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Original article

## Impact of E-Cigarette Minimum Legal Sale Age Laws on Current Cigarette Smoking

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### ABSTRACT

**Purpose:** The purpose of this study was to use individual-level data to examine the relationship between e-cigarette minimum legal sale age (MLSA) laws and cigarette smoking among U.S. adolescents, adjusting for e-cigarette use.

**Methods:** In 2016 and 2017, we regressed (logistic) current (past 30-day) cigarette smoking (from 2009–2014 National Youth Tobacco Surveys [NYTS]) on lagged (laws enacted each year counted for the following year) and unlagged (laws enacted January–June counted for that year) state e-cigarette MLSA laws prohibiting sales to youth aged <18 or <19 years (depending on the state). Models were adjusted for year and individual- (e-cigarette and other tobacco use, sex, race/ethnicity, and age) and state-level (smoke-free laws, cigarette taxes, medical marijuana legalization, income, and unemployment) covariates.

**Results:** Cigarette smoking was not significantly associated with lagged MLSA laws after adjusting for year (odds ratio [OR] = .87, 95% confidence interval [CI]: .73–1.03;  $p = .10$ ) and covariates (OR = .85, .69–1.03;  $p = .10$ ). Unlagged laws were significantly and negatively associated with cigarette smoking (OR = .84, .71–.98,  $p = .02$ ), but not after adjusting for covariates (OR = .84, .70–1.01,  $p = .07$ ). E-cigarette and other tobacco use, sex, race/ethnicity, age, and smoke-free laws were associated with cigarette smoking ( $p < .05$ ). Results unadjusted for e-cigarette use and other tobacco use yielded a significant negative association between e-cigarette MLSA laws and cigarette smoking (lagged: OR = .78, .64–.93,  $p = .01$ ; unlagged: OR = .80, .68–.95,  $p = .01$ ).

**Conclusions:** After adjusting for covariates, state e-cigarette MLSA laws did not affect youth cigarette smoking. Unadjusted for e-cigarette and other tobacco use, these laws were associated with lower cigarette smoking.

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### IMPLICATIONS AND CONTRIBUTION

After adjusting for covariates, e-cigarette minimum legal sale age laws covering youth under age 18 or 19 did not affect current (30-day) cigarette smoking among adolescents in the National Youth Tobacco Survey between 2009 and 2014. Workplace smoke-free indoor air laws were negatively associated with current cigarette smoking.

**Conflicts of Interest:** The authors have no conflicts of interest relevant to this article to disclose.

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During 2011–2014, marked changes in tobacco use occurred among U.S. middle and high school students; most notably, e-cigarette use increased considerably, and conventional cigarette (hereafter “cigarette”) use continued to decline [1]. The observed increase in e-cigarette use has been attributed to multiple factors, including curiosity, flavors that appeal to youth, and widespread advertising [2]. Some have argued that the observed decrease in cigarette smoking may be attributed to the marked increase in e-cigarette use [3,4] as opposed to tobacco control measures, such as smoke-free laws [5]. However, according to an analysis of repeated cross-sectional data from the 2004–2014 National Youth Tobacco Survey (NYTS), the observed increase in e-cigarette use during this period did not significantly affect the declining trend in cigarette smoking [6]. According to analyses of cross-sectional data from national and California-based samples of adolescents, in addition to dual users of cigarettes and e-cigarettes, many adolescents became e-cigarette-only users during this period, many of whom had risk profiles that made them unlikely to initiate tobacco product use with cigarettes [6,7]. Moreover, the U.S. Surgeon General concluded that youth e-cigarette use is strongly associated with tobacco product use, including cigarettes [2]. In addition, multiple longitudinal studies found that youth and young adults who use e-cigarettes (compared with those that do not) have more than twice the odds of initiating cigarette smoking or being current (past 30-day) cigarette smokers at follow-up (6–18 months later) [8–11].

Through authority granted by the Family Smoking Prevention and Tobacco Control Act, the U.S. Food and Drug Administration finalized its “deeming rule” in May 2016 that prohibited the sale of e-cigarettes to individuals younger than age 18 [12]. In addition, as of October 2017, five states (California, Hawaii, Maine, New Jersey, and Oregon) and the District of Columbia had instituted minimum legal sale age (MLSA) laws of 21 for e-cigarettes [13].

