zarzuela and Sun, 2022).

Recommendations for Health Care Providers and Schools

Health Care Providers

The American Academy of Pediatrics (AAP) has recommendations for physicians and other healthcare providers to talk to youth and their families about e-cigarette use. AAP recommends that all physicians ask about tobacco and nicotine use in their routine screenings by using communication that is comprehensible to youth. For example, AAP recommends pediatricians ask questions such as “Do you use any vaping products, like e-cigarettes or JUUL? Have you used them in the last year?” (AAP, 2019). Physicians need to be aware of different terminology and adjust their communication to individuals since there are many different terms for electronic nicotine delivery systems. Another reason to ask questions that are not as direct

as “Do you smoke?” is due to the interpretation of “smoking” as some people might not consider e-cigarettes (or vaping) to be “smoking.” Groner et al. (2015) recommend that in addition to asking about a patient’s use of e-cigarettes, providers should also ask if there were attempts to use as well as their friends’ use or attempts. In addition, AAP recommends pediatricians counsel parents and caregivers who use tobacco about the importance of quitting tobacco product use.

If someone is an active e-cigarette consumer, then AAP recommends that the pediatrician talk with the patient about quitting. Physicians are recommended to provide clear, personalized information about the negative impact of tobacco use and vaping. AAP suggests using messages that resonate with youth related to “breathing, athletic performance, health, or appearance” (AAP, 2019). Other messages that are appropriate are the outbreak of vaping-related lung disease, tobacco product costs to the consumer, and the deceitful marketing from the tobacco industry. Finally, it may be helpful to assess the patient’s level of addiction. There are tools related to e-cigarettes such as: The Hooked On Nicotine Checklist, E-Cigarette Dependence Scale, or Modified Fagerstrom Tolerance Questionnaire that can be used.

After discussing quitting e-cigarettes, AAP suggests that physicians help patients make a successful quit plan (AAP, 2019). First, determine the young patient’s desire to quit, then help them set a quit date; it is recommended that the quit date is planned within two weeks of this discussion. When setting the quit date, it is helpful to think about avoiding times that might be stressful to the patient; for example, periods when college readiness or accountability assessments like the SAT or state tests are being administered are probably stressful times. Inform the patient to identify people or situations that may tempt them to vape, but also

identify people that can support them and encourage their success in quitting. Since withdrawal symptoms are often associated with quitting nicotine, the young patient should be informed and given strategies to manage these symptoms. Consider finding cessation support services, or, if a person is moderately to severely addicted, then it might be reasonable to use pharmacotherapy. If the patient is not ready to quit completely, physicians can still discuss strategies for decreasing their consumption and revisit the topic at their next visit.

In the state of Indiana, the Indiana Department of Health (IDH) offers a telephone-based cessation service called Indiana Tobacco Quitline (IDH, 2023A). Indiana also has a program called Quit Now Indiana which works with healthcare providers and employers to help connect patients and employees with free services such as individualized coaching, nicotine replacement therapy, and online support (IDH, 2023B). Vape-Free Indiana also offers resources for parents, youth, educators, and health care professionals (Vape-Free Indiana, 2023).

Schools

No federal policy exists to restrict e-cigarette use in schools. In the absence of a federal policy, states, municipalities, and schools have adopted policies and created programs to deter e-cigarette use by students. Currently, no "best practice" guidelines have been established for schools to follow for deterring student consumption of e-cigarettes. The lack of "best practice" guidelines stems from the lack of a sufficient number of studies being published that evaluate existing school-based e-cigarette prevention programs.

Using existing evidence several states have created "toolkits" to guide schools in addressing e-cigarette use by students. The Indiana Department of Health has created the Vape-Free Schools Toolkit (VFST) to provide resources for those working "to address the use of

tobacco products, especially e-cigarettes in schools" (IDH, 2022). This document outlines potential ways for various school staff to address youth consumption of e-cigarettes with the support of the community.

Most school districts in the state of Indiana include e-cigarettes in their tobacco-free policies, including all public-school districts in Marion County, Indiana (IDH, 2022). As of October 2022, 25 counties in the state of Indiana had at least one public school that did not include e-cigarettes in their tobacco-free policies (IDH, 2022). According to the VFST, for a school campus to be recognized as being "tobacco-free," their policies must include the following:

- Prohibition of all tobacco products, including electronic products, THC products such as Delta 8, 9, and 10, and emerging heat not burn products.[3]
- Adopted policy is effective 24 hours a day.
- School buildings, grounds, and vehicles are tobacco free.
- All students, staff, parents, and visitors are subject to the policy's regulations.

The VFST also encourages that the policies:

- Require consistent enforcement and define consequences for violations of the policy for students, staff, and visitors.
- Provide referrals for resources to help students and staff overcome addiction to nicotine and use of tobacco and vape products.
- Provide annual notification of the tobacco-free and vape-free policy in school materials, including: handbooks, manuals, contracts, newsletters, and websites.
- Require tobacco education for staff.
- Make announcements about the policy at school-sponsored events.
- Require tobacco education for students in the health education curriculum.
- Provide supportive discipline options (non-punitive) for positive student outcomes.
- Educate parents, students, and staff about electronic cigarettes, including the dangers of vaping.
- Incorporate information on electronic cigarettes into health education classes and curriculum.
- Provide youth engagement and empowerment training and opportunities.

[3] Heat not burn tobacco products are electronic devices that heat tobacco instead of burning tobacco like traditional cigarettes. Heat not burn products are different from e-cigarettes because they use real tobacco, not the flavored liquid nicotine typically found in e-cigarettes.

