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The influence of electronic cigarette age purchasing restrictions on adolescent tobacco and marijuana use

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ABSTRACT

Objective. In the United States, many states have established minimum legal purchase ages for electronic nicotine delivery systems (ENDS) to ban adolescent purchases, but these policies may also affect other related substance use. We explore whether ENDS are substitutes or complements for cigarettes, cigars, smokeless tobacco, and marijuana among adolescents by using variation in state-level implementation of ENDS age purchasing restrictions.

Methods. We linked data on ENDS age purchasing restrictions to state- and year-specific rates of adolescent tobacco and marijuana use in 2007–2013 from the Youth Risk Behavior Surveillance System. This data provides a nationally representative sample of adolescents who attend public and private schools. We performed a fixed effect regression analysis exploring the influence of ENDS age purchasing restrictions on outcomes of tobacco use and marijuana use, controlling for state and year fixed characteristics, age-race cohorts, cigarette excise taxes, and cigarette indoor use restrictions.

Results. For cigarette use, we separate our results into cigarette use frequency. We found causal evidence that ENDS age purchasing restrictions increased adolescent regular cigarette use by 0.8 percentage points. ENDS age purchasing restrictions were not associated with cigar use, smokeless tobacco use, or marijuana use.

Conclusions. We document a concerning trend of cigarette smoking among adolescents increasing when ENDS become more difficult to purchase.

1. Introduction

Tobacco use is the single largest cause of preventable disease and death (U.S. Department of Health and Human Services, 2014) in the United States and carries a high financial cost. In the USA alone, tobacco use is estimated to cost $289 billion a year, including $130 billion going to direct medical care for adults and more than $150 billion in lost productivity (U.S. Department of Health and Human Services, 2014). While the adult current cigarette use rate has declined from 40% since the release of the first Surgeon General Report on smoking in 1964, 18.1% of adults (Agaku et al., 2014) and 14% of high school students (Arrazola et al., 2013) still smoke. Each day, more than 3200 persons younger than 18 years of age (hereafter referred to as adolescents) smoke their first cigarette (U.S. Department of Health and Human Services, 2014). Since the majority of smoking begins in adolescence (U.S. Department of Health and Human Services, 2014), preventing cigarette use among this population remains an urgent public health priority.

Electronic nicotine delivery systems (ENDS) are a new class of tobacco products that deliver aerosolized nicotine via a battery-powered device. ENDS products include e-cigarettes, atomizers, vape-pens, vape pipes, hookah-pens, e-hookahs, e-vaporizers, e-cigars, and e-pipes. ENDS first entered the United States market in approximately 2007 and have subsequently rapidly increased in use (Riker et al., 2012). There is a high rate of dual-use between ENDS and cigarettes and 93%–96% of ENDS-using students have tried cigarettes in the past (Wills et al., 2015; Johnston et al., 2014). As of 2014, ENDS officially surpassed cigarettes as the most commonly used tobacco product among adolescents, with rates of current use at 13.4% vs 9.2% respectively (Arrazola et al., 2015; Johnston et al., 2015).

While ENDS are not without health risks to adolescents, particularly in terms of nicotine's higher addiction potential (U.S. Department of Health and Human Services, 2012; Apelberg et al., 2014) and lasting brain effects (U.S. Department of Health and Human Services, 2014), studies suggest they are less harmful than cigarettes (Hampton, 2014; Abrams, 2014; Brandon et al., 2015; McNeill et al., 2015). A study by the British government suggests that ENDS use has 5% of the harm of cigarette use (McNeill et al., 2015). In nonsmoker adults, ENDS use can have multiple health effects similar to, but often less severe than, conventional tobacco smoking (Pisinger and Dossing, 2014; Vardavas

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et al., 2012). Smokers may experience fewer adverse health effects from ENDS than from cigarettes (Flouris et al., 2012; Farsalinos et al., 2014; Polosa et al., 2014). The chemical profile of ENDS has suggested that ENDS expose individuals to lower concentrations of tobacco-specific toxicants than cigarettes (Goniewicz et al., 2014; Cheng, 2014; Orr, 2014).

A central issue in determining health implications of ENDS is understanding how they promote or discourage adolescent cigarette use. In isolation, the substitution of one potentially less harmful product (ENDS) for a known harmful product (cigarettes) would be a health-improving outcome, and the reverse would be a worse outcome. Substitution can be explored by increasing monetary costs (e.g. price increases) or increasing non-monetary costs (e.g. age purchasing restrictions) of one good and observing if this raises or lowers consumption of another good (Etter, 2015).

Early published literature offers differing views on if ENDS and cigarettes are substitutes: one study found no substitution using prices and retail data (Huang et al., 2014), and a second study suggested cigarette price increases raise the likelihood of trying e-cigarettes using experimental data (Grace et al., 2015). Cigarettes have been found to be complements with marijuana (Chaloupka et al., 1999; Farrelly et al., 2001) and smokeless tobacco (Tauras et al., 2007), raising the question of whether ENDS are complements or substitutes for alternative tobacco products and marijuana as well. Another factor to consider in understanding the relationship between ENDS and marijuana is that some ENDS devices can be used to vaporize other substances, such as marijuana, opium, and crack cocaine (Young-Wolff et al., 2014; Marynak et al., 2014). Using ENDS to vaporize marijuana can decrease the odor and allows it to be used more discretely (Etter, 2015), which may promote a complement relationship between the two.

