Race/ethnicity modifies the association between school prevalence of e-cigarette use and student-level use: Results from the 2014 US National Youth Tobacco Survey

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ABSTRACT

This study assessed racial/ethnic moderation of the association between school prevalence of lifetime e-cigarette use and students' use. Using multilevel regression methods and data from the 2014 US National Youth Tobacco Survey, we found attending schools with high rates of e-cigarette use was positively associated with students' lifetime use of e-cigarettes, especially for white students. A cross-level interaction term indicated a weaker association between non-Hispanic black race and attending high-use schools (odds ratio [OR] =0.61, 95% confidence interval [CI] =0.39, 0.95). Results implicate race/ethnicity as an important effect modifier in the link between school contexts and teenage e-cigarette use.

1. Background

1.1. Introduction

Since their introduction to US markets in 2007, electronic cigarettes, or "e-cigarettes," have seen a dramatic increase in use, especially among adolescents (Carroll Chapman and Wu, 2014). This increase in e-cigarette use in concert with the fall of conventional cigarette use is a trend that health professionals have received with cautious optimism, since e-cigarettes may be less harmful than "combustible" cigarettes. Whereas conventional cigarettes promote oxidative stress, activation of inflammatory pathways, and release of numerous carcinogenic toxins, extant research suggests that these risks are less severe in e-cigarettes (Farsalinos and Polosa, 2014). Instead of combustion, e-cigarettes involve the delivery of nicotine and flavoring to the user via vaporization of a liquid contained in the atomizer of the e-cigarette. Thus, e-cigarettes may reduce harm for smokers seeking alternative nicotine delivery systems (Ambrose and Barua, 2004; Greenland et al., 1998).

Despite these theoretical benefits, doubts have been raised regarding the health risks associated with teenage e-cigarette use. E-cigarette nicotine cartridges often contain propylene glycol, diethylene glycol, and other secondhand vapors that become aerosolized during use to generate gaseous 1,2-propanediol, glycerine, nicotine, and PM2.5 (Schober et al., 2014). A recent study by Jensen et al. indicated that the concentration of carcinogenic formaldehyde in high-voltage e-cigarette vapor is greater than that found in traditional cigarettes (Jensen et al., 2015). E-cigarette use has also been touted as an effective way of quitting traditional tobacco products, but evidence to support this claim is equivocal. A randomized trial of 40 smokers found that e-cigarette use alleviated the desire to smoke after overnight abstinence compared to a placebo (Bullen et al., 2010). Several longitudinal studies have substantiated this claim, suggesting that both biological and behavioral improvements associated with e-cigarette use are beneficial for those looking to quit (Biener and Hargraves, 2015; Caponnetto et al., 2013; Polosa et al., 2013). However, a study of 1549 participants found no reduction in 6-month quit rates when comparing e-cigarettes to non-users (Grana et al., 2014), while Borderud et al. (2014) found that e-cigarette users were *more* likely to be smoking at the time of follow-up compared to non-users in an intention-to-treat analysis.

Given both the rapid rise in popularity and disputed claims regarding the harm reduction potential of e-cigarettes, many scholars have investigated the correlates of use among adolescents. Yet, little attention has been paid to how e-cigarette use may vary according to school-level trends and among racial/ethnic groups. Recent reports indicate lower use of e-cigarettes among non-Hispanic black versus non-Hispanic white and Hispanic students (Singh, 2016), and among students attending schools with high versus low e-cigarette use

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prevalence (Corsi and Lippert, 2016). However, it remains unclear whether race/ethnicity modifies the link between the school context and student e-cigarette use, as is the case with conventional smoking (Kandel et al., 2004). Further, it is not known whether any such effect modification is robust to adjustments for student-level use of conventional cigarettes. As conventional smoking is both strongly associated with electronic cigarette use and more common among non-Hispanic white teens (Blum et al., 2000), the association between school context and student vaping may be attenuated by conventional smoking to a greater degree for white versus non-white students.

In the present study, we use multilevel modeling techniques and cross-sectional data from the 2014 wave of the US National Youth Tobacco Survey (NYTS) in order to address three questions: (1) How does e-cigarette use cluster at the school level? (2) Does race/ethnicity modify the association between school-level prevalence of use and student-level e-cigarette use? (3) Does use of conventional cigarettes mediate the joint associations among race/ethnicity, school-level prevalence of e-cigarette use, and student-level use?

1.2. Trends in E-cigarette use

Previous findings from the NYTS indicate that past 30-day use of e-cigarettes among a nationally representative sample of middle and high school students rose from 1.5% in 2011 to 16.0% in 2015 (Singh, 2016). In the same period, use of traditional combustible cigarettes fell from 15.8% to 9.3% (Singh, 2016). A contemporary study in 27 European Union countries reported a similar rise in prevalence, from 7.2% in 2012 to 11.6% in 2014 (Filippidis et al., 2016).

