**University of Maryland Baltimore County**

**The Effects of a County-Level E-cigarette Tax on Youth Vaping Incidence and its Policy Implications**

**Tanguy Ringoir**

**Advising Professor: Dr. Dennis Coates**

**ECON 699**

**Dr. David Mitch**

**Abstract**

The EVALI-outbreak of the summer of 2019 ushered in a period of rapid policy changes at the federal, state, and local level, aimed at curbing e-cigarette usage among youth. The most common policy response at the state level has been the enactment of an e-cigarette tax. This paper discusses the regulatory environment of e-cigarettes, and investigates the effectiveness of one of the earliest implemented e-cigarette taxes: the 30% tax on the wholesale price of e-cigarettes in Montgomery County, Maryland. Difference-in-difference estimation is applied to data from the Maryland Youth Risk Behavior Survey and Youth Tobacco Survey. Findings indicate that the tax had a significant impact on youth vaping incidence, with a reduction of 1.4 percentage points observed in the year following the enactment of the tax. The data from three years after the policy’s enactment shows a greater impact of a reduction of 3.8 percentage points, attributable to the e-cigarette tax. These results are consistent with the concept of youth’s e-cigarette consumption being more elastic over a longer time horizon. The conclusion is that e-cigarette taxes could be a good policy to try and curb e-cigarette usage among youth, but the likely negative effects on smoking cessation rates of adults should be taken into consideration.

**I. Introduction**

Life expectancy in the United States peaked in 2014, and has seen a gradual decline since. Smoking is the leading cause of preventable death, responsible for half a million American deaths every year. Smokers die on average 10 years earlier than nonsmokers and 16 million Americans are living with a disease caused by smoking. These facts reported by the Centers for Disease Control and Prevention (CDC)[[1]](#footnote-1) illustrate the gravity of the situation. Fortunately, a Chinese man named Hon Lik invented a device aimed at improving the health of smokers: the e-cigarette.

Hon Lik was a Chinese pharmacist whose father died of lung cancer (Satel, 2020). Since up to 90%[[2]](#footnote-2) of lung cancer deaths can be attributed to cigarette smoking, it comes as no surprise that Hon Lik’s father was a smoker. Similarly struggling with this addiction, Hon Lik tried to quit but failed. His invention intended to deliver nicotine – the addictive chemical in cigarettes – without many of the harmful chemicals. The National Cancer Institute has identified over 7,000 chemicals in tobacco smoke. An astonishing 250 chemicals are found to be harmful to both smokers and people exposed to secondhand smoke, including about 70 known carcinogens[[3]](#footnote-3). Almost all of these chemicals find their way into the smokers’ lungs via the tar in cigarette smoke. Since e-cigarettes don’t burn tobacco, there is no tar. Hon Lik’s invention was brought on the Chinese market in 2003, but adoption of this new technology among Americans was slow due to its low-nicotine content (Satel, 2020). When diffusion started picking up in the early 2010’s, it didn’t just attract the attention of current smokers: Apart from this target market, youth were attracted to the innovation as well.

These youth should not be vaping. The e-cigarette is not a harmless device, it is a harm reduction product. Incidence of e-cigarette usage among youth has increased substantially this past decade. The government – at the federal, state, and local level – has enacted numerous policies to address what Surgeon General Jerome Adams called an e-cigarette epidemic among youth[[4]](#footnote-4).

In this paper, I will – due to their substitutability and interconnectedness of policy implications – discuss both cigarette and e-cigarette usage contemporaneously where appropriate. I will start by describing the incidence of cigarette and e-cigarette usage by youth over time. I will then provide argumentation in favor of government intervention, before diving into e-cigarette’s regulatory environment. The most common policy enacted by states to counter the youth vaping epidemic has been an e-cigarette tax. The theoretical justification for this is that youth are likely quite price sensitive, and would therefore purchase fewer e-cigarettes. The state of Maryland is currently considering such an e-cigarette tax, but Montgomery County already imposed a 30% tax on the wholesale price in 2015. Using data on vaping incidence by youth in Maryland, I will investigate whether this vaping tax reduced usage among youth. Finally, I will discuss what policymakers should keep in mind before voting on Maryland Senate Bill 3, which proposes to enact an e-cigarette tax in the state of Maryland, and which will affect both vaping youth and smokers that struggle with addiction.

**II. Cigarette and e-cigarette incidence by youth over time**

Ever since Surgeon General Luther Terry reported the negative health effects of smoking in 1964, cigarette use in the United States has been in decline. This decline is especially noticeable in our youth. Just in the last 20 years, current[[5]](#footnote-5) cigarette smoking by high schoolers has decreased from over 35% to well under 10% today[[6]](#footnote-6).

While cigarette smoking in youths has declined, in 2016 Surgeon General Jerome Adams declared a new health epidemic among youths: electronic cigarette (e-cigarette) use. E-cigarettes contain a battery, a heating element, and a place to hold a liquid. The liquid usually contains nicotine (the addictive drug in regular cigarettes), flavorings, and other chemicals. The liquid gets heated into an aerosol, which users then inhale into their lungs. The Youth Tobacco Survey last year found that a quarter of high school students vaped within the previous 30 days. This number is over twice as big as the reported frequency just three years prior.

The following figure from a national youth survey conducted by the CDC shows incidence of both cigarette and e-cigarette usage among youth over time.

**Figure 1a**

Source: Data collected from National Youth Tobacco Survey (NYTS) on youth grades 6 – 12.

We notice that current usage and experimentation (see Figure 1b in appendix) of cigarettes among youth has seen a steady decline, although experimentation numbers remain quite elevated. E-cigarette usage and experimentation has increased more than tenfold in the past eight years.

Furthermore, the age of youth when they experiment with e-cigarettes is declining over time. Using the same national survey, I calculated the average age at which a youth would experiment with e-cigarettes and I graphed its distribution for the years 2014, 2018, and 2019. These figures (2a, 2b, and 2c) can be found in the appendix. The calculated[[7]](#footnote-7) average ages of experimentation of e-cig use were 14.577 in 2014, 14.094 in 2018, and 14.086 in 2019. Comparing data from 2014 with data from 2018, we can see that the average age decreased substantially, and that the mode of the distribution declined from 16 to 14. We also notice that there is a big jump from age 13 to 14, which might be due to the individual’s transition from middle school to high school. The 2019 data shows incidence of vaping evening out, with higher participation at middle schools.

We can conclude that great progress has been made in the area of cigarette usage among youth, but the increase in e-cigarette usage threatens to addict another generation to nicotine.

**III. Arguments in favor of government intervention**

There is no question that government intervention is warranted in both the cigarette and e-cigarette markets. Policy analysis textbooks – such as Weimer’s “public policy bible” – often consider market failures as reasons for government intervention. In this section, I will discuss the market failures in both the cigarette and e-cigarette markets.

In the cigarette market, the main market failure is the negative externality of the exhaled smoke. This negative externality manifests itself in the impaired health of individuals not personally involved in the smoking of cigarettes. The CDC states that more than 41,000 Americans die every year due to secondhand smoke exposure[[8]](#footnote-8). Even thirdhand smoke (THS) can be dangerous – this is when tobacco smoke lingers in rooms or on clothes.

It is a bit more complicated for the e-cigarette market. Even though secondhand vaping is not risk-free, it’s hardly comparable to secondhand smoke[[9]](#footnote-9). The main market failure in the e-cigarette market is information asymmetry. Information asymmetry is a market failure in which there is an information imbalance across parties in the transaction. Among youth, evidence suggests that buyers have an information disadvantage. Even though some e-cigarettes don’t contain nicotine, most of them do. The nation’s biggest seller of e-cigarettes is JUUL, which according to Nielsen data controlled about three quarters of the e-cigarette market in 2018. JUUL pods always contain nicotine, and about two-thirds of youth are unaware of this (Willett, 2018). This means that youth are unaware of the dangers that vaping represent. If we assume that users are rational and are oriented towards the future, then informing youth of the health risks should change current behavior. However, this rationality model does not necessarily need to apply to youth, or to an addictive product. Due to social ties and myopia, change in behavior might be inhibited (Stone, 2012). Informing youth about the dangers of vaping is important, but therefore not necessarily sufficient in reducing usage.

**IV. The regulatory environment**

In this section I will examine the regulatory environment and some of the enacted policies in the e-cigarette market, and discuss the potential effects of those policies on the cigarette market. Policy responses came in the form of either regulation or taxation, and I will discuss both in turn, drawing upon the current literature.