- Provide positive and restorative practices to further support students in remaining or becoming tobacco-free.

Regarding the consequences students face due to violating the tobacco-free policies, VFST argues that penalties such as expulsion and suspension add to negative outcomes but do not address the issues of tobacco addiction, targeted e-cigarette marketing, and long-term consequences. The VFST recommends that the ways to address students' violation of these policies are to notify parents/guardians, get a guidance counselor or nurse involved, have the student participate in tobacco education programming as well as school or community service, connect the student to tobacco cessation treatment, or participate in peer-to-peer engagement opportunities. A significant amount of research has shown that student expulsion and suspension are associated with deleterious student outcomes. A meta-analysis conducted by Noltemeyer et al. (2015) concluded that a significant negative relationship exists between student suspensions and student achievement and a significant positive relationship exists between suspensions and student dropout. The Indiana VFST recommendation of not suspending or expelling students for e-cigarette use is consistent with the AAP recommendation. In particular, AAP states that "out-of-school suspension and expulsion are counterproductive to the intended goals, rarely if ever are necessary, and should not be considered as appropriate discipline in any but the most extreme and dangerous circumstances, as determined on an individual basis rather than as a blanket policy" (Lamont, et al, 2013).

The VFST also includes a list of resources for prevention including:

- Sweet Deception – a peer-to-peer education program created by VOICE.
- CATCH My Breath – youth e-cigarette prevention program. It provides current information to teachers, parents, and health professionals to equip students with the

knowledge and skills they need to make informed decisions about the use of e-cigarettes. It utilizes a peer-led approach.

- INDEPTH – an alternative to suspension or citation that helps schools and communities address teen vaping in a supportive environment; it is an interactive program that teaches students about nicotine dependence, establishing healthy alternatives and how to kick the unhealthy addiction that got them in trouble in the first place. It was developed by the American Lung Association.
- Other curriculums from the Truth Initiative and Stanford Medicine.

Economic Costs of E-Cigarette Consumption

As discussed above, the consumption of e-cigarettes is associated with numerous health consequences. The health care costs attributable to e-cigarette consumption are considered to be direct costs. But there are also indirect costs associated with e-cigarette consumption. Indirect costs associated with e-cigarettes are the impacts of secondhand aerosol exposure, the impacts of consumption on fetal health, and the value of lost productivity in the workplace. Only one study to date has quantified the direct costs of e-cigarette use and no studies have estimated indirect costs.

Direct Costs

Wang and colleagues (2022) are the first and only researchers to estimate the direct costs of e-cigarette use. They found the use of e-cigarettes costs the US $15.1 billion annually in adult health care expenditures. This is equivalent to $2,024 per e-cigarette user every year. The $15.1 billion in total healthcare expenditure is broken down into four categories: hospital nights, Emergency Room (ER) visits, doctor visits, and home visits. The total expenditures from nights spent in the hospital receiving inpatient care were $5.4 billion, ER visits resulted in $930 million, the number of visits to a doctor (non-hospital related) contributed $6.1 billion, and the expenditures from the total number of home care visits were $2.7 billion. Wang et al. deconstruct these costs by those who use e-cigarettes exclusively as well as those who use e-

cigarettes with other tobacco products. The total expenditures from those exclusively using e-cigarettes were $1.3 billion of the total $15.1 billion which is equivalent to $1,796 per exclusive user. Individuals who use other tobacco-related products in addition to e-cigarettes have a per-unit cost of $2,050 per multi-user and contribute $13.8 billion of the total adult healthcare expenditures ($15.1 billion). Differences in expenditures for exclusive use and dual/poly use are attributed to differences in prevalence rates. Using 2015-2018 National Health Interview Survey data, the authors estimated the prevalence of exclusive use of e-cigarette and dual/poly use of e-cigarettes to be 0.2% and 3.5%, respectively.[4]

Specific contributors to the expense of e-cigarette consumption can be related to the development of nicotine addiction and treatment for the addiction (Marques et al., 2021; Dinardo and Rome, 2019; Kaliamurthy and Camenga, 2022), increased incidents of mental health issues (Becker et al., 2020), increased cardiovascular health issues (Merecz-Sadowska et al., 2020; Benowitz and Fraiman, 2017; Glantz and Bareham,2018; Lippi et al., 2019), increased risk of diabetes (Gotts et al., 2019), increased lung health issues and other breathing issues (Muthumalage et al., 2019; Carter et al., 2017; Ghosh et al., 2018; Reidel et al., 2018; Viswam et al., 2018; Chaumont et al., 2019; Honeycutt et al., 2022; McConnell et al., 2017), and development of e-cigarette or vaping use-associated lung injury (Alexander et al., 2020; Hallowell et al., 2020).

[4] Several more recent studies have confirmed that a sizeable fraction of individuals that use e-cigarettes also use traditional cigarettes. For example, a study by Boayke and colleagues (2022) used 2020 BRFSS data and found 33.34% of e-cigarette users were dual users and 66.67% of e-cigarette users to exclusively use e-cigarettes. Kramarow and Elgaddal (2023) used 2021 NHIS data and found 28.9% of e-cigarette users were dual users and 71.1% of e-cigarette users to exclusively use e-cigarettes.

