Original investigation

Differences in Adolescent E-cigarette and Cigarette Prevalence in Two Policy Environments: South Korea and the United States

Hong-Jun Cho MD, PhD¹, Lauren M. Dutra ScD², Stanton A. Glantz PhD^{3,4}

¹Department of Family Medicine, Asan Medical Center, University of Ulsan College of Medicine, Seoul, South Korea;

²RTI International, Berkeley, California; ³Center for Tobacco Control Research and Education, University of California, San Francisco, California; ⁴Department of Medicine, University of California, San Francisco, California

Corresponding Author: Hong-Jun Cho, MD, PhD, 88, Olympic-ro 43-gil, Songpa-gu, Seoul, Republic of Korea 05505. Telephone: 82-2-3010-3812; Fax: 82-2-3010-3815; E-mail: hjcho@amc.seoul.kr

Abstract

Introduction: In the context of different regulatory environments, different patterns of e-cigarette use have emerged among adolescents worldwide. The United States and South Korea are two examples, the latter of which has maintained much more extensive regulation of e-cigarettes.

Methods: This analysis compares the prevalence of e-cigarette and conventional cigarette use between 2011 and 2015 from the Korean Youth Risk Behavior Web-based Survey and the U.S. National Youth Tobacco Survey, both nationally representative samples of middle and high school students that use similar questions.

Results: E-cigarette prevalence (past 30 days) among South Korean adolescents decreased from 4.7% in 2011 (95% confidence interval [CI]: 4.4–5.0) to 4.0% (3.7–4.3) in 2015 but increased dramatically among US adolescents from 0.9% (0.7–1.2) to 11.2% (9.9–12.7). Cigarette prevalence (past 30 days) decreased in South Korea from 12.1% (11.6–12.7) to 7.8% (CI: 7.3–8.3) and in the United States from 11.1% (9.5–12.6) to 6.1% (5.1–7.3). Combined prevalence of cigarette and e-cigarette use (adjusting for dual users) decreased in South Korea from 13.2% (12.7–13.8) to 8.5% (8.0–9.1) but increased in the United States from 11.3% (9.7–12.9) to 14.0% (12.4–15.7).

Conclusions: In South Korea, where e-cigarettes are extensively regulated, adolescent e-cigarette use remained stable at a low level, whereas in the United States, where e-cigarette regulation has been limited, e-cigarette use increased. Combined e-cigarette plus cigarette use declined in South Korea whereas it increased in the United States. The restrictive policies in South Korea likely contributed to lower overall product use.

Implications: This paper compared the strength of regulation of South Korea and the United States with the prevalence of adolescents' e-cigarette and cigarette use and suggests that more restrictive policies likely to contribute to lower e-cigarette use and overall use of e-cigarette and cigarette.

Introduction

Electronic cigarettes (e-cigarettes) are devices that deliver a heated nicotine solution as an aerosol.^{1–3} Research from several countries has demonstrated high and rapidly increasing levels of e-cigarette

use among adolescents.^{4–6} Any adolescent e-cigarette use is worrisome because many e-cigarettes contain the addictive drug nicotine, and all e-cigarettes (even those labeled nicotine free) expose users to ultrafine particles and chemicals.⁷ Nicotine adversely affects brain

development in adolescents, causing problems with cognition and emotional regulation.^{8,9} Moreover, several US studies have found that adolescents who use e-cigarettes, even those at low risk of smoking cigarettes, are more likely to subsequently initiate cigarette smoking.^{3,10–13}

Different trends in adolescent use have emerged worldwide in the context of regulatory schemes ranging from banning importation of e-cigarettes to little or no regulation of these devices. South Korea (hereafter Korea) and the United States have implemented starkly different regulatory schemes for e-cigarettes. E-cigarettes were introduced in both countries around the same time, in 2007, and these two nations use almost identical surveillance measures to capture adolescent e-cigarette use, presenting the opportunity to compare trends in use in two very different regulatory environments.