The Tobacco Control Act of 2009 gave the Food and Drug Administration (FDA) the power to regulate the tobacco industry[[10]](#footnote-10). In 2016, the FDA expanded the definition of “tobacco product” to include e-cigarettes[[11]](#footnote-11). This extension of authorities means that the FDA regulates both the cigarette and e-cigarette markets. The FDA has a negative stance towards vaping, and the focus of the agency – together with the CDC – has been to discourage youth from vaping. Little to no attention is paid to current smokers attempting to quit their habit using e-cigarettes. A popular paper by Nutt et al. in 2014 claimed that e-cigarettes were 95% safer than regular cigarettes and Nutt declared e-cigs “the greatest health advance since vaccines”[[12]](#footnote-12). Both the FDA and the CDC disagree, and claim that long-term risks are unknown. This is true, but to some degree irrelevant, since the long-term risks of cigarette smoking are well-known and certainly worse than those of e-cigarettes. Furthermore, both U.S. agencies claim there is no evidence that e-cigarettes are a quit smoking aid and decline to approve them as such[[13]](#footnote-13). Canada’s regulatory agency also states that current research on e-cigarettes as a smoking cessation device is “inconclusive”[[14]](#footnote-14), although they recognize the health benefits of vaping compared to smoking. The FDA’s negative stance is to some degree understandable considering that the U.S. is the only country where vaping among youth is such an issue, but it can be dangerous to the health of smokers.

Several countries have a more pro-vaping stance compared to the FDA in the United States. The United Kingdom’s Public Health England (PHE) is the clearest example: They funded Nutt’s research mentioned earlier, and agree that e-cigarettes are less harmful than cigarettes. They claim that e-cigarettes “aren’t completely risk free but they carry a small fraction of the risk of cigarettes”. They also call quitting cigarettes with an e-cigarette particularly effective “when combined with expert face-to-face support”[[15]](#footnote-15). This contrasts with the FDA’s opinion, but the latest research backs up the PHE’s claim (Hajek, 2019 and Fairchild, 2019). The UK’s policy stance – based on compelling evidence – is to incentivize current smokers to quit using e-cigarettes, but at the same time disincentivize non-smoking youth to pick up vaping.

For many years, policy changes only happened at the state and local level. There were few regulations, and at the start of 2019 only nine states had implemented an e-cigarette tax (see figure 3a in the appendix). Within five states, there were some local-level e-cigarette taxes. One of the municipalities was Montgomery County in Maryland, which I will be using for my empirical analysis later in the paper. Consistent with the public policy theory of punctuated equilibrium, a catalyst came along that caused a policy window to open up: the EVALI-outbreak.

EVALI is an acronym that stands for E-cigarette, or Vaping, product use Associated Lung Injury. The outbreak from the summer of 2019 caused about 3000 individuals – mostly youth – to get hospitalized, with 68 confirmed deaths. The outbreak was contained within the U.S. and was due to e-cigarettes containing black market and unsafe cannabis tetrahydrocannabinol (THC). Vitamin E acetate was added to thicken a watered-down liquid that would go into an e-cigarette, thereby reducing costs. The inhalation of this oil badly damaged the lungs of thousands of individuals. Within weeks, the Minnesota Department of Health determined the correct cause of the outbreak[[16]](#footnote-16), but the CDC waited four entire months before agreeing with their determination[[17]](#footnote-17) – thereby contributing to the uncertainty and misinformation that was out there. Their paper (Boudi, 2019) confirmed that all fluid samples taken from injured lungs were caused by vitamin E acetate. Apart from a series of policy responses at all levels of government, the uncertainty and rampant misinformation reported by the media also caused the public’s opinion on vaping to change, with a majority of Americans currently thinking that vaping is not healthier than smoking regular cigarettes[[18]](#footnote-18).

Within six months after the EVALI-outbreak, the FDA enacted two major policy changes: the T21 law and the ban on e-cigarette flavors. I will discuss both in turn.

The T21 law came into being on December 20, 2019 when the President signed legislation amending the aforementioned Act that gave the FDA the power to regulate the tobacco industry[[19]](#footnote-19). The law raises the federal minimum age for sale of tobacco products from 18 to 21 years, and immediately took effect. The purpose of the law was to make it more difficult for youth to gain access to vaping products. One issue was that 18 and 19-year-olds at high schools could buy e-cigarettes and distribute them to classmates. Raising the federal minimum age to 21 makes it more difficult for youth to gain access to these vaping products, while not discouraging smokers to quit.

Unlike the aforementioned policy, the ban on e-cigarette flavors – which the FDA issued a couple of weeks after the T21 law – has negative consequences. The policy makes a lot of intuitive sense: Youth are attracted to the variety of flavors, such as fruit, and mint, and by preventing the sale of these flavors, youth will be less likely to initiate vaping[[20]](#footnote-20). The ban didn’t apply to two flavors – menthol and tobacco – which I will discuss in turn.

Menthol cigarettes are just as dangerous as non-menthol cigarettes and seem less harsh, thereby appealing to new smokers and young people. Studies have shown that menthol cigarettes are more addictive than non-menthol cigarettes[[21]](#footnote-21) and at least 70% of African Americans who smoke use menthol cigarettes[[22]](#footnote-22). There is evidence suggesting that African-Americans disproportionately use menthol e-cigarettes to try to quit smoking (Richards, 2015). Since menthol cigarettes are associated with a lower likelihood of quitting smoking, and since they are disproportionately used by African Americans who are already in worse health on average, it makes sense for the ban not to include the menthol flavor. Banning menthol flavoring would likely have resulted in fewer African-Americans succeeding in their quest to quit smoking.

Harrell et al. (2017) found that 98% of school-going vaping youth in Texas used an e-cigarette flavor other than tobacco. The paper also states that the flavor ban on non-tobacco flavorings will therefore likely benefit youth and young adult prevention efforts, but the impact on adult smoking cessation would be unclear. The reason for that last comment was because adults prefer flavors as well (Harrell, 2017 and Gravely, 2020). Research by Friedman & Xu (2020) and Zare & Zheng (2018) have both shown that flavors are the key to helping smokers quit. Banning flavors might therefore drive many e-cigarette users back to cigarettes, and impairing their health in the process.

Just like at the federal level, the EVALI-outbreak proved to be a catalyst for policy change at the state level. Before the summer of 2019, states had often proved unsuccessful in their attempts to impose e-cigarette taxes. Their most successful year was 2017, but even then 19 states failed to implement e-cigarette taxes out of 24 with proposals[[23]](#footnote-23). The main argument against this kind of legislation was the effect it would have on current cigarette smokers. The story changed after the EVALI-outbreak, and legislators took advantage of the misinformation[[24]](#footnote-24) out there. Using the outbreak as an argument in favor of taxation, 23 states had passed e-cigarette taxes by April 2020, even though nicotine vaping had nothing to do with the outbreak. See figure 3b in the appendix for the latest data on state-level e-cigarette taxes.

The effectiveness of such an e-cigarette tax will also depend on the price elasticity of demand, with a higher number – in absolute value – meaning that the tax will likely be more effective in its attempt to curb usage. Using Nielsen Retail Scanner data, Cotti et al. (2020) found a price elasticity of -2.6 for e-cigarettes. Other research also found high sensitivity of e-cigarette demand to price changes, with e.g. Heckman et al. (2019) finding a price elasticity of demand of -1.5. E-cigarettes would therefore be one of the only addictive products for which demand might be elastic. Conclusions are mixed however, with Corrigan et al. (2020) speculating that these high – in absolute value – price elasticities of demand could be due to the fact that almost half of e-cigarette sales occur online: Customers observing high retail prices would buy online, making it seem as though demand decreased when it didn’t. Their own estimate of the elasticity is -0.56, making it inelastic. Among youth, Pesko et al. (2018) found the e-cigarette demand might be close to unit elasticity. Still, e-cigarette demand is almost certainly more elastic than cigarette demand (Alvarez, 2020).

Taxing e-cigarettes causes smokers to be less responsive to taxation of regular cigarettes (Pesko, 2020), and the observation that e-cigarette demand is relatively elastic might be due to the fact that individuals addicted to nicotine have a substitute in regular cigarettes. Cotti et al. found evidence that e-cigarettes and cigarettes are substitutes, with a positive cross-price elasticity of 1.1. This suggests that increasing the price of e-cigarettes by 10% could increase cigarette sales by 11%. They simulate that for every e-cigarette pod not bought because of an e-cigarette tax, 6.2 extra packs of cigarettes will be bought. Due to this substitutability, policy makers should carefully consider whether discouraging vaping by youth in this way is worth the cost.