Indirect Costs

In addition to the healthcare costs that impact people who use e-cigarettes, there are costs imposed on others. Similar to traditional cigarette use, e-cigarettes expose non-users to secondhand aerosol. The difference in the exposure to secondhand smoke/aerosol from traditional cigarettes and e-cigarettes is that e-cigarettes do not expose individuals to toxic tobacco-specific products (Czogala et al., 2014); however, non-consumers of e-cigarettes are exposed to nicotine and other constituents in the aerosol. Ballbè et al. (2014) found that homes with at least one e-cigarette consumer had 2.7 times more airborne nicotine and cotinine concentrations compared to homes that had zero tobacco consumption. Ballbè and colleagues confirm the findings of Czogala et al. (2014) that individuals who do not consume tobacco products and are passively exposed to e-cigarettes absorb nicotine. Islam et al. (2022) found that the prevalence of secondhand aerosol exposure from e-cigarettes increased from 11.7% to 15.6% between the years 2014 to 2019 and this increase in secondhand aerosol exposure was associated with higher prevalence rates of wheezing, bronchitis symptoms, and shortness of breath among young adults in southern California.

Another indirect cost of e-cigarette consumption is its risk on pregnancy. Vilcassim et al. (2023) explain that there is evidence that suggests e-cigarette exposure during pregnancy can harm maternal and fetal health as well as create adverse effects that include “increased systemic inflammation, low birth weight, preterm birth, and small size for gestational age status.” A study by Li et al. (2019) found in an experiment using female mice that “continuous e-vapor exposure during pregnancy increased markers of oxidative stress, inflammation, and fibrosis in the adult offspring, independent of nicotine.” Their experiment suggests that e-cigarette use and exposure can impact the offspring by risking their kidney health.

E-cigarette use by employees can impact the workplace and impose costs upon employers. Graham et al. (2020) conducted a cross-sectional survey of working adults between the ages of 18 and 65 years in November 2019. They found that e-cigarette consumption can create costs to the employer through absenteeism and presenteeism (lost productivity), and impact other employees by triggering tobacco users to smoke and vape. Specifically, Graham et al. (2020) estimated that 7% of former tobacco users who were exposed to a co-worker who used e-cigarettes return to consuming tobacco. In addition, among current tobacco users, 46% to 48% reported vaping by coworkers was a trigger for them to return to smoking and vaping, respectively. This triggering of employees to consume tobacco then adds to the economic costs borne by employers. Moreover, Graham et al. (2020) reported that approximately one-third of employees stated that concern for their child's vaping led to their presenteeism and absenteeism.

Access to E-Cigarettes Via the Internet

In the United States, e-cigarettes can be purchased through various websites. Amendments to the Preventing All Cigarette Trafficking (PACT) Act of 2010 in 2021 resulted in regulations for the online distribution of e-cigarettes, vapes, flavored and smokeless tobacco, and other electronic nicotine delivery systems (ATF, 2023). The PACT Act bans the United States Postal Service from mailing e-cigarettes of any kind. Major common carriers (United Parcel Service (UPS), Federal Express and DHL) also stopped shipping vapor products. Some regional carriers and local delivery providers continue to ship vape products to consumers. Purchasing e-cigarettes online is still available in most states, but individuals must be age 21 or older; the Act requires "age verification delivery requirements to these devices and properly labeling packages

that contain them" (ATF, 2022). For example, when purchasing from an online vendor, such as Element Vape, you must type your full legal name, birthdate, permanent address, and the last four digits of your social security number which is "verified by a third-party software and cross-referenced with public record" (Element Vape, 2023). If there is a failure in matching to public record, then the purchaser is required to upload a non-expired government-issued I.D. Most online vendors have a verification system requiring an adult to sign for the delivery of e-cigarette products. On the producer side, vendors "are required by federal, state, and local laws to meet sales reporting, tobacco product shipping and tax requirements to ensure they are compliant with cigarette regulations" (ATF, 2023). These efforts from the PACT Act are meant to prevent youth from accessing e-cigarettes.

In addition to the federal guidelines and major carrier policies described above, some states have banned the shipping of e-cigarettes, including Arkansas, Georgia, Louisiana, Maine, Massachusetts, New Hampshire, New York, Oregon, South Dakota, Utah, and Vermont. Moreover, Maryland bans the shipping of disposable vape devices. New Jersey and Rhode Island ban the shipping of flavored e-liquid and prefilled devices containing nicotine besides tobacco. Anchorage, AK bans the shipping of any e-cigarettes. Chicago, IL bans the shipping of e-liquid and prefilled devices. San Francisco bans the shipping of e-liquid and prefilled devices that contain nicotine. The District of Columbia (DC) bans the shipping of any flavored e-liquid besides tobacco (Vape Street, 2023).

Seaman et al. (2022) reviewed studies that estimated the fraction of e-cigarettes that were sold online. Seaman and colleagues concluded that online sales compose approximately one third or less of the US e-cigarette marketplace. Other studies have examined the

prevalence of purchasing e-cigarettes on the internet among adults and youth. Braak et al. (2019) used 2016 International Tobacco Control Four Country Smoking and Vaping Survey data to estimate the fraction of current vapers who bought their vaping products online. Braak and colleagues found that in the United States 26.8% of adults who currently use e-cigarettes bought them online. Hsu et al. (2019) used 2014 and 2016 survey data drawn from GfK's KnowledgePanel to estimate the fraction of e-cigarette users who typically purchase e-cigarettes online. Hsu and colleagues found 21.5% and 17.5% of e-cigarette users usually purchased their e-cigarettes online in 2014 and 2016, respectively.