ENDS minimum legal purchase ages are a recent policy, which if properly enforced, could make it more difficult for adolescents to obtain ENDS. For example, adolescents may now be forced to purchase ENDS devices through an intermediary or online (Williams et al., 2015). Therefore, the implementation of these restrictions can be used to explore if ENDS are substitutes or complements with cigarettes and marijuana because the non-monetary costs of purchasing ENDS products has increased (Williams et al., 2004). New Jersey implemented the first minimum legal purchase age in March, 2010, and as of November 2014, 40 states had age restrictions in place (Marynak et al., 2014). The minimum legal purchasing age among these states is 18, except for four states (Alabama, Alaska, New Jersey, and Utah) in which the age is 19 (Marynak et al., 2014). As of 2014, cigarettes had the same minimum legal purchase age in all states with ENDS age purchasing restrictions (Centers for Disease Control and Prevention, 2014a). The Food and Drug Administration, Center for Tobacco Products (FDA-CTP) has proposed a national ENDS minimum purchasing age of 18, but this has not yet been implemented.

In this study, we explore possible substitution effects within a vulnerable adolescent population that is more likely to initiate cigarette use than adults. We use access restrictions from state-level variation in ENDS age purchasing restrictions to explore if ENDS are economic substitutes or complements for cigarettes (e.g. does cigarette consumption increase or decrease as ENDS become more difficult to access). ENDS age purchasing restrictions were enacted in different states at different times, providing policy variation akin to a natural experiment. We explore the effect that these policies have had on cigarette use and marijuana use. We do not explore the effect of these policies on ENDS use because state-level data on ENDS use is not yet available over multiple waves for adolescents.

2. Methods

We use state-level aggregated data from the Youth Risk Behavior Surveillance System (YRBSS) (Centers for Disease Control and Prevention, 2014b). YRBSS is a biennial national school-based survey of adolescents conducted by Centers for Disease Control and Prevention (CDC) and state health departments to monitor health risk behaviors. It utilizes a two-stage, cluster sample design to produce a representative sample of students in grades 9–12 in its jurisdiction, and data are weighted to adjust for school and student nonresponse and to make the data representative. The data are typically collected between February and May of each year (Brener et al., 2013). We extract the data from 2007, 2009, 2011, and 2013 to correspond to a period before and during the implementation of ENDS age purchasing restrictions. ENDS first entered the US market in 2007 (Friedman, 2015).

To explore how ENDS age purchasing restrictions are associated with the use of tobacco and marijuana, we use four different measures of cigarette smoking intensity, and measures of cigar use, smokeless tobacco use, and marijuana use. The smoking intensity measures that we use are: 1) recent cigarette use (at least 1 day over the past 30 days), 2) casual cigarette use (between 1 and 19 days over the past 30 days) 3) regular cigarette use (at least 20 days over the past 30 days), 4) and heavy cigarette use (every day over the past 30 days). We also use recent (past 30 days) cigar use, smokeless tobacco use, and marijuana use as outcome measures.

We obtained data on ENDS age purchasing restrictions from a report by the CDC (Marynak et al., 2014). We matched this data using the February–May time window over which students were interviewed. Wyoming changed their policy halfway through the data collection in 2013, and we treat this state as if the policy had been in effect the full year. We exclude the state of Massachusetts from our analysis because age purchasing restrictions were implemented at the county level at different points in time (Global Advisors on Smokefree Policy (New Jersey GASP), 2015).

In addition to ENDS age purchasing restrictions, we match the following onto the YRBSS data and use this as control variables in our regression analysis: racial/ethnic composition of adolescents, the combined state and federal cigarette excise taxes, and cigarette indoor use laws. We obtained state-level cigarette excise taxes from the State Tobacco Activities Tracking and Evaluation (STATE) System maintained by the CDC (Centers for Disease Control and Prevention, 2014a), and added the federal excise taxes, which were $0.39 in 2007, and $1.01 in 2009, 2011, and 2013. We adjust the tax levels for inflation. We also obtained state-level cigarette indoor use restrictions for restaurants, workplaces, and bars from the STATE system. For racial/ethnic composition of adolescents, we used Survey of Epidemiology and End Results (SEER) population data to construct three state-level ratios: White, other race, and Hispanic 10–19 year olds as a share of all adults (Roth, 2015). We used 19 as the upper bound because of how the data were grouped. For cigarette indoor use restrictions, the STATE system only provides data through 2012, so we impute 2013 data using 2012 data.

To explore the association of ENDS age purchasing restrictions on these substance use measures, we estimate a state and year fixed effects regression model. The inclusion of state and year fixed effects allows us to exploit variation in ENDS age purchasing restrictions independent of state-level time-invariant unobservable characteristics, and unobservable characteristics unique to a particular year. For example, anti-smoking sentiment and non-changing population characteristics unique to a particular state from 2007 to 2013 is controlled by the inclusion of a state fixed effects. The national introduction of ENDS over time is controlled for by year fixed effects. We also include separate linear time trends for states enacting ENDS age purchasing restrictions and states not enacting age purchasing restrictions, which control for time-varying omitted variables in these two groups of states, such as changing anti-smoking sentiment.

We perform the regression analysis using 4 annual observations for states with complete information from 2007 to 2013. Cigarette and marijuana use information is provided in all years for 33 states (and 34 for select outcomes), cigar use is provided in all years for 25 states, and smokeless tobacco is provided in all years for 28 states. In Table 1, we show the variation in ENDS age purchasing restrictions by state and year for the largest (34 states) and smallest (25 states) samples.

In addition to measuring the association of ENDS age purchasing restrictions on tobacco and marijuana use measures during the period immediately after implementation, we also examine the association on outcomes 2 years before a restriction was in place. If significant associations are found before the policy was implemented, this may indicate that restrictions were endogenously enacted in states with changing cigarette use relative to non-implementing states, or some other omitted variable bias. If significant associations are not found in the prior period, then we argue any associations that we find in the period in which the policy was implemented exhibit evidence of causality. We also examine the association that restrictions have in the 2 years after implementation to observe any lagged effects.

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