Given the unknown risks of e-cigarettes, the uptick in teenage use is concerning. Scholars have recently sought to identify the correlates of teenage e-cigarette use. Important correlates including older age (Carroll Chapman and Wu, 2014; Krishnan-Sarin et al., 2015), male sex (Jiang et al., 2016; Fotiou et al., 2015; Barnett et al., 2015), and using conventional tobacco products (Fotiou et al., 2015; Lippert, 2016) or knowing someone who does (Jiang et al., 2016). Recent work has also sought to identify the reasons undergirding teenage e-cigarette use, which appear to favor recreational and experimental purposes rather than tobacco cessation (Patrick et al., 2016). These findings bolster concerns over adolescent e-cigarette use as a means to *new* nicotine addictions versus tobacco desistence.

School context has also been identified as a key correlate of e-cigarette use. Analyses of US data from 2013 found that the proportion of students who reported e-cigarette use within a school was positively associated with an individuals' odds of use, above and beyond key student-level risk factors like conventional tobacco use (Corsi and Lippert, 2016). Past publications investigating adolescent use of conventional tobacco products support the notion that school environments play a crucial role in personal use (Alexander et al., 2001; Ellickson et al., 2003). Several theories have been proposed to explain such findings. First, it may be that school-level substance use approximates access to materials and substance-using peer models for new users to initiate a given risk behavior. In support of this possibility, Ellickson et al. (2003) reported that non-smoking students were likelier to be current smokers after one year if they had smoking friends. Second, excessive school-level use among peers may cultivate an environment where individuals perceive that use is normative and benign. Many studies have concluded that adolescents who report high rates of use among adults or peers are likelier to smoke or initiate smoking themselves (Botvin et al., 1992a, 1992b; Choi et al., 2003).

Recently, Corsi and Lippert (2016) reported that the broad increase in adolescent e-cigarette use may be partially driven by school-level correlates, such as social norms, and lack of sanctions within particular schools. Giovenco et al. (2016) further highlight the importance of the point-of-sale environments surrounding school zones in contributing to adolescent e-cigarette use. These findings are in line with a theoretical framework connecting schools to adolescent health devel-

oped by Frohlich et al. (2001, 1982). The authors of this model view health behaviors as "generated practices" that both shape—and are shaped by—the contexts in which human lives are embedded, such as schools and neighborhoods. As health-risk behaviors are repeatedly performed, the contextual qualities that initially influence their emergence may become reinforced, facilitating the diffusion of the behavior in environments where it is already common. Regarding e-cigarettes, this process is evidenced by the increasing school-level clustering of e-cigarette use between 2011 and 2013—years marked by rapid increases in the population-wide prevalence of e-cigarette use among US teenagers (Corsi and Lippert, 2016). This pattern supports the theoretical perspective outlined by Frohlich and colleagues (Frohlich et al., 2001, 1982), and also suggests that the school context has become a *more* important correlate of adolescent e-cigarette use over time.

1.3. Race/ethnicity in the school context

Scholars have previously noted the need to characterize racial/ethnic differences in health behaviors and outcomes in the context of community settings, like schools (Acevedo-Garcia et al., 2003; Leventhal and Brooks-Gunn, 2000). A comprehensive study of more than 30,000 high school students indicated that several school-level variables such as percent minority, competitive climate, and students per teacher differentially affected blacks and Hispanics as compared to non-Hispanic whites with respect to cigarette smoking (Johnson and Hoffmann, 2000). Furthermore, using data from the National Longitudinal Study of Adolescent Health, Kandel et al. (2004) explicitly modeled interactions between school-level variables and race, and reported that compared to non-Hispanic whites, scholastic attitudes modified the odds of smoking initiation and transition to daily use in blacks and Hispanics. From the same data, Griesler et al. (2002) found that the effect of peer pressure was also greater for persistent tobacco use in non-Hispanic whites compared to blacks. A consistent finding was that non-Hispanic whites are more likely to initiate or continue smoking, depending on their social context. For instance, non-Hispanic white adolescents had a significantly greater risk of initiating smoking or continuing to smoke if they knew someone who smoked (e.g., classmates, parents), but comparable associations were not found for blacks.

Although sparse in number, these studies offer insights into possible effect modification by school-level factors on the relationship between race/ethnicity and substance use. Drawing upon the theory of "collective lifestyles," (Frohlich and Potvin, 1999) we speculate that differential clustering of white and nonwhite students creates separate microenvironments within schools, each with their own prescriptive and proscriptive influences. Given what we know about racial/ethnic differences in adolescent substance use behaviors in general, we expect that the school prevalence of e-cigarette use will constitute an important correlate of student-level use, but that this association will be stronger for non-Hispanic whites versus nonwhites. We further expect that such racial/ethnic moderation will be partially attenuated by student-level use of conventional cigarettes, which are known (and strong) correlates of teen e-cigarette use (Dutra and Glantz, 2014) and are used far more commonly among non-Hispanic white versus nonwhite students (Wallace et al., 2003, 2002; Rigotti et al., 2000). We test these suppositions using multilevel regression techniques and data from the 2014 US National Youth Tobacco Survey.

2. Methods

2.1. Data

Data are drawn from the National Youth Tobacco Survey (NYTS) conducted in 2014. The NYTS is a national sample of US middle and high school students (grades 6–12 in public and private schools), covers all 50 states and the District of Columbia, and was developed by