Among youth, lower rates of purchasing e-cigarettes online are observed. A study by Creamer (2020) used national data from the 2019 Youth Risk Behavior Survey (which surveys students in grades 9-12) to assess the fraction of young e-cigarette users who purchase vaping products online. Creamer and colleagues found that 3.6% of the high school students under age 18 who vaped usually purchased e-cigarettes online in 2019. This compared to 1.8% of high school e-cigarette users aged 18+ who usually purchased e-cigarettes online during the same year. Using the 2021 National Youth Tobacco Survey data, Gentzke et al. (2022) found that 2.9% of youth e-cigarette users purchased e-cigarettes online. The most recent study by Do and colleagues (2023) estimated that 2.1% of Individuals aged 15-to-20 purchased their e-cigarettes from the Internet in 2022. Most young people continue to obtain e-cigarettes from social sources and purchase their e-cigarettes from retail stores which include vape shops, gas stations, and convenience stores.

Regulation of E-Cigarettes

All levels of government, including federal, state, and local governments, have been involved in regulating e-cigarettes in the US.

Regulation by the Food and Drug Administration

At the federal level, the Food and Drug Administration (FDA) has regulated cigarettes, smokeless, and roll-your-own tobacco since 2009. Effective August 8, 2016 the FDA finalized a rule, known as the Deeming Rule, to regulate all tobacco products. The Deeming Rule asserts the FDA's authority to regulate the manufacturing, distribution, and marketing of e-cigarettes as part of the Family Smoking Prevention and Tobacco Control Act (Tobacco Control Act). The Deeming Rule included requirements for e-cigarette manufacturers to fill out a Premarket Tobacco Product Application (PMTA) that demonstrates to the agency that marketing of an e-cigarette would be appropriate for the protection of public health. The FDA would then review the application and make sure that the e-cigarettes are appropriate for the protection of public health. As of March 17, 2023, the FDA has received applications for more than 26 million deemed products and has made determinations on 99% of these applications. As of May 18, 2023, the FDA authorized 23 tobacco-flavored e-cigarette products and devices, which are the only e-cigarettes that currently may be lawfully sold or distributed in the US (FDA, 2023). The Tobacco Control Act does not provide FDA with authority to impose taxes on tobacco products or regulate indoor air quality, occupational health and safety, or hazardous waste disposal.

Youth Access and Tobacco 21 Laws

On December 20, 2019, the President of the United States signed legislation which amended the Federal Food, Drug, and Cosmetic Act and raised the federal minimum age for sale of tobacco products from 18 to 21 years. The legislation became effective immediately, making

it illegal for a retailer to sell any tobacco product (cigarettes, e-cigarettes, cigars, etc.) to anyone under the age of 21. The new federal minimum age of sale applies to all retail establishments and persons with no exceptions.

Prior to the federal government raising the minimum age for sale of tobacco products from 18 to 21 years, twelve states including Arkansas, California, Connecticut, Delaware, Hawaii, Illinois, Maryland, New Jersey, New York, Oregon, Vermont, and Virginia raised the age to buy e-cigarettes to 21, along with Washington, DC (CDC, 2023). Subsequent to the Federal minimum sales age increase, all remaining states (including Indiana) passed legislation to increase their tobacco age to 21 with the exception of Alaska, Arizona, Kansas, Missouri, Montana, North Carolina, South Carolina, Wisconsin, and West Virginia. The strength of the state laws (including penalty sizes and level of enforcement) varies considerably across the 41 states that have enacted a minimum sales age of 21 for e-cigarettes. In Indiana, violating the Tobacco 21 law is a Class C infraction for both the business that sells the vaping product and the youth that purchases the vaping product. The maximum fine for the business and youth are $400 and $500, respectively. There are no provisions in Indiana for business license suspension or revocation. The Indiana State Excise Police is the designated enforcement agency and compliance checks are conducted once per year per retailer.

Research shows that youth obtain e-cigarettes predominantly through social sources, such as friends, classmates, and peers (Tanski et al., 2018; Groom et al., 2021). Increasing the legal purchase age of e-cigarettes to 21 would reduce the likelihood that a high school student would be able to legally purchase tobacco products for other students and underage friends.

With the minimum legal sale age set at 21, legal purchasers of e-cigarettes would be less likely to be in the same social networks as high school students and therefore less able to sell or give e-cigarettes to them.

Research on the effects of e-cigarette minimum legal purchase age laws generally finds that these laws reduce underage e-cigarette use or decrease the growth in youth e-cigarette use (Pesko, 2023; Desimone et al., 2022; Abouk and Adams, 2017; Nguyen, 2020). A few recent studies have focused exclusively on the impact of tobacco 21 laws (and not just any minimum legal sales age) on e-cigarette use by youth. The findings from these studies are consistent with previous minimum legal purchase age studies and conclude that raising the minimum legal age to purchase e-cigarette to 21 substantially reduces youth e-cigarette use (Abouk et al., 2023; Bryan et al., 2020).

Taxes and Prices

The federal government, all 50 states, DC, and many municipalities tax cigarettes. The current federal excise tax on cigarettes is $1.01 per pack. State excise tax rates currently range from $0.17 per pack in Missouri to $4.35 per pack in New York, while the tax per pack in DC is $4.50. Unlike combustible cigarettes, there is currently no federal tax on e-cigarettes and only 30 states (including Indiana), DC, and a few cities, towns, and counties in the US impose taxes on e-cigarettes.

When governments increase excise taxes on tobacco products, retail prices increase, and in turn this causes a decrease in the consumption of tobacco products. Economists use a concept called the price elasticity of demand to measure how responsive consumption of tobacco is to a change in the price of tobacco. Technically, the price elasticity of demand is the

percentage change in the consumption of a tobacco product in response to a 1% change in the price of the tobacco product, with all else remaining constant.