Minnesota was the first state to enact an e-cigarette tax in 2010 (Saffer, 2019). If the policy is to be judged on the basis of its intended consequences, then the experiment turned out to be somewhat successful: The Minnesota Department of Health reports that vaping rates among youth in Minnesota are lower than the national average[[25]](#footnote-25). The success of the policy shouldn’t solely be based on the rates of vaping incidence among youth, however, and Saffer investigates the negative consequences of the e-cigarette tax. They estimate that the Minnesota e-cigarette tax prevented 32,400 adult smokers from quitting, and if the tax were to be enacted on a national level, 1.8 million smokers would be deterred from quitting in a ten-year period. The purpose of the ensuing empirical analysis is to contribute to the literature that tries to inform policy makers on the pros and cons of e-cigarette tax legislation, such as Maryland Senate Bill 3.

**V. Data**

The data used comes from the Maryland Youth Risk Behavior Survey and Youth Tobacco Survey (YRBS/YTS), collected by the Maryland Department of Health (MDH) Center for Tobacco Prevention and Control, with the CDC having cleaned and analyzed the data. The biennial survey first started asking vaping-related questions in 2014, and the data covers the years 2014, 2016, and 2018. The data contains 24 Maryland counties and the 30% tax in Montgomery County went into effect on August 19, 2015. This is after the first time period, but before the second time period.

The data will be used to analyze whether the e-cigarette tax reduced the amount of current youth vapers, and so this will be the dependent variable. Control variables are all available demographics: age, gender, and race. Table 1 describes the characteristics of each of the three samples.

**Table 1: Description of samples from years 2014, 2016, and 2018.**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **2014** | | **2016** | | **2018** | |
|  | ***Montgomery County*** | ***Control*** | ***Montgomery County*** | ***Control*** | ***Montgomery County*** | ***Control*** |
| Observations | 4,212 | 47,878 | 3,640 | 40,896 | 1,344 | 35,674 |
| **Gender** |  |  |  |  |  |  |
| Male | 2,018 (47.91%) | 23,230 (48.52%) | 1,828 (50.22%) | 19,985 (48.87%) | 648 (48.21%) | 17,366 (48.68%) |
| Female | 2,194 (52.09%) | 24,648 (51.48%) | 1,812 (49.78%) | 20,911 (51.13%) | 696 (51.79%) | 18,308 (51.32%) |
| **Age** |  |  |  |  |  |  |
| 12 | 20 (0.47%) | 278 (0.58%) | 10 (0.27%) | 214 (0.52%) | 4 (0.30%) | 142 (0.40%) |
| 13 | 23 (0.55%) | 194 (0.41%) | 13 (0.36%) | 139 (0.34%) | 5 (0.37%) | 139 (0.39%) |
| 14 | 911 (21.63%) | 10,868 (22.70%) | 657 (18.05%) | 8,018 (19.61%) | 225 (16.74%) | 7,696 (21.57%) |
| 15 | 1,061 (25.19%) | 12,855 (26.85%) | 1,021 (28.05%) | 11,294 (27.62%) | 333 (24.78%) | 9,886 (27.71%) |
| 16 | 1,091 (25.90%) | 12,333 (25.76%) | 974 (26.76%) | 11,120 (27.19%) | 429 (31.92%) | 8,875 (24.88%) |
| 17 | 919 (21.82%) | 9,695 (20.25%) | 774 (21.26%) | 8,475 (20.72%) | 281 (20.91%) | 7,360 (20.63%) |
| 18 | 187 (4.44%) | 1,655 (3.46%) | 191 (5.25%) | 1,636 (4.00%) | 67 (4.99%) | 1,576 (4.42%) |
| **Race** |  |  |  |  |  |  |
| Asian | 674 (16.00%) | 1,916 (4.00%) | 580 (15.93%) | 1,833 (4.48%) | 213 (15.85%) | 1,346 (3.77%) |
| Black | 785 (18.64%) | 10,617 (22.18%) | 646 (17.75%) | 9,003 (22.01%) | 253 (18.82%) | 6,718 (18.83%) |
| Hispanic | 486 (11.54%) | 1,449 (3.03%) | 384 (10.55%) | 1,443 (3.53%) | 178 (13.24%) | 1,222 (3.43%) |
| White | 2,267 (53.82%) | 33,896 (70.80%) | 2030 (55.77%) | 28,617 (69.98%) | 700 (52.08%) | 26,388 (73.97%) |

We notice that Montgomery County has a more racially diverse population compared to the 23 other Maryland counties that make up the control. A difference of means test confirms this observation, and also helped identify a comparable county, useful for sensitivity analysis later:

**Table 2: Difference of means test for the year 2014.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | |  |  |
|  | ***Montgomery County, %*** | ***Howard***  ***County, %*** | ***Control, %*** | ***P Value for Montgomery County***  ***vs. Howard County*** | ***P Value for Montgomery County vs. Control*** |
| **Gender** |  |  |  |  |  |
| Female | 52.09 | 50.71 | 51.48 | 0.2220 | 0.4488 |
| **Age** |  |  |  |  |  |
| 12 | 0.47 | 0.36 | 0.58 | 0.4329 | 0.3827 |
| 13 | 0.55 | 0.58 | 0.41 | 0.8371 | 0.1736 |
| 14 | 21.63 | 23.24 | 22.70 | 0.0888 | 0.1113 |
| 15 | 25.19 | 23.04 | 26.85 | 0.0270 | 0.0196 |
| 16 | 25.90 | 27.28 | 25.76 | 0.1702 | 0.8388 |
| 17 | 21.82 | 22.27 | 20.25 | 0.6323 | 0.0153 |
| 18 | 4.44 | 3.24 | 3.46 | 0.0060 | 0.0009 |
| **Race** |  |  |  |  |  |
| Asian | 16.00 | 17.23 | 4.00 | 0.1440 | 0.0000 |
| Black | 18.64 | 18.98 | 22.18 | 0.7017 | 0.0000 |
| Hispanic | 11.54 | 2.96 | 3.03 | 0.0000 | 0.0000 |
| White | 53.82 | 60.83 | 70.80 | 0.0000 | 0.0000 |

Difference of means tests for the years 2016 and 2018 can be found in the appendix (Tables 3 and 4). We notice indeed that the racial composition of the county’s population is significantly different from that of the control. Howard County has a more comparable racial composition, although it has more Whites and fewer Hispanics.

The following table shows the proportion of youth that vaped in the previous 30 days for the three years of data, both for Montgomery County and for the remaining 23 counties making up the control:

**Table 5: Proportion of youth that are current e-cigarette users in 2014, 2016, and 2018.**

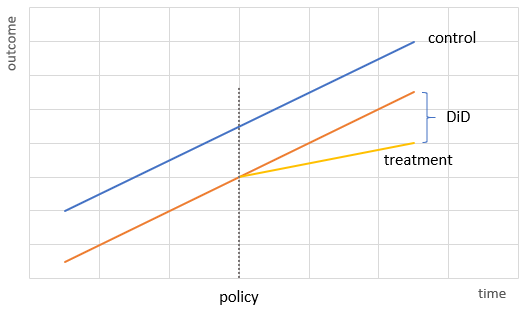
|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | **2014** | | **2016** | | **2018** | |
|  | ***Montgomery County*** | ***Control*** | ***Montgomery County*** | ***Control*** | ***Montgomery County*** | ***Control*** |
| Total | 16.07% | 21.70% | 8.10% | 14.96% | 19.05% | 29.67% |
| **Gender** |  |  |  |  |  |  |
| Male | 16.90% | 23.03% | 8.75% | 15.99% | 18.98% | 28.57% |
| Female | 15.31% | 20.44% | 7.45% | 13.98% | 19.11% | 30.72% |
| **Age** |  |  |  |  |  |  |
| 14 | 9.77% | 15.18% | 5.48% | 10.46% | 10.22% | 21.21% |
| 15 | 14.04% | 20.90% | 6.17% | 13.18% | 15.92% | 27.37% |
| 16 | 16.68% | 23.49% | 7.08% | 15.40% | 21.45% | 32.72% |
| 17 | 21.98% | 26.04% | 12.53% | 19.04% | 24.20% | 36.26% |
| 18 | 24.06% | 28.88% | 13.61% | 21.64% | 25.37% | 37.25% |
| **Race** |  |  |  |  |  |  |
| Asian | 6.82% | 11.64% | 3.10% | 6.93% | 11.74% | 14.86% |
| Black | 16.05% | 16.16% | 5.57% | 9.71% | 12.65% | 17.98% |
| Hispanic | 18.72% | 18.84% | 12.24% | 11.09% | 15.73% | 19.80% |
| White | 18.26% | 24.12% | 9.56% | 17.33% | 24.43% | 33.86% |

Note: Ages 12 and 13 were omitted from the table due to the low amount of observations.