Korea quickly regulated e-cigarettes after their arrival on the market in 2007.¹⁴ By 2008, Korea considered e-cigarettes a tobacco product and prohibited use in all indoor places where cigarette smoking is prohibited; prohibited sales to minors and advertisements on television, radio, and billboards; levied excise taxes; prohibited sales by Internet and mail; and required health warning labels. The government levied a local tax of 400 Korean Won (~\$0.3) per mL of nicotine solution in 2010 and increased the tax to 1799 Korean Won (~\$1.6) per mL of nicotine solution in 2014 (where it remained as of April 2017). The tobacco tax for a pack of cigarettes in Korea was 3318 Korean Won (~\$2.8; 74% of the price of cigarettes). In November 2011, the Korean Ministry of Gender Equality and Family issued a regulation stating that e-cigarette components, including the battery, atomizer, and cartridge, are hazardous to adolescents under the Adolescent Protection Act¹⁴ and therefore prohibited sales, rent, and distribution of the hazardous instruments to adolescents. Violators can be fined or sentenced to jail. This law also requires that vendors of such items label their products “hazardous to adolescents.” In 2015, text health warnings were introduced on nicotine cartridges. The Act on Fair Labeling and Advertising prohibited e-cigarette manufacturers from making health claims about their products, and, in October 2012, the Fair Trade Commission ordered for two e-cigarette makers to correct their false health claims.¹⁵

Despite Korea’s strict regulation of e-cigarettes, enforcement remains a problem. Even though e-cigarette advertising is illegal in Korea, e-cigarette companies use Internet websites and blogs as marketing tools.¹⁴ Non-nicotine containing cartridges are not regulated as a tobacco product in Korea. Because nicotine-containing e-cigarette cartridges cannot be easily differentiated from non-nicotine-containing cartridges, excluding nicotine-free e-cigarettes from tobacco products may have hampered the regulation of e-cigarettes in Korea.

During this same period, most US states set the age of purchase to 18 (although many laws were weak ones promoted by industry),^{16,17} some states and localities prohibited e-cigarette use where cigarette use was prohibited, and one state taxed e-cigarettes.¹⁸ Although US states began placing age requirements on e-cigarette purchases in 2010,¹⁹ and the first state smoke-free air law to include e-cigarettes took effect in 2010 in New Jersey,²⁰ there was no federal regulation of e-cigarettes in the United States until May 2016, when the U.S. Food and Drug Administration issued its “deeming” rule asserting jurisdiction over e-cigarettes.²¹ The rule, which went into effect in the August of 2016, set a national minimum age for purchase of 18 effective immediately and required warning labels on e-cigarettes effective August 2018. The rule did not impose any restrictions on advertising or flavors or implement any taxes.

The aim of this analysis was to compare adolescent e-cigarette and cigarette use in Korea and the United States between 2011 and 2015. In Korea, where e-cigarettes were strictly regulated between 2011 and 2015, adolescent e-cigarette use remained stable at low levels; in the United States, where e-cigarettes were subject to some local regulations but no national regulation, e-cigarette use increased. Current cigarette use fell in both countries, but combined prevalence of e-cigarette and cigarette use fell in Korea whereas it increased in the US.

Methods

Data

The Korean and U.S. Centers for Disease Control and Prevention (CDC) conducted annual surveys of nationally representative samples of middle and high school students between 2011 and 2015 using similarly worded questionnaires. Prevalence of Korean adolescents’ e-cigarette and cigarette use were estimated from the Korea Youth Risk Behaviors Web-based Survey (KYRBS), which is administered annually by the Korean CDC. KYRBS is a nationally representative cross-sectional school-based study of middle and high school students. The number of respondents ranged from 67 671 in 2015 to 75 643 in 2011.²² All respondents were between the ages of 12 and 18.

Prevalence of US adolescents’ e-cigarette use and cigarette use were estimated from the CDC’s school-based National Youth Tobacco Survey (NYTS).²³ NYTS is an annual nationally representative cross-sectional sample of US middle and high school students obtained from all 50 states and the District of Columbia. The number of respondents ranged from 15 664 in 2013 to 21 560 in 2012.²⁴ Respondents were between the ages of 9 and 21 years old, but 93.2% of the total sample was between the ages of 12 and 18.

