The Effect of E-Cigarette Regulation on Youth Smoking Incidence: An Empirical Analysis

Alex Goldsmith

**Introduction**

\*Note on terminology: as the term ‘e-cigarettes’ can refer either to specifically electronic devices shaped like cigarettes or more generally to a range of devices that deliver nicotine through aerosolization of a liquid, I adopt the term Electronic Nicotine Delivery System, or ENDS, used by the CDC and various authors in the literature.

In recent years there has been an explosive increase in adolescent use of ENDS to the extent of being termed as an “epidemic” by the FDA and CDC[[1]](#endnote-1). This dramatic and visible trend has not escaped the attention of regulators. While the FDA was not granted authority to regulate ENDS until 2016, state regulators have been active since as early as 2010. By 2012, twelve states had enacted Minimum Legal Sales Age laws, prohibiting sales of ENDS to minors[[2]](#endnote-2). In 2013, twelve more had followed suit. By the time an FDA rule banning sales of ENDS to minors came into effect on August 8th, 2016, 46 states had already passed their own MLSA laws. The bureaucratic slowness of the FDA, while possibly unfortunate for public health, is a boon to researchers. The piecemeal nature of the enactment of ENDS regulation has created a natural experiment in which empirical research can be used to investigate true impact of ENDS regulation.

As taught by the esteemed Thomas Hazlett, the purported intent of government regulation can rarely be taken at face value. An even more foolish assumption is that the impact of regulation conforms to its stated intention and yields no unintended consequences. Although the stated intention of the FDA is certainly admirable, the regulation of ENDS is no different than the regulation of any other lucrative enterprise: rents are at play, and interest groups are at work. “We continue to believe any FDA action to restrict sales of e-cigs to minors will benefit tobacco manufacturers,” says Bonnie Herzog, managing director of equity research at Wells Fargo Securities LLC. Jidong Huang, associate professor of economics at GSU, comments that Juul competitor and tobacco giant Altria didn’t pull its flavored ENDS products because of concerns for the public health. “It’s because it doesn’t affect their bottom line,” Huang states. “It’s very likely that this ban is going to benefit the tobacco industry overall[[3]](#endnote-3).” So why are tobacco companies happy about a ban that reduces the attractiveness of their e-cigarettes? The industry, along with a number of experts, believe that ENDS and cigarettes have some measure of substitutability. If the appeal of ENDS is lowered (as the proposed FDA regulations intend) consumers may switch to smoking more harmful combustible cigarettes.

To give credit where credit is due, Commissioner of the FDA Scott Gottlieb appears to be aware of this possibility. “I don’t want to create a situation where the combustible products have features that make them more attractive than the non-combustible products,” he tells in a 2018 press statement. “Or a situation where those who currently use menthol-flavored cigarettes might find it less attractive to switch completely to an e-cigarette.” The bottom line is that if the proposed regulations are truly in the public interest, they must be shown to be both effective and harmless. That is, the data should show that regulation decreases youth ENDS use without increasing youth smoking.

The research question that determines the public health impact of the FDA’s proposed regulations is simple, though finding the answer can be complex. Are ENDS and cigarettes complements or substitutes? A simple examination of correlation reveals a positive relationship (r = .317). This positive correlation, however, does not imply that that ENDS and cigarettes are economic complements. The use of JIF or Skippy peanut butter is also positive correlated: it simply means that people that buy one or the other product enjoy peanut butter in general. Similarly, the positive correlation between ENDS and cigarette use could be the result of an unobserved propensity for substance use. Because this propensity cannot be observed and controlled, I make use of state-level variables that are uncorrelated with the omitted variable. The enactment of Minimum Legal Sales Age laws and prohibitions on self-service displays increase the non-monetary cost of ENDS use, allowing the data to show the substitution (or not) to combustible cigarettes.

**Theory**

The introduction of Minimum Legal Sales Age laws raises the cost of ENDS to adolescents by adding additional barriers to purchase (minors must resort to online sales, purchase through an intermediary, or travel to non-complying retailer). Similarly, prohibitions on self-service displays increase the difficulty of theft and require a greater degree of customer and sales-clerk interaction. According to the law of demand, these increased costs of ENDS are predicted to significantly reduce rates of use among adolescents. Of specific interest are the second order effects of these regulations. If cigarettes and ENDS are complements, theory predicts that regulation will have the added benefit of reducing youth cigarette use. If on the other hand cigarettes and ENDS are substitutes, regulation of ENDS could have the unfortunate side-effect of increasing youth cigarette use.