We notice that vaping prevalence in Montgomery County is generally lower compared to the other Maryland counties, but we notice similar characteristics and trends. Vaping prevalence increases by age and for both Montgomery County and the control, females used to vape less than males, but this was no longer the case in 2018. Asians are the least likely to vape, while Whites are the most likely. The temporary dip in vaping prevalence from 2014 to 2016 is consistent with observations at the national level, as could be seen on figure 1a.

**VI. Estimation method**

Difference-in-difference estimation is often used to evaluate policy changes. The idea is that there are two places that are similar in all ways, except for some observed differences that we can control for within a regression model. The first of the two places implements a policy change, resulting in a change in the variable of interest. If we were to simply look at the change in the variable of interest after some period of time, we would be ignoring the fact that the variable might have changed irrespective of whether there was a policy change or not. We are not able to observe the counter-factual (what the variable would look like if the policy didn’t pass), and this is where the second place comes in. We can treat the second place as a control group and implement a natural experiment. We assume that trends in both places move parallel to each other, and we subtract (post control – pre control) from (post treatment – pre treatment). I created a graphical representation illustrating the procedure:



For this analysis, Montgomery County will act as the treatment group, while the other 23 Maryland counties make up the control. To establish the effect of the Montgomery County e-cigarette tax on vaping incidence, two difference-in-difference regressions were run, with 2014 being the pre and either 2016 or 2018 being the post. In both regressions we control for county-fixed effects. Additionally, clustered standard errors – errors correlated within a county and uncorrelated across counties – were used. Clustering the standard errors in this way also takes care of the heteroskedasticity present in this Linear Probability Model (LPM).

For the 2016-post period, the following model was estimated:

with Xi representing the demographic control variables, and Cj representing the other counties.

For the 2018-post period, the following model was estimated:

with Xi representing the demographic control variables, and Cj representing the other counties.

**VII. Empirical findings**

Table 6 shows the regression output of the two regressions previously mentioned. For the age category, 15-year-olds are the omitted condition. Apart from the 12-year-old category, we observe higher vaping incidence among older youth. We notice that white youth are substantially more likely to vape than non-white youth. Considering the increasing trends in vaping usage among youth, it might seem peculiar that there is a significantly negative coefficient for the 2016 Post period – meaning that vaping incidence among Maryland youth decreased between 2014 and 2016 – but this is consistent with findings on the national level, as could be seen on Figure 1a earlier. Looking at the Montgomery dummy, we notice that youth in Montgomery County were already using e-cigarettes substantially less, by about 10 percentage points.

|  |  |  |
| --- | --- | --- |
|  | 2016 Post period | 2018 Post period |
| Age 12 | 0.242\*\*\* | 0.183\*\*\* |
|  | (0.0334) | (0.0312) |
|  |  |  |
| Age 13 | -0.00401 | -0.0321 |
|  | (0.0147) | (0.0180) |
|  |  |  |
| Age 14 | -0.0425\*\*\* | -0.0584\*\*\* |
|  | (0.00542) | (0.00440) |
|  |  |  |
| Age 16 | 0.0247\*\*\* | 0.0400\*\*\* |
|  | (0.00353) | (0.00505) |
|  |  |  |
| Age 17 | 0.0573\*\*\* | 0.0724\*\*\* |
|  | (0.00662) | (0.00839) |
|  |  |  |
| Age 18 | 0.0875\*\*\* | 0.102\*\*\* |
|  | (0.0109) | (0.0130) |
|  |  |  |
| Female | -0.0189\*\*\* | -0.00106 |
|  | (0.00383) | (0.00320) |
|  |  |  |
| Asian | -0.0877\*\*\* | -0.124\*\*\* |
|  | (0.00504) | (0.00806) |
|  |  |  |
| Black | -0.0520\*\*\* | -0.0728\*\*\* |
|  | (0.00707) | (0.00981) |
|  |  |  |
| Hispanic | -0.0247\* | -0.0543\*\*\* |
|  | (0.0119) | (0.0101) |
|  |  |  |
| Post period | -0.0687\*\*\* | 0.0642\*\*\* |
|  | (0.00587) | (0.0129) |
|  |  |  |
| Montgomery | -0.101\*\*\* | -0.106\*\*\* |
|  | (0.00356) | (0.00598) |
|  |  |  |
| Montgomery | -0.0138\* | -0.0385\*\* |
| × Post period | (0.00578) | (0.0131) |
|  |  |  |
| Constant | 0.283\*\*\* | 0.288\*\*\* |
|  | (0.00375) | (0.00785) |
| *N* | 96,626 | 89,108 |
| *R*2 | 0.0384 | 0.0464 |

**Table 6: Regression output with Current Vaper as dependent variable.**

Controlled for county-level fixed effects, with counties omitted from output.

Cluster-robust standard errors in parentheses.

\* *p* < 0.05, \*\* *p* < 0.01, \*\*\* *p* < 0.001

The interaction term between Montgomery and the Post period indicates the difference-in-difference causal effect. For 2016, we notice a statistically significant negative coefficient[[26]](#footnote-26). This means that, if the assumptions for the difference-in-difference estimation hold, the e-cigarette tax reduced vaping incidence among youth by about 1.4 percentage points in the year following its enactment.

The observed impact is even greater over time, with results showing youth vaping incidence reduced by 3.8 percentage points when comparing the 2014 dataset to the 2018 dataset. This indicates that long-run elasticities are greater in absolute value than short-run elasticities. This is consistent with theoretical predictions from Becker in the late 80s and early 90s, as well as empirical work on addictive products by Gordon and Baohung from 2015.

**VIII. Differing responses to the tax across social groups**

Regressions were run on multiple social groups, which can be found on tables 7 through 10 in the appendix. We notice that females reacted more strongly to the tax increase, especially when looking at the 2018 post period. This means that females have a greater – in absolute value – price elasticity of demand for e-cigarettes, and are more price-sensitive. We can also see that older youth are more likely to change their behavior due to the tax increase. Asians and Hispanics did not react to the price change, while Blacks initially showed evidence of lower vaping incidence, but this evidence disappeared when looking at the 2018 post period. White kids, which are the most likely to vape, reacted strongly both initially and over time.

**IX. Limitations**

We don’t know whether the price of e-cigarettes increased in Montgomery County following the e-cigarette tax, or whether the manufacturer absorbed the increased cost. Microeconomic theory tells us that addictive products tend to be inelastic – concurring with Corrigan’s research mentioned earlier – and so it sounds unrealistic that the manufacturer would absorb all the cost. Microeconomic theory states that profit-maximizing firms selling inelastic goods will not pay the tax themselves, but will transfer most of the increased cost onto the customer. Despite the uncertainty, it is therefore likely that the price consumers paid for e-cigarettes increased.

Data limitations prevent us from verifying a crucial assumption of difference-in-difference estimation: parallel trends. Vaping salience was low in the early 2010’s, and most surveys didn’t include vaping-related questions. As could be seen in Figure 1a, e-cigarette usage among youth spiked in 2013-2014. The media attention increased salience, causing surveys – such as the YRBS survey – to include it in 2014. Due to this lack of data, parallel trends before 2014 cannot be established. Datasets will improve with the passage of time, and confidence in these kinds of estimation techniques will improve with them. With the data we have, we can show correlation and control for demographic indicators, but we cannot ascertain causation.

Montgomery County is one of the wealthiest counties in the United States, and one criticism of the implemented estimation technique is that Montgomery County might not be comparable to other Maryland counties: Perhaps poorer counties would react differently to an e-cigarette tax. Due to this lack of generalizability, we therefore can’t necessarily predict how other counties would react to a similar e-cigarette tax. One argument in favor of the aforementioned analysis is that we’re not comparing purchasing power of a Montgomery County resident to a resident from another county. We are comparing the purchasing power of a youth in Montgomery County to a youth from another county, and those are likely more comparable.

**X. Sensitivity Analysis**

To check the robustness of the coefficient estimates, three types of sensitivity analysis were conducted. First, a proxy for socioeconomic status (homeownership of the parents) was included in the 2016 regression. Second, the control group was changed to Howard County, because the argument can be made that Howard County is the most similar to Montgomery County. Finally, placebo tests were run to test whether the tax had a significant effect on vaping incidence in counties other than Montgomery County.