Based on the theory that cigarettes and e-cigarettes are economic substitutes, studies published in 2014 [14] and 2015 [15] raised concern that limiting access to e-cigarettes could lead to increases in population-level cigarette smoking. This concern was heightened by a 2015 analysis of U.S. state-level data on adolescent cigarette smoking that found that between 2002 and 2013, states that had passed e-cigarette MLSA laws had .9% higher smoking prevalence than states without such laws [16]. As of April 2017, two additional analyses found significantly higher cigarette smoking among youth covered by e-cigarette MLSA laws [17,18]. In contrast, a subsequent study using individual-level data from high school students in the Monitoring the Future study found significantly lower smoking among youth covered by e-cigarette MLSA laws [19]. None of these analyses adjusted for youth e-cigarette or other tobacco product (hereafter “other tobacco”) use, which are highly associated with cigarette smoking [2]. In addition, all but two [18,19] used state-level data, rather than individual-level data, therefore not accounting for key covariates for the association between e-cigarette MLSA laws and cigarette smoking.

To address this gap in the scientific literature, the present study used individual-level data from the 2009–2014 NYTS to assess the relationship between e-cigarette MLSA laws and cigarette smoking among youth, adjusting for e-cigarette and other tobacco use, as well as other individual and state-level covariates. The relationship between e-cigarette MLSA laws and youth e-cigarette use was also assessed.

## Methods

### Sample

NYTS is a cross-sectional, pencil-and-paper, school-based survey of U.S. middle and high school students in grades 6 through 12 [20–24]. NYTS started in fall 1999 and has been conducted in the spring of 2000, 2002, 2004, 2006, 2009, 2011, and annually thereafter. This analysis was restricted to the five NYTS waves conducted during 2009–2014 (2009, 2011, 2012, 2013, and 2014) because respondents’ state of residence, a restricted use variable, first became available in 2009, and at the time of submission, state cigarette tax information was available through 2014. Response rates for the surveys and sample sizes were 84.8% (N = 17,855) [2009], 72.7% (N = 15,008) [2011], 73.6% (N = 19,488) [2012], 67.8% (N = 14,074) [2013], and 73.3% (N = 16,952) [2014]. To align with the published literature [16], the analysis only included youth aged 12–17, resulting in a restricted sample size of 85,861 of 101,561 potential participants (84.5%). Respondents with missing values for any variable of interest were also excluded, resulting in an analytic sample of 83,026 of 85,861 participants (96.7%).

### Dependent variable

The primary dependent variable was dichotomized current (30-day) cigarette smoking (“0” for 0 days and “1” for  $\geq 1$  day). Current (past 30-day) e-cigarette use was also assessed as a dichotomous dependent variable (“0” for 0 days and “1” for  $\geq 1$  day).

### Independent variables

*Individual level.* Adjusted models included individual-level correlates of cigarette smoking, including sex (male and female [reference]), race/ethnicity (non-Hispanic white [reference], Hispanic, non-Hispanic black, and non-Hispanic other), age (in years, centered at 12), current (past 30-day) e-cigarette use, and current (past 30-day) other tobacco use (“0” for 0 days and “1” for  $\geq 1$  day) [2]. We also included these variables to account for potential differences in e-cigarette MLSA coverage by demographics [25] and the potential impact of e-cigarette MLSA laws on e-cigarette use and other tobacco use [2]. To ensure comparability across years, other tobacco use was restricted to products assessed every year in the 2009–2014 NYTS: chewing tobacco/snuff/dip, cigars/cigarillos/little cigars, pipes, and bidis. E-cigarette prevalence was assumed to be zero in 2009 because e-cigarettes entered the U.S. marketplace around 2007 [2], and current adolescent e-cigarette use was only 1.1% in 2011, the first year that NYTS included questions on e-cigarette use [1].

*State level.* The State Tobacco Activities Tracking and Evaluation (STATE) System was used to create a dichotomized variable and a continuous variable [16] for e-cigarette MLSA laws prohibiting sales to youth younger than 18 or 19 years old (depending on the state) [26]; state e-cigarette MLSA laws prohibiting sales to those younger than 21 years old were not included in the analysis because no such law existed during the assessment period (i.e., 2009–2014). The dichotomized variable was coded as “0” for no law and “1” for a law. The continuous variable was the number of months the MLSA was in place during the survey period (2009–2014) divided by the total number of months of

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