While not directly predictive of the possible impact of the FDA’s proposed ban of fruit and candy flavors for ENDS products, analysis of prior regulations can help reveal the complementarity or substitutionability of ENDS and cigarettes among adolescents. Like the prohibitions on youth purchases and self-service displays, the proposed flavor ban adds a non-monetary cost to the purchase of ENDS (quality adjusted price of the products increases). The results of this study may serve to help inform about the net public health impact of ENDS regulation.

**Literature**

This study is most directly related to the work of Dutra, Glanz, Arrazola, and King[[4]](#endnote-4). Dutra et al. investigate the relationship between Minimum Legal Sales Age laws and youth smoking using data from the National Youth Tobacco Survey for 2009 through 2014. I attempted to replicate their work as best I could, with some differences. Without the advantage of conducting my study at a later date, I was able to include a few more years of data, up to 2017. Additionally, I also included an analysis of the effectiveness of MLSA regulation and applied their methodology to an investigation on the impact of self-service display bans. Dutra et al. find that the enactment of MLSA laws decrease youth smoking rates, suggesting complementarity between ENDS and cigarettes.

Abouk and Adams[[5]](#endnote-5), using individual-level data from Monitoring the Future surveys for 2007 to 2014, come to the same conclusion as Dutra et al. Analyzing the effect of MLSA laws on smoking likelihood and intensity, the authors find a negative effect in both cases. The authors additionally find a negative effect of MLSA laws on ENDS use, providing evidence that the laws are indeed effective.

Pesko, Hughes, and Faisal[[6]](#endnote-6) use state-level data from the Youth Risk Behavior Surveillance System for 2007 to 2013. In contrast to the individual-level studies, Pesko et al. find a positive effect of age purchasing restrictions on youth smoking rates, indicating a substitution effect. Dave, Feng, and Pesko[[7]](#endnote-7) follow up a year later with an expanded range of time (2005 – 2015) and added data from the national version of the YRBSS. The authors again find a positive relationship between age purchasing restrictions and youth smoking rates.

Unfortunately, the literature on ENDS flavor bans relies on hypotheticals, as there is no state-level variation to exploit for flavor regulation. Buckell, Marti, and Sindelar[[8]](#endnote-8) use a discrete choice experiment to predict the effect of flavor bans. They find that a reduction of flavor availability for ENDS would increase choice of cigarettes. Although their experiment was conducted on adult smokers, their findings have relevance to the FDA’s agenda of restricting youth ENDS use. Buu, Hu, Piper, and Lin[[9]](#endnote-9), using data from the Population Assessment of Tobacco and Health, find that the use of ENDS flavoring is associated with a lower quantity of cigarette use. Without policy variation on flavor restrictions however, causality is difficult to prove. Shiffman et al.[[10]](#endnote-10) analyze data from an online questionnaire. The authors find that interest in ENDS flavors was not highly correlated with interest in ENDS in general. In the absence of empirical data on current use however, the literature on ENDS flavor restrictions has low predictive power.

**Table 1**

|  |  |  |  |
| --- | --- | --- | --- |
| Regulation | Decreases ENDS use? | Increases cigarette use? | Study |
| Minimum Legal Sales Age | Unclear | Yes | Pesko et al. (2016) |
|  | Unclear | Yes | Dave et al. (2017) |
|  | Unclear | No | Dutra et al. (2017) |
|  | Yes | No | Abouk, Adams (2017) |
| Self-Service Display Bans |  |  | Unstudied |
| Flavor Bans (Hypothetical) | Yes | Yes | Buckell et al. (2017) |
|  | Unclear | Yes | Buu et al. (2018) |
|  | No | Unclear | Shiffman et al. (2015) |

**Methodology**

The analysis conducted in this paper is conducted using pooled data from 7 years of the National Youth Tobacco Survey (2011 - 2017). The survey is conducted annually from February to the end of June. Two dependent variables were created from survey responses. To judge effectiveness of ENDS regulation, I created a binary variable where 0 indicates that the respondent has not used ENDS in the past 30 days, and 1 indicates that the respondent has used ENDS at least one day out of the past 30. To analyze second order effects, I created a binary variable where 0 indicates that the respondent has not smoked cigarettes in the past 30 days and 1 indicates that the respondent has smoked cigarettes on at least 1 day of the past 30.

Two primary explanatory variables were created using data from the CDC. Using information on enactment dates of state MLSA laws from the STATE system of the CDC, I created a binary variable to indicate the existence of a MLSA for a given state and year. Similarly, the binary variable SSDB indicates the existence of a self-service display ban for a given state and year. Information on SSDB enactment dates was sourced from a 2017 Morbidity and Mortality Weekly Report from the CDC. These variables were coded as 0 if a state had not yet enacted the law by May 1st of a given year and 1 if the law was in effect by May 1st.