We know that vaping usage is related to socioeconomic status (SES), but the dataset does not contain information about indicators of SES such as the education level of the parents or their level of income. A proxy for such socioeconomic indicators is available for years 2014 and 2016: homeownership of the parents. According to the Federal Reserve Board’s triennial Survey of Consumer Finances (SCF), median family income in the U.S. when renting was $35,600 in 2019, while it was $77,400 for families that owned the home they lived in. There is also a large differential in family wealth based on housing status: Median family wealth was $6,300 for renters, while it was $255,000 for homeowners. In 2014 in Montgomery County, 67.64% of youth reported that their parents (or guardians) own the home or place where they were currently living. Surprisingly, this is lower than the 70.08% number for the other 23 counties. It turns out that there is a lot of economic inequality in Montgomery County, and the relatively high amount of Hispanics with low SES brings the number down substantially. The growth of international migration and the Hispanic population – and their cultural influences and priorities – are given as reasons for the large amount of renting in the county by the Montgomery County Planning Department[[27]](#footnote-27).

**Table 11: Regression output for the 2016 post period with and without the homeowner dummy and with Current Vaper as dependent variable.**

|  |  |  |
| --- | --- | --- |
|  | without | with |
|  | homeowner | homeowner |
| Age 12 | 0.242\*\*\* | 0.234\*\*\* |
|  | (0.0334) | (0.0325) |
|  |  |  |
| Age 13 | -0.00401 | -0.00485 |
|  | (0.0147) | (0.0144) |
|  |  |  |
| Age 14 | -0.0425\*\*\* | -0.0424\*\*\* |
|  | (0.00542) | (0.00537) |
|  |  |  |
| Age 16 | 0.0247\*\*\* | 0.0245\*\*\* |
|  | (0.00353) | (0.00353) |
|  |  |  |
| Age 17 | 0.0573\*\*\* | 0.0572\*\*\* |
|  | (0.00662) | (0.00663) |
|  |  |  |
| Age 18 | 0.0875\*\*\* | 0.0836\*\*\* |
|  | (0.0109) | (0.0107) |
|  |  |  |
| Female | -0.0189\*\*\* | -0.0199\*\*\* |
|  | (0.00383) | (0.00386) |
|  |  |  |
| Asian | -0.0877\*\*\* | -0.0884\*\*\* |
|  | (0.00504) | (0.00480) |
|  |  |  |
| Black | -0.0520\*\*\* | -0.0604\*\*\* |
|  | (0.00707) | (0.00619) |
|  |  |  |
| Hispanic | -0.0247\* | -0.0346\*\* |
|  | (0.0119) | (0.0119) |
|  |  |  |
| Post period | -0.0687\*\*\* | -0.0688\*\*\* |
|  | (0.00587) | (0.00586) |
|  |  |  |
| Montgomery | -0.101\*\*\* | -0.102\*\*\* |
|  | (0.00356) | (0.00355) |
|  |  |  |
| Montgomery | -0.01381\* | -0.01378\* |
| × Post period | (0.00578) | (0.00578) |
|  |  |  |
| Homeowner | . | -0.0364\*\*\* |
|  |  | (0.00551) |
|  |  |  |
| Constant | 0.283\*\*\* | 0.312\*\*\* |
|  | (0.00375) | (0.00548) |
| *N* | 96626 | 96626 |
| *R*2 | 0.039 | 0.040 |

Controlled for county-level fixed effects, with counties omitted from output.

Cluster-robust standard errors in parentheses.

\* *p* < 0.05, \*\* *p* < 0.01, \*\*\* *p* < 0.001

We notice that the coefficient on the homeownership dummy is negative, significant, and has a magnitude of about 3.6 percentage points. This means that SES is negatively associated with vaping incidence. We also observe robust estimates, since including the dummy for homeownership did not materially affect any of the coefficient estimates, including the interaction term between Montgomery and the post period.

Due to the fact that Montgomery County is one of the richest counties in the United States, I changed the control group to Howard County to see whether the coefficient estimates would be affected. This county is just as rich as Montgomery County, while we saw earlier that the racial composition of the county was more similar to Montgomery County compared to the other counties. Additionally, fewer youth in Montgomery County were current vapers in 2014 compared to the control group (12.38% vs. 18.59%), and Howard County started at a lower level too (11.57%). The following table shows the regression output using both the 23 counties, and Howard County as the control:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | 23 counties as control | | Howard County as control | |
|  | 2016 Post period | 2018 Post period | 2016 Post period | 2018 Post period |
| Age 12 | 0.242\*\*\* | 0.183\*\*\* | 0.195 | 0.247 |
|  | (0.0334) | (0.0312) | (0.0463) | (0.0579) |
|  |  |  |  |  |
| Age 13 | -0.00401 | -0.0321 | -0.0118 | -0.0487 |
|  | (0.0147) | (0.0180) | (0.00191) | (0.00555) |
|  |  |  |  |  |
| Age 14 | -0.0425\*\*\* | -0.0584\*\*\* | -0.0295 | -0.0484 |
|  | (0.00542) | (0.00440) | (0.00494) | (0.00443) |
|  |  |  |  |  |
| Age 16 | 0.0247\*\*\* | 0.0400\*\*\* | 0.0167 | 0.0363\* |
|  | (0.00353) | (0.00505) | (0.00247) | (0.00219) |
|  |  |  |  |  |
| Age 17 | 0.0573\*\*\* | 0.0724\*\*\* | 0.0598 | 0.0639 |
|  | (0.00662) | (0.00839) | (0.0125) | (0.0211) |
|  |  |  |  |  |
| Age 18 | 0.0875\*\*\* | 0.102\*\*\* | 0.0831\*\* | 0.0961\* |
|  | (0.0109) | (0.0130) | (0.000701) | (0.00395) |
|  |  |  |  |  |
| Female | -0.0189\*\*\* | -0.00106 | -0.0139 | -0.00702 |
|  | (0.00383) | (0.00320) | (0.00243) | (0.00112) |
|  |  |  |  |  |
| Asian | -0.0877\*\*\* | -0.124\*\*\* | -0.0790 | -0.106 |
|  | (0.00504) | (0.00806) | (0.00837) | (0.0131) |
|  |  |  |  |  |
| Black | -0.0520\*\*\* | -0.0728\*\*\* | -0.0229 | -0.0390 |
|  | (0.00707) | (0.00981) | (0.00949) | (0.00896) |
|  |  |  |  |  |
| Hispanic | -0.0247\* | -0.0543\*\*\* | 0.0251 | -0.00646 |
|  | (0.0119) | (0.0101) | (0.0176) | (0.0198) |
|  |  |  |  |  |
| Post period | -0.0687\*\*\* | 0.0642\*\*\* | -0.0775\*\* | 0.0560\*\* |
|  | (0.00587) | (0.0129) | (0.000283) | (0.000432) |
|  |  |  |  |  |
| Montgomery | -0.101\*\*\* | -0.106\*\*\* | 0.00437 | 0.00635 |
|  | (0.00356) | (0.00598) | (0.00147) | (0.00160) |
|  |  |  |  |  |
| Montgomery | -0.0138\* | -0.0385\*\* | -0.00365\* | -0.0304\*\* |
| × Post period | (0.00578) | (0.0131) | (0.000164) | (0.000247) |
|  |  |  |  |  |
| Constant | 0.283\*\*\* | 0.288\*\*\* | 0.162\*\* | 0.165\*\* |
|  | (0.00375) | (0.00785) | (0.00223) | (0.00154) |
| *N* | 96,626 | 89,108 | 14,560 | 10,681 |
| *R*2 | 0.0384 | 0.0464 | 0.037 | 0.029 |

**Table 12: Regression output with Current Vaper as dependent variable with different control groups.**

The homeowner dummy for the 2016 post period didn’t materially affect coefficient estimates and was omitted.

Controlled for county-level fixed effects.

Cluster-robust standard errors in parentheses.

\* *p* < 0.05, \*\* *p* < 0.01, \*\*\* *p* < 0.001

We notice that the interaction terms have the same sign, with slightly lower magnitudes. The significance actually increased substantially, and the results are consistent with our previous findings. The reduction in vaping is more pronounced for the 2018 post period, indicating a greater price sensitivity over time. We also observe a three percentage point reduction in vaping incidence in Montgomery County attributable to the e-cigarette tax.