Variables

Cigarette Prevalence

In the KYRBS, cigarette smoking prevalence was obtained by dividing the number of adolescents who responded “yes” to the question “Have you ever tried cigarette, even one puff in your life?” and between “1–2 days” and “Every day” to the question “During the past 30 days, on how many days did you smoke cigarettes, even one cigarette?” by the number of respondents to the KYRBS. In the NYTS, cigarette smoking prevalence was obtained by dividing the number of adolescents who responded “yes” to the question “Have you ever tried cigarette smoking, even 1–2 puffs?” and between “1 and 2 days” and “All 30 days” to the question “During the past 30 days, on how many days did you smoke cigarettes?” by the number of respondents to the NYTS.

E-cigarette Prevalence

In the KYRBS, e-cigarette use prevalence was obtained by dividing the number of adolescents who responded “yes” to the question “Have you used e-cigarettes in the past 30 days?” by the number of respondents to the KYRBS. For the NYTS, for 2011–2013, e-cigarette prevalence was obtained by dividing the number of adolescents who responded “e-cigarette” to the question “During the past 30 days, which of the following [tobacco] products did you use on at least one day?” by the total number of NYTS respondents for each year. For 2014 and 2015, e-cigarette prevalence was obtained by dividing the number of adolescents who responded between “1 or 2 days” and “All 30 days” to the question “During the past 30 days, on how many

days did you use electronic cigarettes or e-cigarettes?” (examples of e-cigarette brands included blu, 21st Century Smoke, and NJOY in 2014 and NJOY, Blu, VUSE, MarkTen, Finiti, Starbuzz, and Fantasia in 2015) by the number of NYTS respondents in each year.

Combined Prevalence of Cigarettes and E-cigarettes

For both KYRBS and NYTS, we calculated the combined prevalence of cigarette and e-cigarette use by summing the number of users of cigarettes and e-cigarettes, subtracting the number of dual users so that they were not counted twice, and then dividing by the total number of survey respondents.

Prevalence of Dual Use of Cigarettes and E-cigarettes

We calculated dual use by dividing the number of adolescents who reported using both e-cigarettes and cigarettes in the past 30 days by the total number of survey respondents.

Cigarette Only Prevalence

Cigarette only prevalence is the number of adolescents who reported smoking cigarettes but not using e-cigarettes, divided by the total number of survey respondents.

E-cigarette Only Prevalence

E-cigarette only prevalence was the number of adolescents who reported using e-cigarettes but not smoking cigarettes divided by the total number of survey respondents.

Year

Survey year was coded as a linear term. We conducted an exploratory analysis in which we centered year on 2013, coded it as quadratic, and included it in the metaregression (instead of linear year), and the quadratic term yielded no significant p values ($p > .681$).

Statistical Analysis

We used SPSS 21 to obtain prevalence and 95% confidence intervals (CIs) for the KYRBS, adjusting for KYRBS-provided weights and stratification variables. We used SAS 9.3 (surveyfreq) to obtain prevalence and 95% CIs for the NYTS, adjusting for NYTS-provided weights and stratification variables. We used metareg in Stata to calculate p values for changes in use in both countries over time. We did not adjust for baseline (pre-2011) levels of e-cigarette use because e-cigarettes arrived in both countries in the same year (2007),^{7,25–27} and the existing research suggests that current e-cigarette prevalence was close to zero for adolescents in both countries in 2009.^{28,29}

Results

E-cigarette Prevalence

Among Korean adolescents, e-cigarette prevalence, including e-cigarette only users and dual users of cigarettes and e-cigarettes, remained stable at around 4% (p for trend = .953; Figure 1 and Supplementary Table 1). In the United States, e-cigarette use increased from 0.9% (0.7–1.2) in 2011 to 11.2% (9.9–12.7) in 2015 (p for trend = .015).

Cigarette Prevalence

Among Korean adolescents, cigarette smoking prevalence decreased from 12.1% (11.6–12.7) in 2011 to 7.8% in 2015 (7.3–8.3; p for

trend = .001, Figure 2 and Supplementary Table 1). Among US adolescents, cigarette smoking prevalence decreased from 11.2% (9.5–12.6) in 2011 to 6.1% (5.1–7.3) in 2015 (p for trend = .009).