An extensive body of research has examined the effects of cigarette taxes and prices on the demand for cigarettes in the United States. Reviews of the literature on cigarette demand conclude that cigarette prices are inversely related to cigarette smoking by both adults and youth (National Cancer Institute, 2016; Community Preventive Services Task Force, 2012). A Community Preventive Services Task Force review (2012), based on 116 studies from the United States and other high-income countries, concluded that the overall median price elasticity estimates for cigarettes were –0.37 for adults and –0.74 for youth. This implies that a 10% increase in the price of cigarettes will reduce the consumption of cigarettes by 3.7% for adults and 7.4% for youth.

A limited number of studies have examined the effect of e-cigarette prices and/or e-cigarette taxes on the demand for e-cigarettes. These studies generally find a significant inverse relationship between e-cigarette prices/taxes and e-cigarette use. The estimated e-cigarette elasticities are generally larger (in absolute terms) than what is typically estimated for cigarettes. For example, Huang and Colleagues (2015) were the first to examine the economic determinants of the demand for e-cigarettes in the US. The study employed retail store scanner data from 52 US markets from 2009-2012. The study found e-cigarettes to be very responsive to price changes with price elasticities of demand for disposable cigarettes to be centered around -1.2, while those of reusable e-cigarettes to be centered around -1.9. Several more recent studies have also used retail scanner data and have estimated similar price elasticities of demand for e-cigarettes (Zheng et al., 2016; Zheng et al., 2017; Huang et al., 2018).

Other studies have used survey data to estimate the price elasticity of demand for e-cigarettes (Pesko and Warman, 2017; Saffer et al., 2018; Pesko et al., 2018; Diaz, et al., 2023). Three of these studies estimated the price elasticity of youth e-cigarette demand. All three studies found youth e-cigarette consumption to be responsive to e-cigarette prices. Diaz et al. (2023) found the price elasticity of demand for e-cigarettes for high school students to range between -0.92 and -1.16. Pesko and Warman (2017) estimated a youth price elasticity of demand of -2.2 for e-cigarette cartridges. Pesko et al. (2018) found that a 10% increase in disposable e-cigarette prices was associated with a 9.7% reduction in the number of days youth e-cigarette users use e-cigarettes. One study by Saffer et al. (2018) estimated the price elasticity of e-cigarette demand for adults. Saffer and colleagues used data extracted from the 2014 and 2015 Tobacco Use Supplements to the Current Population Survey to estimate an e-cigarette prevalence price elasticity of demand of -1.2 for adults. Finally, one study by Pesko et al. (2020) examined the effects of e-cigarette taxes on e-cigarette demand among adults and concluded that a $1.00 increase in tax per fluid ml of vaping liquid reduces the probability of current vaping among adults by 15.3%.

Several other studies have found that increasing e-cigarette taxes results in increased use of combustible cigarettes (Cotti et al., 2022; Pesko et al., 2020; Saffer et al., 2020; Friedman and Pesko, 2020; and Pesko and Warman, 2021). This suggests that e-cigarettes and combustible cigarettes are economic substitutes. The finding that e-cigarettes and combustible cigarettes are economic substitutes may be of concern to policymakers because policies that are intended to reduce the consumption of one good (such as a tax increase) may actually be increasing the consumption of the other good.

Vape-free Air Laws

There is little federal regulation restricting smoking in the workplace. In August 1997, Executive Order 13058, "Protecting Federal Employees and the Public from Exposure to Tobacco Smoke in the Federal Workplace," was signed. The executive order banned smoking in all executive branch facilities, including all interior space owned, rented, or leased by the executive branch of the federal government. The ban on smoking was later extended to e-cigarettes. Prior to the 1997 executive order, the federal government banned smoking on all domestic flights and by 2000, the US banned smoking on all international flights. In 2016, the Department of Transportation explicitly banned the use of e-cigarettes on all flights where smoking was banned.

Restrictions on smoking in private workplaces have been primarily enacted at the state and local levels. Currently 28 states and the District of Columbia have enacted comprehensive smoke-free air laws that ban smoking in all non-hospitality workplaces, restaurants, and bars (American Non-Smokers' Rights Foundation, 2023). Moreover, as of April 1, 2023, there were 1,169 municipalities that had enacted comprehensive smoke-free air laws that ban smoking in all non-hospitality workplaces, restaurants, and bars. Fewer states have enacted comprehensive vape-free air laws. As of July 1, 2023, 19 states had banned e-cigarette use in all non-hospitality workplaces, restaurants, and bars and 1,035 municipalities had banned e-cigarette use in 100% smoke-free venues (American Non-Smokers' Rights Foundation (ANRF), 2023). While the state of Indiana does not prohibit e-cigarette use in workplaces, restaurants, or bars, 18 cities and counties in Indiana do ban e-cigarette use in workplaces, restaurants, or bars. Marion County (except the cities of Beech Grove, Lawrence, Southport, and Speedway) bans smoking in all non-hospitality workplaces, restaurants, and bars (ANRF, 2023).

The empirical evidence on the effect of vape-free air laws on e-cigarette use is mixed. A study by Choi et al. (2022) found the prevalence of youth having ever used e-cigarettes and youth having used e-cigarettes in the past 30 days in states with e-cigarette-inclusive smoke-free policies decreased during 2017-2019, while the prevalence of these measures in states without e-cigarette-inclusive smoke-free policies increased. A similar finding was observed by Lee et al. (2019) who found adults living in states with aerosol-free policies were less likely to use e-cigarettes compared with those living in states without aerosol-free policies. Other studies found vape-free policies not to deter e-cigarette consumption. For example, Yang et al. (2022) found there were no statistically significant differences in e-cigarette use behaviors between participants living in states with and without aerosol-free policies. Moreover, Friedman et al. (2022) found adding worksite vaping restrictions to smoke-free policies yielded no further reduction in vaping by adults in the US.[5] Finally, another recent study (Nguyen and Bornstein, 2021) found bans on e-cigarette use in public places and workplaces in Canadian provinces had no impact on adult vaping behavior.