Placebo tests were performed as part of the sensitivity analysis. Here, we interacted each of the county dummies with the post period to test whether any of the coefficients on these interactions terms were significant. Finding insignificance or positive coefficients would increase the confidence in our results. Unfortunately, significance with negative coefficients were observed for some counties. The coefficients and associated p-values are shown in the table below:

**Table 13: Coefficients and p-values of interaction terms for each county.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  | |  |
| **County** | ***2016 DiD effect*** | ***2016 P Value*** | ***2018 DiD effect*** | ***2018 P Value*** |
| Allegany | .0238037 | 0.000 | .0589677 | 0.000 |
| Anne Arundel | .0126572 | 0.036 | .0095225 | 0.477 |
| Baltimore County | .0091035 | 0.137 | **-.0288895** | **0.036** |
| Calvert | **-.0344425** | **0.000** | .0807226 | 0.000 |
| Caroline | -.0023917 | 0.672 | .0781346 | 0.000 |
| Carroll | .0727512 | 0.000 | .0582511 | 0.000 |
| Cecil | **-.0434299** | **0.000** | .0237964 | 0.073 |
| Charles | **-.0179718** | **0.004** | **-.1253546** | **0.000** |
| Dorchester | **-.0191851** | **0.002** | .0192024 | 0.152 |
| Frederick | -.0076611 | 0.200 | .0117527 | 0.399 |
| Garrett | .0057357 | 0.309 | **-.02652** | **0.048** |
| Harford | **-.042563** | **0.000** | -.0187307 | 0.182 |
| Howard | -.0095315 | 0.119 | -.0065416 | 0.627 |
| Kent | .0379714 | 0.000 | .1927116 | 0.000 |
| **Montgomery** | -.0138136 | 0.026 | -.0384612 | 0.007 |
| Prince George's | .0135368 | 0.024 | **-.1268987** | **0.000** |
| Queen Anne's | .0198279 | 0.002 | .0646349 | 0.000 |
| Saint Mary's | .0019565 | 0.734 | .0389889 | 0.006 |
| Somerset | .0164305 | 0.006 | **-.0543656** | **0.000** |
| Talbot | .0054398 | 0.334 | .0822022 | 0.000 |
| Washington | .0053958 | 0.359 | -.0154041 | 0.260 |
| Wicomico | -.0111133 | 0.057 | -.0112275 | 0.396 |
| Worcester | .052158 | 0.000 | .0462336 | 0.001 |
| Baltimore City | .0075573 | 0.202 | **-.0984315** | **0.000** |

We notice that five of the 23 other counties had significant negative coefficients on the interaction term for the 2016 post period, and six for the 2018 post period. This lowers our confidence that the tax lead to lower incidence of youth vaping in Montgomery County. Finding statistically significant results for other counties is understandable, considering both the omission of many variables that explain youth behavior, and the lack of independence among sampled individuals within the counties. When a youth starts to vape, due to social ties, the probability that other youth within that same school start vaping goes up. Since our difference-in-difference estimation technique is picking up any deviations from trend compared to the other Maryland counties, we’re picking up any and all shocks to the system, compounded by the dependence between individuals within a county. Also, when looking at Montgomery’s most comparable county, we notice that the change in vaping incidence in Howard County was statistically insignificant.

**XI. Discussion**

This paper was the first to look at the effects of the Montgomery County e-cigarette tax, and findings agreed with previous research that increased e-cigarette prices lead to lower vaping incidence among youth. Previous research on tax enactment had often focused on Nielsen scanner data, but this would likely have underestimated the true impact: Higher retail prices would have incentivized customers to purchase e-cigarettes online or in other counties. Tax revenue raised from the tax provides further evidence of this.

The Office of Management and Budget (OMB), and the Department of Finance estimated that the tax would raise between $1.54 to $2.56 million annually[[28]](#footnote-28). In reality, the tax raised just over $300,000, indicating that customers likely purchased their products online or elsewhere. Furthermore, net revenues were substantially lower due to an enforcement and compliance effort. The bill required two tax staff members costing $100,000 each, with an additional $30,000 earmarked for travel expenditures ($3,000 for each of 10 sanctioned trips). Both the inefficiency and the tax avoidance can be reduced by enacting a similar law at the state level, which Maryland Senate Bill 3 proposes to do.

Before the approval of the bill’s enactment, it is important for policymakers to keep in mind that vaping has helped people quit smoking and that e-cigarettes are up to 95% safer than cigarettes. Anti-vaping legislation will result in fewer smokers being able to transition to a healthier alternative. E-cigarettes should be considered a harm reduction product, and policymakers should attempt to find a balance between encouraging smokers to quit smoking and start vaping instead, and the fact that we need to try and limit e-cigarette usage among youth.

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**Appendix**

**Figure 1b**

Source: Data collected from National Youth Tobacco Survey (NYTS) on youth grades 6 – 12.

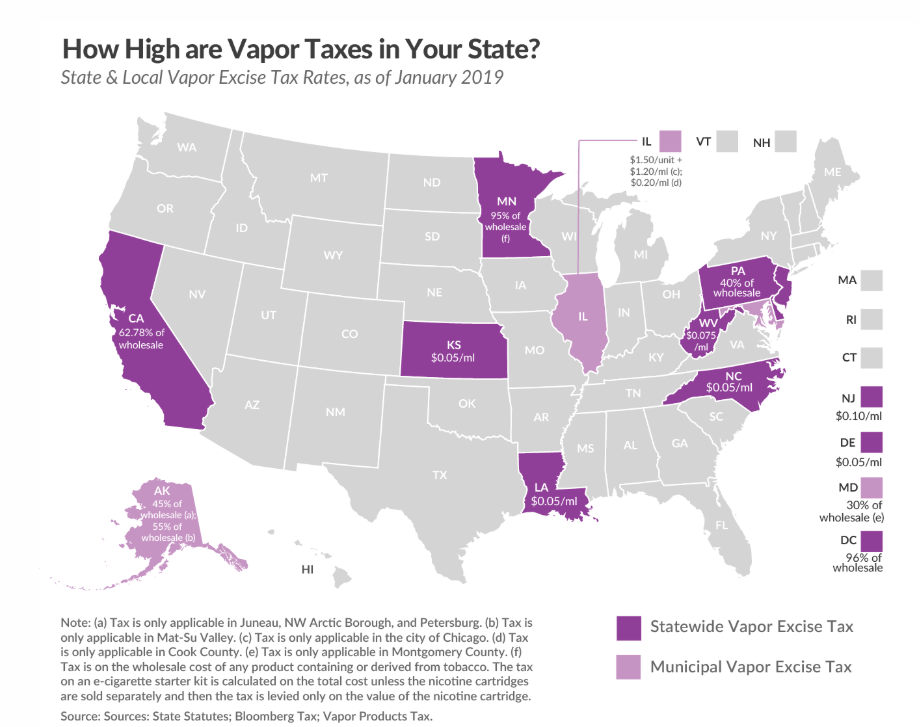
**Figure 2a**

**Figure 2b**

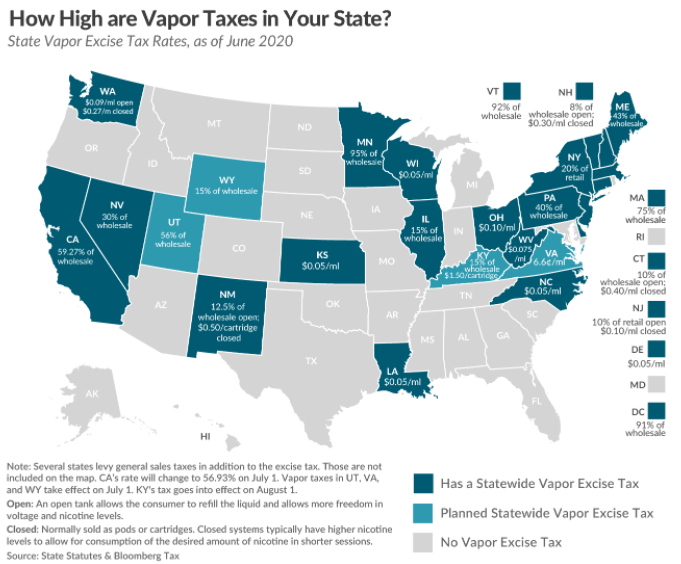
**Figure 2c**

Source: Data collected from National Youth Tobacco Survey (NYTS) on youth grades 6 – 12.

**Figure 3a**



**Figure 3b**



Source: Tax Foundation.