Following convention from Dutra et al., the sample was restricted to ages 11 through 17, the range for which there are both significant numbers of respondents and the respondents are covered by minimum legal sale age laws (n = 127,278). For models controlling for level of ENDS use, the sample was further restricted, as a survey question for frequency of 30 ENDS use was only included beginning in 2014 (n = 69,854).

**Table 1**

Summary Statistics

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
| N | 17,000 | 22,383 | 16,636 | 19,936 | 16,228 | 18,873 | 16,222 |
|  | [%] | [%] | [%] | [%] | [%] | [%] | [%] |
| MLSA | [18.27] | [25.76] | [41.39] | [49.26] | [78.41] | [91.26] | [100] |
| SSDB | [0] | [0] | [1.05] | [1] | [28.01] | [38.71] | [100] |
| Male | [50.75] | [50.42] | [49.44] | [50.80] | [50.33] | [50.56] | [49.63] |
| Female | [49.25] | [49.58] | [50.56] | [49.20] | [49.67] | [49.44] | [50.37] |
| Asian | [3.74] | [5.39] | [5.31] | [5.09] | [4.51] | [6.04] | [4.92] |
| Black | [21.70] | [15.49] | [22.60] | [19.48] | [17.74] | [19.57] | [21.52] |
| Hispanic | [21.26] | [15.78] | [10.13] | [12.31] | [12.36] | [12.83] | [11.02] |
| Other | [0.69] | [0.73] | [3.50] | [4.17] | [4.08] | [5.01] | [3.67] |
| White | [52.60] | [62.61] | [58.46] | [58.95] | [61.31] | [56.56] | [58.87] |
| ENDS 30d | [.95] | [1.80] | [2.46] | [10.07] | [11.47] | [8.41] | [8.38] |
| Smoke 30d | [12.06] | [9.74] | [9.00] | [7.34] | [7.54] | [5.94] | [6.69] |
|  | Mean (SE) | Mean (SE | Mean (SE) | Mean (SE) | Mean (SE) | Mean (SE) | Mean (SE) |
| Age | 14.2 (1.81) | 14.1 (1.85) | 14.3 (1.83) | 14.2 (1.84) | 14.2 (1.81) | 14.2 (1.85) | 14.3 (1.85) |

The literature is divided on the inclusion of controls for state fixed effects. Dutra et al. exclude state fixed effects from their models because of concerns of collinearity between state indicators and the state level indicator for ENDS regulation. Pesko et al. and Dave et al. however include state fixed effects. I decided to include models both with and without state fixed effects, however as can be seen in Tables 3 and 4, coefficients for the variable of interest were significant only in models that included state fixed effects. This indicates that the effect of MLSA or SSCB law is difficult to separate from pre-existing state-level heterogeneity if the variation is not controlled for. I did not, however, include controls for state-specific time trends in an effort to avoid masking identifying variation. This paper therefore implicitly relies on the assumption of parallel time trends across states.

As well as varying the inclusion of state fixed-effects, I created models that controlled for ENDS use by the respondent, either through a binary variable (1 if the respondent has smoked cigarettes in the past month, 0 if not) or categorical (levels representing different frequencies of cigarette use). Unfortunately, because the analysis uses pooled cross-sectional data rather than true panel data, it is ambiguous whether ENDS use is a mediating or confounding variable in model. To be conservative, I reported results both with and without this control.

**Results**

According to difference in difference analysis, the legislation of minimum sales age laws decreased rates of youth ENDS use (*p* = .011). Banning self-service displays of ENDS also decreased rates of youth ENDS use (*p* = .040). The results suggest that the ENDS regulations investigated are indeed effective at reducing rates of adolescent use.

While the MLSA model that excluded controls for ENDS use and state fixed effects yielded a statistically significant negative effect of MLSA laws on youth cigarette use, the finding was not robust. Controlling for state fixed-effects moved the coefficient higher, but removed its significance. Controlling for ENDS use in the past 30 days moved the coefficient higher still. Controlling for the frequency of ENDS use in the past 30 days yielded the highest coefficient, on the verge of significance (*p* = .107).

A similar pattern emerged for the analysis of self-service display bans. Coefficients increased as controls were added. The final model, controlling for frequency of ENDS use in the past 30 days, yielded a statistically significant positive effect of self-service display bans on youth smoking (*p* = .025).

\*Note: All models are controlled for age, gender, race, and year fixed effects.