Flavor Bans

The federal government, several states, and numerous localities have implemented policies banning the sale of flavored tobacco products. The most comprehensive policies ban the sale of all flavored tobacco products without exemptions for certain flavors, products, or retailers.

[5] One limitation of the Friedman study is that vape-free air laws were merged with the survey data by quarter-year based on laws in effect the first day of each quarter. Therefore, if a vape-free air policy went into effect on January 2 for a particular location, individuals surveyed in that location during the first quarter would have been coded as not facing a vape-free air law despite the fact that the individuals did face a vape-free air law for 89 out of 90 days that quarter.

In 2009, as part of the Family Smoking Prevention and Tobacco Control Act, Congress banned characterizing flavors[6] in combustible cigarettes except for menthol. In February 2020, the FDA prioritized enforcement against flavored cartridge/pod-based e-cigarette products, except for menthol and tobacco flavor.

Massachusetts became the first state in the US to ban the sale of all flavored tobacco products, including menthol cigarettes and flavored e-cigarettes, in 2019.[7] The only exception to the Massachusetts law is that flavored tobacco products can still be sold at licensed smoking bars where consumption must occur on-site. In 2020, three other states (New Jersey, New York, and Rhode Island) enacted bans on the sale of flavored e-cigarettes. In January 2021, California banned nearly all flavored tobacco products; the only exemptions from the policy are for premium cigars, loose leaf tobacco, and hookah tobacco. Other state flavor bans have been limited to specific products.

There have been significant local level efforts to ban flavors in tobacco products. According to The Campaign for Tobacco-Free Kids, more than 365 localities have enacted laws restricting flavored tobacco sales in some manner, with more than 125 localities prohibiting the sales of all flavored tobacco products, including menthol, without exception (CTFK, 2023).

[6] A characterizing flavor is a taste or aroma, excluding the taste or aroma of tobacco, imparted either prior to or during consumption of a tobacco product or any byproduct produced by the tobacco product, including but not limited to, menthol, mint, wintergreen, fruit, chocolate, vanilla, honey, candy, cocoa, dessert, alcoholic beverage, herb, or spice. Characterizing flavor includes flavor in any form, mixed with or otherwise added to any tobacco product or nicotine delivery device, including electronic smoking devices.

[7] Massachusetts' flavor ban became effective November 27, 2019 for e-cigarettes and June 1, 2020 for all other products.

A small but growing number of studies have evaluated the effects of flavor bans on e-cigarette use; these studies indicate that flavor bans are effective at reducing e-cigarette consumption. Studies that use sales data find reductions in e-cigarette use after the implementation of flavor bans (Katchmar et al., 2021; Liber et al., 2021; Ali et al., 2020), and one study (Gammon et al., 2021) found the rate of increase in e-cigarette sales was much lower in San Francisco, which enacted a flavor ban, than it was in two comparison cities that did not adopt a ban on flavored tobacco products. Five studies relied on individual-level survey data to assess the impact of flavor bans on tobacco use. Three of these studies found that flavored tobacco bans led to reductions in the use of any flavored tobacco products (Kingsley et al., 2018; Kingsley et al., 2021; Yang et al., 2020) and one study found that the San Francisco flavored tobacco product ban was associated with an increase in cigarette smoking among high school students (Friedman, 2021).[8] Only one study that used survey data specifically focused on the effects of flavor bans on e-cigarette use (Hawkins et al., 2021). Hawkins and colleagues (2021) found county-level restrictions on flavored tobacco products significantly decreased e-cigarette use among high school students in Massachusetts between 2011 and 2017.

Spending on Comprehensive Tobacco Control Programs

During the past 30 years, states and the federal government have funded a variety of programs and policies in an effort to prevent initiation and promote cessation of combustible tobacco products. Following the rapid rise in e-cigarette use by youth, the federal government and numerous states have funded efforts to prevent e-cigarette use by youth and young adults

[8] The study by Friedman has been widely criticized because the data collection from San Francisco schools (as part of the 2019 YRBS) was collected in November-December 2018. This suggests that all the survey data were collected before the San Francisco flavor ban went into effect and therefore the effect of the flavor ban could not be evaluated.

as part of their comprehensive tobacco control efforts. Tobacco control funds are typically used for health communication interventions, cessation interventions, state and community interventions, surveillance and evaluation, and administration and management. In fiscal year (FY) 2023, all 50 states and District of Columbia (DC) appropriated $733.1 million for established and emerging tobacco product prevention and cessation programs (CTFK, 2023). These appropriations are significantly less than the $3.3 billion CDC recommends states spend to maintain comprehensive tobacco control programs. In FY 2023, only two states, Oregon and Maine, funded tobacco prevention and cessation programs at or above the CDC-recommended levels.

Numerous state-specific reports and several national studies have provided convincing evidence that state tobacco control spending reduces conventional cigarette use (Biener et al., 2000; Massachusetts Department of Public Health, 2000; Abt Associates, 1999; CDC, 1996; Arizona Department of Health Services, 1999; Florida, 2001; Bauer et al., 2000; Manley et al., 1997; Farrelly et al., 2003; Tauras et al., 2005; Tauras et al., 2018; Farrelly et al., 2008). Only one study to date has examined the effects of state spending on comprehensive tobacco control programs on e-cigarette use (Tauras et al., 2021). The study found that increased spending on tobacco control programs reduced the number of high school students who vape and decreased the number of days vaping products were used by high school students. In particular, the study found that a 50% increase in state spending on tobacco control during the time of the surveys was associated with a 7.46% lower high school student vaping prevalence rate.