**Table 3: Difference of means test for the year 2016.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | |  |  |
|  | ***Montgomery County, %*** | ***Howard***  ***County, %*** | ***Control, %*** | ***P Value for Montgomery County***  ***vs. Howard County*** | ***P Value for Montgomery County vs. Control*** |
| **Gender** |  |  |  |  |  |
| Female | 49.78 | 52.09 | 51.13 | 0.0594 | 0.1179 |
| **Age** |  |  |  |  |  |
| 12 | 0.27 | 0.61 | 0.52 | 0.0340 | 0.0422 |
| 13 | 0.36 | 0.65 | 0.34 | 0.0901 | 0.8642 |
| 14 | 18.05 | 18.66 | 19.61 | 0.5222 | 0.0231 |
| 15 | 28.05 | 28.42 | 27.62 | 0.7371 | 0.5756 |
| 16 | 26.76 | 27.35 | 27.19 | 0.5846 | 0.5738 |
| 17 | 21.26 | 21.05 | 20.72 | 0.8287 | 0.4412 |
| 18 | 5.25 | 3.27 | 4.00 | 0.0001 | 0.0003 |
| **Race** |  |  |  |  |  |
| Asian | 15.93 | 21.14 | 4.48 | 0.0000 | 0.0000 |
| Black | 17.75 | 16.29 | 22.01 | 0.1146 | 0.0000 |
| Hispanic | 10.55 | 2.88 | 3.53 | 0.0000 | 0.0000 |
| White | 55.77 | 59.68 | 69.98 | 0.0012 | 0.0000 |

**Table 4: Difference of means test for the year 2018.**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  |  | |  |  |
|  | ***Montgomery County, %*** | ***Howard***  ***County, %*** | ***Control, %*** | ***P Value for Montgomery County***  ***vs. Howard County*** | ***P Value for Montgomery County vs. Control*** |
| **Gender** |  |  |  |  |  |
| Female | 51.79 | 52.12 | 51.32 | 0.8588 | 0.7375 |
| **Age** |  |  |  |  |  |
| 12 | 0.30 | 0.13 | 0.40 | 0.3364 | 0.5642 |
| 13 | 0.37 | 0.53 | 0.39 | 0.5323 | 0.9189 |
| 14 | 16.74 | 18.28 | 21.57 | 0.2815 | 0.0000 |
| 15 | 24.78 | 25.56 | 27.71 | 0.6293 | 0.0181 |
| 16 | 31.92 | 27.88 | 24.88 | 0.0185 | 0.0000 |
| 17 | 20.91 | 23.58 | 20.63 | 0.0875 | 0.8058 |
| 18 | 4.99 | 4.04 | 4.42 | 0.2234 | 0.3215 |
| **Race** |  |  |  |  |  |
| Asian | 15.85 | 18.41 | 3.77 | 0.0703 | 0.0000 |
| Black | 18.82 | 20.40 | 18.83 | 0.2914 | 0.9947 |
| Hispanic | 13.24 | 3.51 | 3.43 | 0.0000 | 0.0000 |
| White | 52.08 | 57.68 | 73.97 | 0.0027 | 0.0000 |

**Table 7: Regression output with Current Vaper as the dependent variable showing differing reactions to the tax increase across gender and age for the 2016 post period.**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
|  | Females | 14-year-olds | 17-year-olds |
| Age 12 | 0.201\*\*\* | . | . |
|  | (0.0459) |  |  |
|  |  |  |  |
| Age 13 | 0.0243 | . | . |
|  | (0.0220) |  |  |
|  |  |  |  |
| Age 14 | -0.0406\*\*\* | . | . |
|  | (0.00530) |  |  |
|  |  |  |  |
| Age 16 | 0.0129\*\* | . | . |
|  | (0.00376) |  |  |
|  |  |  |  |
| Age 17 | 0.0314\*\*\* | . | . |
|  | (0.00591) |  |  |
|  |  |  |  |
| Age 18 | 0.0740\*\*\* | . | . |
|  | (0.0128) |  |  |
|  |  |  |  |
| Female | . | 0.000909 | -0.0525\*\*\* |
|  |  | (0.00645) | (0.00829) |
|  |  |  |  |
| Asian | -0.0928\*\*\* | -0.0663\*\*\* | -0.125\*\*\* |
|  | (0.00566) | (0.00692) | (0.0108) |
|  |  |  |  |
| Black | -0.0529\*\*\* | -0.0115 | -0.0844\*\*\* |
|  | (0.00741) | (0.0120) | (0.0113) |
|  |  |  |  |
| Hispanic | -0.0263 | 0.00897 | -0.0601\* |
|  | (0.0128) | (0.0103) | (0.0228) |
|  |  |  |  |
| Post period | -0.0648\*\*\* | -0.0459\*\*\* | -0.0717\*\*\* |
|  | (0.00615) | (0.00803) | (0.00979) |
|  |  |  |  |
| Montgomery | -0.0941\*\*\* | -0.0914\*\*\* | -0.0952\*\*\* |
|  | (0.00397) | (0.00310) | (0.00594) |
|  |  |  |  |
| Montgomery | -0.0154\* | 0.00725 | -0.0323\*\* |
| × Post period | (0.00607) | (0.00802) | (0.00970) |
|  |  |  |  |
| Constant | 0.271\*\*\* | 0.200\*\*\* | 0.387\*\*\* |
|  | (0.00439) | (0.00447) | (0.00715) |
| *N* | 49,565 | 20,454 | 19,863 |
| *R*2 | 0.032 | 0.018 | 0.040 |

Controlled for county-level fixed effects, with counties omitted from output.

Cluster-robust standard errors in parentheses.

\* *p* < 0.05, \*\* *p* < 0.01, \*\*\* *p* < 0.001

**Table 8: Regression output with Current Vaper as the dependent variable showing differing reactions to the tax increase across race for the 2016 post period.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  | Black | Hispanic | Asian | White |
| Age 12 | 0.175\* | 0.429\*\* | 0.354\*\* | 0.238\*\*\* |
|  | (0.0756) | (0.120) | (0.100) | (0.0301) |
|  |  |  |  |  |
| Age 13 | -0.0446 | -0.0295 | 0.00692 | 0.0111 |
|  | (0.0293) | (0.0857) | (0.0329) | (0.0228) |
|  |  |  |  |  |
| Age 14 | -0.0131 | -0.0381\* | -0.0332\* | -0.0519\*\*\* |
|  | (0.00668) | (0.0157) | (0.0133) | (0.00518) |
|  |  |  |  |  |
| Age 16 | 0.00547 | -0.0155 | 0.0143 | 0.0339\*\*\* |
|  | (0.00522) | (0.0251) | (0.0109) | (0.00423) |
|  |  |  |  |  |
| Age 17 | 0.0224\*\* | 0.00221 | 0.0242 | 0.0742\*\*\* |
|  | (0.00786) | (0.0170) | (0.0134) | (0.00615) |
|  |  |  |  |  |
| Age 18 | 0.0553\*\*\* | -0.0217 | 0.0440\* | 0.117\*\*\* |
|  | (0.0133) | (0.0257) | (0.0202) | (0.0132) |
|  |  |  |  |  |
| Female | -0.0118 | -0.0191 | -0.0227\*\*\* | -0.0206\*\*\* |
|  | (0.00614) | (0.00983) | (0.00536) | (0.00399) |
|  |  |  |  |  |
| Post period | -0.0660\*\*\* | -0.0757\*\*\* | -0.0458\*\*\* | -0.0706\*\*\* |
|  | (0.00524) | (0.0135) | (0.00752) | (0.00782) |
|  |  |  |  |  |
| Montgomery | -0.198\*\*\* | 0.164\*\*\* | -0.105\*\*\* | -0.102\*\*\* |
|  | (0.00277) | (0.0101) | (0.00387) | (0.00366) |
|  |  |  |  |  |
| Montgomery | -0.0392\*\*\* | 0.00704 | 0.0103 | -0.0220\*\* |
| × Post period | (0.00517) | (0.0139) | (0.00740) | (0.00769) |
|  |  |  |  |  |
| Constant | 0.357\*\*\* | 0.0457\*\* | 0.181\*\*\* | 0.276\*\*\* |
|  | (0.00553) | (0.0127) | (0.00772) | (0.00433) |
| *N* | 21,051 | 3,762 | 5,003 | 66,810 |
| *R*2 | 0.028 | 0.026 | 0.051 | 0.033 |

Controlled for county-level fixed effects, with counties omitted from output.

Cluster-robust standard errors in parentheses.