**Table 3**

Effectiveness of MLSA laws: Probability respondent used ENDS in past 30 days

|  |  |  |
| --- | --- | --- |
| Model Iteration | 1 | 2 |
| MLSA | .994  [.938, 1.05] | .891\*\*  [.815, .974] |
| State indicators? | No | Yes |

Estimates are odds ratios. 95% Confidence Intervals indicated in brackets.

\* *p* < .10 \*\**p* < .05

**Table 4**

Effectiveness of SSDB laws: Probability respondent used ENDS in past 30 days

|  |  |  |
| --- | --- | --- |
| Model Iteration | 1 | 2 |
| SSDB | 1.01  [.915, 1.12] | .912\*\*  [.837, .994] |
| State indicators? | No | Yes |

Estimates are odds ratios. 95% Confidence Intervals indicated in brackets.

\* *p* < .10 \*\**p* < .05

**Table 5**

Consequences of MLSA laws: Probability respondent smoked in past 30 days

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Model Iteration | 1 | 2 | 3 | 4 |
| MLSA | .887\*\*  [.843, .933] | 1.02  [.949, 1.11] | 1.06  [.972, 1.15] | 1.12  [.976, 1.28] |
| ENDS use, binary | — | — | 14.3\*\*  [13.5, 15.2] | — |
| ENDS use, category | — | — | — | Ranges from 6 to 40 |
| State indicators? | No | Yes | Yes | Yes |

Estimates are odds ratios. 95% Confidence Intervals indicated in brackets.

\* *p* < .10 \*\**p* < .05

**Table 6**

Consequences of SSDB laws: Probability respondent smoked in past 30 days

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Model Iteration | 1 | 2 | 3 | 4 |
| SSDB | .955  [.894, 1.02] | 1.05  [.966, 1.24] | 1.06  [.972, 1.16] | 1.18\*\*  [1.04, 1.33] |
| ENDS use, binary | — | — | 13.5\*\*  [12.7, 14.2] | — |
| ENDS use, category | — | — | — | Ranges from 7 to 49 |
| State indicators? | No | Yes | Yes | Yes |

Estimates are odds ratios. 95% Confidence Intervals indicated in brackets.

\* *p* < .10 \*\**p* < .05

**Discussion**

The findings seem to support that the current program of the FDA in regards to ENDS regulation is indeed effective in reducing youth ENDS use, corroborating the results of Abouk and Abrams, and matching the predictions of the law of demand. The results of the analysis of second order effects are mixed. My analysis established neither clear substitutionability of ENDS and cigarettes (as found by Pesko et al. and Dave et al.) nor complementarity (as found by Abouk and Abrams). Instead, the results seemed to depend significantly upon the methodology employed. It is possible that this could be the explanation for the mixed findings in the academic literature.

While the findings of this paper have limited utility in predicting the effect of flavor bans on youth ENDS use and smoking rates, the findings of this paper suggest that the FDA should take reasonable caution when pursuing further regulation of ENDS use. A harm reduction strategy should take serious consideration of the fact that while ENDS are not without harm to adolescents, recent studies suggest that ENDS are at least 95% safer than conventional cigarettes, and law many of the harmful carcinogenic ingredients[[11]](#endnote-11). Indeed, the main danger of ENDS use is its role as a ‘gateway drug’ facilitating the possible transition to cigarette smoking later in life. Without clear evidence for the complementarity of ENDS and cigarettes, the FDA should craft policies that restrict the appeal or availability of ENDS in sync with policies that do the same for cigarettes. Restrictions that reduce the possibility of later transition to cigarette use do not net a public health gain if they incentivize the use of cigarettes today. If the end goal of regulation is to reduce smoking rates among the youth and adult population, restrictions should focus primarily upon cigarettes. This way, there is less possibility for second order effects of regulation to harm public health. My recommendation to the FDA is to make sure they do not create the situation where ENDS are restricted behind lock and key in specialty shops, while flavored cigarillos and menthol cigarettes are available at any gas station.

**Limitations**

This analysis has a number of limitations, some due to methodological choices and others due to the data. Firstly, the National Youth Tobacco Survey is not a perfect random sample. The survey is applied to all students within a randomly selected school, making use of cluster sampling. Although the NYTS provides weight and stratification variables, I unfortunately lack the econometric knowledge to apply these to the data. Secondly, it is possible that some portion of the effect of ENDS regulation is delayed in time. While Dutra et al. include year-lagged variables to investigate this hypothesis, they did not find any significant difference between contemporaneous and year-lagged effects, and I did not include lagged variables in this analysis.