Indiana and Marion County Efforts to Deter E-cigarette Consumption

For many years, the state of Indiana has underfunded tobacco control programs. In FY2023, $9,332,809 was allocated for tobacco control efforts. This level of funding represents just 12.7% of what the CDC recommends that Indiana spend for tobacco prevention and cessation efforts. Some of this funding was presumably spent to prevent electronic cigarette use by youth, though unfortunately, data does not exist on how much was spent on these efforts.

The state of Indiana has enacted a number of policies to regulate the use of e-cigarettes. For example, on July 1, 2020, Indiana's new minimum purchase age law of 21 for e-cigarettes went into effect. In addition, on July 1, 2022, Indiana's electronic cigarette tax went into effect. The tax is imposed on the retail sale of consumable material and vapor products in Indiana and is equal to fifteen percent (15%) of the gross retail income received by the retail dealer for the sale. The person who acquires consumable material or vapor products in a retail transaction is liable for the tax on the transaction and shall pay the tax to the retail dealer as a separate added amount at the time of the transaction. Moreover, retailers and manufacturers of e-cigarettes must obtain a tobacco sales certificate from the Indiana Alcohol and Tobacco Commission and distributors must obtain a license to sell electronic cigarettes from the Department of State Revenue. Furthermore, all retail locations selling electronic cigarettes shall post and maintain signs that: 1) state "The sale of tobacco or electronic cigarettes to persons under 21 years of age is forbidden by Indiana law"; 2) state "Smoking by Pregnant Women May Result in Fetal Injury, Premature Birth, and Low Birth Weight"; and 3) display a toll-free number for assistance to callers in quitting smoking. Indiana also fines individuals who are less than the age of 21 and are caught purchasing or possessing e-cigarettes. In addition, self-service displays and vending

machines selling or distributing electronic cigarettes are restricted to areas of licensed premises accessible to persons over 21 years of age. It is also illegal for retailers to make a delivery sale of e-liquid to a person under age 21 or ship e-liquid without making a good faith effort to verify the age of the purchaser. Indiana also prevents tobacco and vaping businesses from operating within 1,000 feet of a public or private elementary or secondary school.

No statewide restrictions on the use of electronic cigarettes in public places and workplaces exist in Indiana. In particular, there are no state restrictions on using e-cigarettes in private worksites, restaurants, bars, government worksites, commercial or home-based daycare centers, hotels and motels, private and public multi-unit housing, or public schools and universities in the state of Indiana.

Indiana does not preempt local jurisdictions from enacting vape-free air laws. Currently 18 cities or counties in Indiana regulate where e-cigarettes can be used. Marion County bans the use of e-cigarettes in all private worksites, restaurants, and bars. The state of Indiana has no prohibitions on the sale of flavored e-cigarettes. Moreover, no cities or counties in Indiana prohibit the sale of flavored e-cigarettes.

Shortcomings in the Policy Literature and Recommendations for Future Research

While much has been learned about the effects of public policies on the demand for e-cigarettes since their introduction in the US 15 years ago, much more research is needed. From data collections to empirical analyses, more efforts need to be made in order to understand the effects of policies on e-cigarette consumption.

Only two published studies have examined the effects of tobacco 21 laws on youth e-cigarette use. These studies focused on individuals who had not yet completed high school. While this is an important group to study, many young adults start using e-cigarettes in college or increase their e-cigarette habit in college due to less parental involvement in daily life. Unfortunately, no studies have examined the effects of tobacco 21 laws on young college students. Moreover, no studies have looked at the effects of tobacco 21 laws by subpopulations of youth and young adults based on gender, socio-economic status, race/ethnicity, etc. Finally, no studies have examined the effects of tobacco 21 laws on e-cigarette initiation and escalation by youth. These studies are desperately needed.

A slightly larger number of studies have investigated the effects of e-cigarette and combustible cigarette prices and taxes on the demand for e-cigarettes and combustible cigarettes. These studies generally find higher e-cigarette taxes and higher e-cigarette prices to have a negative effect on e-cigarette consumption and a positive effect on combustible cigarette consumption. Likewise, these studies generally find higher combustible cigarette taxes and higher combustible cigarette prices to have a negative effect on combustible cigarette consumption and a positive effect on e-cigarette consumption. Given the likely substitution between e-cigarettes and combustible cigarettes, researchers must increase their efforts to determine if current taxation strategies on e-cigarettes and cigarettes by states and localities promote public health. In taxing e-cigarettes, this means evaluating the populations that are using e-cigarettes and balancing the trade-offs between the harm that youth vaping poses and the potential for future addiction to high levels of nicotine, and the potential benefits that e-cigarettes afford to adults who completely transition from cigarettes to e-cigarettes. Moreover,

no studies examining the effects of taxes and prices on e-cigarette consumption have examined e-cigarette initiation, e-cigarette cessation, or other transitions in the e-cigarette uptake continuum (such as the transition from non-daily use to daily use and the transition from daily use to heavy daily use) and e-cigarette regression continuum (such as the transition from daily use to non-daily use) and none has focused on subpopulations of youth and adults. This research is desperately needed.

A limited number of studies have examined the effects of vape-free policies on e-cigarette demand and the results of these studies are mixed. More research, particularly on youth and young adults, is needed, as only one previous study by Choi and colleagues (2022) has examined the effects of aerosol-free policies on youth e-cigarette consumption. Moreover, more studies need to be conducted that take into account local policies as well as state policies. Only one study took into account local policies, but this study had limitations as explained in footnote 5. Additional research to disentangle the mixed results of vape-free air laws is needed. Also, additional research on the effects of vape-free air laws on e-cigarette vaping initiation and cessation and on subpopulations is greatly needed.