\* *p* < 0.05, \*\* *p* < 0.01, \*\*\* *p* < 0.001

**Table 9: Regression output with Current Vaper as the dependent variable showing differing reactions to the tax increase across gender and age for the 2018 post period.**

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
|  | Females | 14-year-olds | 17-year-olds |
| Age 12 | 0.138\*\* | . | . |
|  | (0.0474) |  |  |
|  |  |  |  |
| Age 13 | -0.0272 | . | . |
|  | (0.0244) |  |  |
|  |  |  |  |
| Age 14 | -0.0549\*\*\* | . | . |
|  | (0.00562) |  |  |
|  |  |  |  |
| Age 16 | 0.0335\*\*\* | . | . |
|  | (0.00610) |  |  |
|  |  |  |  |
| Age 17 | 0.0501\*\*\* | . | . |
|  | (0.00850) |  |  |
|  |  |  |  |
| Age 18 | 0.0974\*\*\* | . | . |
|  | (0.0141) |  |  |
|  |  |  |  |
| Female | . | 0.0166\* | -0.0323\*\*\* |
|  |  | (0.00750) | (0.00833) |
|  |  |  |  |
| Asian | -0.136\*\*\* | -0.0883\*\*\* | -0.168\*\*\* |
|  | (0.00849) | (0.0111) | (0.0109) |
|  |  |  |  |
| Black | -0.0860\*\*\* | -0.0289\* | -0.111\*\*\* |
|  | (0.00884) | (0.0111) | (0.0150) |
|  |  |  |  |
| Hispanic | -0.0687\*\*\* | -0.00772 | -0.0841\*\* |
|  | (0.0130) | (0.0105) | (0.0229) |
|  |  |  |  |
| Post period | 0.0888\*\*\* | 0.0525\*\*\* | 0.0829\*\*\* |
|  | (0.0166) | (0.0135) | (0.0170) |
|  |  |  |  |
| Montgomery | -0.0950\*\*\* | -0.112\*\*\* | -0.0957\*\*\* |
|  | (0.00846) | (0.00562) | (0.0103) |
|  |  |  |  |
| Montgomery | -0.0532\*\* | -0.0514\*\* | -0.0590\*\* |
| × Post period | (0.0167) | (0.0139) | (0.0168) |
|  |  |  |  |
| Constant | 0.283\*\*\* | 0.220\*\*\* | 0.392\*\*\* |
|  | (0.0104) | (0.00834) | (0.00991) |
| *N* | 45,846 | 19,700 | 18,255 |
| *R*2 | 0.050 | 0.024 | 0.054 |

Controlled for county-level fixed effects, with counties omitted from output.

Cluster-robust standard errors in parentheses.

\* *p* < 0.05, \*\* *p* < 0.01, \*\*\* *p* < 0.001

**Table 10: Regression output with Current Vaper as the dependent variable showing differing reactions to the tax increase across race for the 2018 post period.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  |  |  |  |  |
|  | Black | Hispanic | Asian | White |
| Age 12 | 0.153 | 0.249 | 0.375\*\* | 0.176\*\*\* |
|  | (0.0740) | (0.156) | (0.127) | (0.0338) |
|  |  |  |  |  |
| Age 13 | -0.0495 | 0.00932 | -0.0219 | -0.0315 |
|  | (0.0469) | (0.0759) | (0.0529) | (0.0204) |
|  |  |  |  |  |
| Age 14 | -0.0314\*\* | -0.0413\* | -0.0406\*\* | -0.0671\*\*\* |
|  | (0.00873) | (0.0181) | (0.0128) | (0.00463) |
|  |  |  |  |  |
| Age 16 | 0.00966 | -0.0175 | 0.0339\* | 0.0519\*\*\* |
|  | (0.00527) | (0.0322) | (0.0147) | (0.00543) |
|  |  |  |  |  |
| Age 17 | 0.0225\* | 0.0214 | 0.0295\* | 0.0932\*\*\* |
|  | (0.00857) | (0.0243) | (0.0116) | (0.00762) |
|  |  |  |  |  |
| Age 18 | 0.0402\* | 0.00374 | 0.0575 | 0.138\*\*\* |
|  | (0.0175) | (0.0389) | (0.0327) | (0.0160) |
|  |  |  |  |  |
| Female | -0.0164\* | -0.0187 | -0.0148 | 0.00558 |
|  | (0.00745) | (0.0118) | (0.00916) | (0.00383) |
|  |  |  |  |  |
| Post period | 0.00150 | -0.00105 | 0.0206 | 0.0867\*\*\* |
|  | (0.0179) | (0.0255) | (0.0180) | (0.00870) |
|  |  |  |  |  |
| Montgomery | -0.214\*\*\* | -0.0570\*\* | -0.141\*\*\* | -0.107\*\*\* |
|  | (0.0103) | (0.0153) | (0.00813) | (0.00399) |
|  |  |  |  |  |
| Montgomery | -0.0348 | -0.0303 | 0.0186 | -0.0314\*\* |
| × Post period | (0.0179) | (0.0249) | (0.0182) | (0.00872) |
|  |  |  |  |  |
| Constant | 0.379\*\*\* | 0.263\*\*\* | 0.208\*\*\* | 0.263\*\*\* |
|  | (0.00954) | (0.0256) | (0.00885) | (0.00522) |
| *N* | 18,373 | 3,335 | 4,149 | 63,251 |
| *R*2 | 0.030 | 0.023 | 0.038 | 0.039 |

Controlled for county-level fixed effects, with counties omitted from output.

Cluster-robust standard errors in parentheses.

\* *p* < 0.05, \*\* *p* < 0.01, \*\*\* *p* < 0.001

1. https://www.cdc.gov/tobacco/data\_statistics/fact\_sheets/fast\_facts/index.htm [↑](#footnote-ref-1)
2. https://www.cdc.gov/cancer/lung/basic\_info/risk\_factors.htm [↑](#footnote-ref-2)
3. https://www.cancer.gov/about-cancer/causes-prevention/risk/substances/secondhand-smoke [↑](#footnote-ref-3)
4. https://e-cigarettes.surgeongeneral.gov/documents/surgeon-generals-advisory-on-e-cigarette-use-among-youth-2018.pdf [↑](#footnote-ref-4)
5. The term “current” refers to usage within the last 30 days. [↑](#footnote-ref-5)
6. Monitoring the Future (MTF) 2018 Survey. [↑](#footnote-ref-6)
7. Counting “8 or younger” as 8, and “19 or older” as 19. [↑](#footnote-ref-7)
8. https://www.cdc.gov/tobacco/data\_statistics/fact\_sheets/fast\_facts/index.htm [↑](#footnote-ref-8)
9. https://www.healthline.com/health/second-hand-vape [↑](#footnote-ref-9)
10. https://www.fda.gov/tobacco-products/rules-regulations-and-guidance/family-smoking-prevention-and-tobacco-control-act-overview [↑](#footnote-ref-10)
11. https://www.federalregister.gov/documents/2016/05/10/2016-10685/deeming-tobacco-products-to-be-subject-to-the-federal-food-drug-and-cosmetic-act-as-amended-by-the [↑](#footnote-ref-11)
12. https://www.bbc.com/news/av/health-26036064 [↑](#footnote-ref-12)
13. https://www.cdc.gov/tobacco/data\_statistics/sgr/2020-smoking-cessation/fact-sheets/adult-smoking-cessation-e-cigarettes-use/index.html [↑](#footnote-ref-13)
14. https://www.heartandstroke.ca/-/media/pdf-files/position-statements/ecigarettesincanada.ashx [↑](#footnote-ref-14)
15. https://www.nhs.uk/smokefree/help-and-advice/e-cigarettes [↑](#footnote-ref-15)
16. https://www.health.state.mn.us/news/pressrel/2020/vaping082120.html [↑](#footnote-ref-16)
17. https://www.cdc.gov/tobacco/basic\_information/e-cigarettes/severe-lung-disease.html [↑](#footnote-ref-17)
18. According to a Reuters poll in September 2019, 63% of adults in the United States disagreed with the statement

    that “vaping is healthier than traditional cigarettes”. [↑](#footnote-ref-18)
19. https://www.fda.gov/tobacco-products/retail-sales-tobacco-products/tobacco-21 [↑](#footnote-ref-19)
20. https://www.fda.gov/news-events/press-announcements/fda-finalizes-enforcement-policy-unauthorized-flavored-cartridge-based-e-cigarettes-appeal-children [↑](#footnote-ref-20)
21. Tobacco Products Scientific Advisory Committee. Menthol Cigarettes and Public Health: Review of the Scientific Evidence and Recommendations. Rockville, MD: US Department of Health and Human Services, Food and Drug Administration; 2011. [↑](#footnote-ref-21)
22. https://www.cdc.gov/tobacco/basic\_information/tobacco\_industry/menthol-cigarettes/index.html [↑](#footnote-ref-22)
23. https://www.cspdailynews.com/tobacco/2017-state-tobacco-legislation [↑](#footnote-ref-23)
24. https://apnews.com/article/de61324121bd497e96ae4f5e64b6236d [↑](#footnote-ref-24)
25. https://www.health.state.mn.us/news/pressrel/2019/survey100219.html [↑](#footnote-ref-25)
26. Without cluster-robust standard errors, there was no significance. [↑](#footnote-ref-26)
27. http://montgomeryplanning.org/wp-content/uploads/2017/07/FinalTechnicalDocument.pdf [↑](#footnote-ref-27)
28. https://www.montgomerycountymd.gov/council/Resources/Files/agenda/cm/2015/150507/20150507\_GO1.pdf [↑](#footnote-ref-28)