Another possible source of bias for the estimates is the omission of controls for cigarette regulation. If ENDS and cigarette regulation are highly correlated (for example by inclusion in the same legislative bill) the cost of ENDS relative to cigarettes will not increase, and individuals will have no incentive to substitute to cigarettes. The analysis furthermore did not account for county and municipal regulation, which could also bias the estimates. One final limitation of this study is that it did not investigate the possible effects of ENDS regulation on smoking intensity, as well as incidence. It is possible that the substitution effect of ENDS regulation may be stronger for dual users of ENDS and cigarettes, and might be discerned by an investigation of smoking intensity.

My recommendation for future research is the use of longitudinal data to capture the dynamic and intertemporal effects of ENDS regulation on youth smoking. Methods should be constructed to differentiate between individuals that delay use of cigarettes by use of ENDS and individuals that initiate use of cigarettes because of an affinity for nicotine developed by ENDS use. While the public health impact of the FDA’s program may be difficult to discern, it is imperative that the FDA construct their regulations to achieve truly helpful outcome, rather than simply following their own self-interest by signaling “well, we are doing something.”

**References**

1. [Gottlieb, Scott, M.D. FDA Statement. November 15, 2018](https://www.fda.gov/NewsEvents/Newsroom/PressAnnouncements/ucm625884.htm) [↑](#endnote-ref-1)
2. [Marynak, Kristy, et al. CDC Morbidity and Mortality Weekly Report. December 12, 2014. "State Laws Prohibiting Sales to Minors and Indoor Use of Electronic Nicotine Delivery Systems"](https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6349a1.htm) [↑](#endnote-ref-2)
3. [Becker, Rachel. The Verge. November 9, 2018. “What a ban on e-cigarette flavors could mean for big tobacco”.](https://www.theverge.com/2018/11/9/18080308/electronic-cigarettes-fda-flavor-ban-vaping-juul-blu-vuse-big-tobacco) [↑](#endnote-ref-3)
4. [Dutra, L. M., Glantz, S. A., Arrazola, R. A., & King, B. A. (2018). Impact of e-cigarette minimum legal sale age laws on current cigarette smoking. Journal of Adolescent Health, 62(5), 532-538.](https://www-sciencedirect-com.libproxy.clemson.edu/science/article/pii/S1054139X17309047) [↑](#endnote-ref-4)
5. [Abouk, R., & Adams, S. (2017). Bans on electronic cigarette sales to minors and smoking among high school students. Journal of health economics, 54, 17-24.](https://www-sciencedirect-com.libproxy.clemson.edu/science/article/pii/S0167629617302436) [↑](#endnote-ref-5)
6. [Pesko, M. F., Hughes, J. M., & Faisal, F. S. (2016). The influence of electronic cigarette age purchasing restrictions on adolescent tobacco and marijuana use. Preventive medicine, 87, 207-212.](https://www-sciencedirect-com.libproxy.clemson.edu/science/article/pii/S0091743516000396) [↑](#endnote-ref-6)
7. [Dave, D., Feng, B., & Pesko, M. F. (2017). The effects of e-cigarette minimum legal sale age laws on youth substance use (No. w23313). National Bureau of Economic Research.](https://www.nber.org/papers/w23313) [↑](#endnote-ref-7)
8. [Buckell, J., Marti, J., & Sindelar, J. L. (2017). Should Flavors be Banned in E-cigarettes? Evidence on Adult Smokers and Recent Quitters from a Discrete Choice Experiment (No. w23865). National Bureau of Economic Research.](https://www.nber.org/papers/w23865) [↑](#endnote-ref-8)
9. [Buu, A., Hu, Y. H., Piper, M. E., & Lin, H. C. (2018). The association between e-cigarette use characteristics and combustible cigarette consumption and dependence symptoms: Results from a national longitudinal study. Addictive behaviors, 84, 69-74.](https://www-sciencedirect-com.libproxy.clemson.edu/science/article/pii/S030646031830251X) [↑](#endnote-ref-9)
10. [Shiffman, Saul, et al. "The impact of flavor descriptors on nonsmoking teens’ and adult smokers’ interest in electronic cigarettes." Nicotine & Tobacco Research 17.10 (2015): 1255-1262.](https://academic-oup-com.libproxy.clemson.edu/ntr/article/17/10/1255/1028251) [↑](#endnote-ref-10)
11. [Royal College of Physicians (2016). Nicotine without smoke: Tobacco harm reduction](https://www.rcplondon.ac.uk/projects/outputs/nicotine-without-smoke-tobacco-harm-reduction-0) [↑](#endnote-ref-11)