Finally, previous studies that utilize sales data have generally found that flavor bans decrease the use of e-cigarette use. Other studies have looked at individual behavior using survey data. Most of these studies have looked at the effects of flavor bans on any tobacco use. Only one study by Hawkins and colleagues (2021) looked specifically at the effects of flavor bans on e-cigarette use by high school students in Massachusetts. Additional studies on youth outside of Massachusetts and studies on adults should utilize survey data to examine the effects of flavor bans on e-cigarette use. The Truth Initiative is currently creating a dataset that

calculates the fraction of each state's population that is covered by tobacco flavor bans, taking into account both state and local flavor bans. This data should be merged with both sales and survey data on youth and adults using national data. Moreover, additional research on the effects of flavor bans on e-cigarette initiation and cessation and on subpopulations is needed.

Several tobacco control policy surveillance systems have tracked total state tobacco control and prevention funding since the late 1990s and early 2000s, including the CDC's State Tobacco Activities Tracking and Evaluation System (STATE), the American Lung Association's State Legislated Actions on Tobacco Issues (SLATI), and the Campaign for Tobacco Free Kids' State Tobacco Control Funding database. Unfortunately, state tobacco control funding data tracked in these systems only report the total funding amounts for state tobacco control-related activities. One tobacco control policy surveillance system funded by Truth Initiative and created by researchers at the University of Illinois at Chicago (UIC) tracked disaggregated spending data by the CDC's Best Practices categories for the fiscal years 2008-2016. The Best Practices Categories included: state and community interventions, health communication interventions, cessation interventions, surveillance and evaluation, and administration and management. Unfortunately, no tobacco control policy surveillance systems have tracked actual state spending on tobacco control by the CDC's Best Practices categories since FY2016.

Moreover, to our knowledge, no tobacco control policy surveillance system has ever tracked expenditures to prevent and control the use of e-cigarettes and other electronic nicotine delivery systems (ENDS). Anecdotal evidence suggests that some states are spending tobacco control money to discourage e-cigarette use. An American Public Media report (2018) found that only 13 states were spending money to discourage e-cigarette use by youth. More

recently, a California executive order by Governor Newsome created a large public education advertising campaign for 2019-2020 to address the outbreak of e-cigarette consumption in that state. In order to address the rise in youth vaping in the United States, researchers need to have access to data on how much money states are spending to discourage e-cigarette use, and how the money is actually being spent.

Subsequent to the creation of a database that tracks state expenditures to prevent and control the use of e-cigarettes and other electronic nicotine delivery systems (ENDS), research will need to analyze the effects of state e-cigarette spending on the demand for e-cigarettes by both youth and adults. Indeed, only one study to date by Tauras et al. (2021) has examined the effects of total tobacco control spending on high school student vaping in the US and no studies have looked specifically at the effects of spending on e-cigarette prevention and control on youth and young adult e-cigarette demand. Further, no studies have looked at spending on any type of tobacco control efforts on the demand for e-cigarettes among adults or subpopulations of adolescents or adults based on race/ethnicity, age, gender, socio-economic status, or other subpopulations. Finally, no studies have examined the effects of tobacco control spending on e-cigarette initiation or cessation. This research is desperately needed.

Conclusion

Despite recent declines in youth vaping prevalence rates in Indiana, electronic vapor products are by far the most common nicotine-related product used by Indiana youth. Marion County youth tend to vape at higher rates than youth statewide. Unlike the recent declines in youth vaping in Indiana, adult vaping prevalence rates have been rising. Indeed, between 2016 and 2021, the prevalence of e-cigarette use among adults in Indiana has increased by 72.3%. In

2021, the prevalence of current e-cigarette use among Indiana adults aged 18+ was 8.1%. This is significantly higher than the national prevalence rate of 6.7% and makes Indiana the state with the seventh highest adult e-cigarette prevalence rate in the country.

While it is generally believed that e-cigarettes are safer than combustible cigarettes, the inhaled nicotine, chemical compounds, and metals that enter the human body once the liquid of an e-cigarette has been aerosolized cause significant human health effects. The use of e-cigarettes costs the US more than $15 billion dollars annually in adult health care expenditures.

Numerous regulations and policies at the federal, state, and local levels have been enacted to control the use of e-cigarettes among the American people. These policies include youth access laws, vape-free air laws, flavor bans, e-cigarette taxation, spending on comprehensive tobacco control programs, and others. Research on the effects of these policies is relatively limited, particularly as compared to the research on the effects of policies on combustible cigarettes. While much has been learned about the effects of public policies on the demand for e-cigarettes since their introduction in the US 15 years ago, much more research is needed. From data collections to empirical analyses, more efforts need to be made in order to understand the effects of policies on e-cigarette consumption. To date, no tobacco control policy surveillance system has tracked expenditures to prevent and control the use of e-cigarettes and other electronic nicotine delivery systems (ENDS) and such a surveillance system is desperately needed. Moreover, the volume of research on any particular e-cigarette policy is small and often times these studies just look at the impact of the policy in one locality; additional studies need to be conducted to verify findings. Finally, there has been no research on the effects of policies on subpopulations of youth and adults defined by gender,

race/ethnicity, or socio-economic status and there has been no research examining the effects of e-cigarette policies on e-cigarette initiation and cessation decisions or other transitions in the e-cigarette uptake and regression continuums using longitudinal data. This research is desperately needed.

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