Combined Prevalence of Cigarettes and E-cigarettes

The combined prevalence of cigarettes and e-cigarettes (accounting for dual use) significantly decreased from 13.2% (12.7–13.8) to 8.5% (8.0–9.1) in Korea (p for trend = .004, Figure 3 and Supplementary Table 1) and increased slightly (but not significantly) from 11.3% (9.7–12.9) to 14.0% (12.4–15.7) in the United States (p for trend = .20).

Figure 1. Current (past 30 days) e-cigarette prevalence and e-cigarette only prevalence (with 95% confidence interval) among adolescents in Korea and the United States. E-cigarette prevalence declined in Korea but increased rapidly in the United States between 2011 and 2015. E-cigarette only prevalence was stable in Korea but increased in the United States.

Figure 2. Current (past 30 days) cigarette and cigarette only prevalence (with 95% confidence interval) among adolescents in Korea and the United States. Between 2011 and 2015, cigarette prevalence and cigarette only prevalence declined in both Korea and the United States.

Figure 3. Current (past 30 days) combined prevalence of cigarettes and e-cigarettes and prevalence of dual use (with 95% confidence intervals) among adolescents in Korea and the United States. Combined prevalence declined between 2011 and 2015 in Korea but increased non-significantly in the United States. Dual use was stable over time in Korea but increased in the United States.

Prevalence of Dual Use of Cigarettes and E-cigarettes

Prevalence of dual use of cigarettes and e-cigarettes remained stable around 3–4% among Korean adolescents. Prevalence of dual use increased almost five-fold from 0.7% in 2011 (0.5–1.0) to 3.4% in 2015 (2.9–4.1, p for trend = .006, Figure 3 and Supplementary Table 1) among US adolescents.

E-cigarette Only Prevalence

E-cigarette only prevalence was stable at around 1% (p for trend = .424) among Korean adolescents. E-cigarette only prevalence increased 46-fold between 2011 (0.2%; 0.1–0.2) and 2015 (7.4%; 6.6–8.4; p for trend = .026) among US adolescents (Figure 1 and Supplementary Table 1).

Cigarette Only Prevalence

Cigarette only prevalence decreased significantly in both countries, from 8.6% (95% CI: 8.2–9.0) to 4.5% (95% CI: 4.2–4.9) in Korea (p for trend = .011), and from 10.3% (95% CI: 8.9–11.8) to 2.7% (95% CI: 2.0–3.5) in the United States (p for trend = .008; Figure 2 and Supplementary Table 1).

Discussion

From 2011 to 2015, e-cigarette prevalence did not change significantly among Korean adolescents but increased by a factor of more than 12 in the United States, with particularly large increases in e-cigarette only use. The higher e-cigarette use in Korea in 2011 reflects earlier market penetration there, perhaps due to the higher cigarette smoking prevalence in Korea than in the United States leading to higher e-cigarette use through dual use of cigarettes and e-cigarettes. Although e-cigarette use was higher in 2011 in Korea than in the United States, by 2014, the US e-cigarette prevalence had surpassed Korea's. Two potential explanations for this difference is the increase in e-cigarette advertising in the United States between

2013 and 2014,³⁰ which was prohibited (albeit imperfectly) in Korea and the fact that e-cigarettes were taxed in Korea.

Cigarette prevalence declined in both countries. In Korea cigarette prevalence decreased continuously from 2011 to 2015.³¹ In 2015, both cigarette prevalence and cigarette-only prevalence were higher in Korea than in the United States.

In Korea, these declines are likely due to strengthening of smoke-free policies, expansion of anti-tobacco campaigns and increasing tobacco tax. However, cigarette prevalence remains higher in Korea than the United States because of Korea's weak regulation of tobacco advertising, promotion and sponsorship.³² Policies that likely contributed to this overall decline in the US include increasing tobacco taxes, improvements in smoke-free law coverage, and anti-smoking media campaigns, such as the Food and Drug Administration *The Real Cost*, the CDC *Tips From Former Smokers*, and Truth Initiative "truth" campaigns as well as anti-smoking media campaigns in some states.

Combined prevalence of cigarette and e-cigarette use declined in Korea between 2011 and 2015 but increased in the United States,³³ likely due to the increasing popularity of e-cigarettes in the United States during this time. Dual use remained relatively stable in Korea but increased in the United States. These findings for the United States are consistent with mounting evidence that never smoking e-cigarette users (compared with never smoking non-users) are more likely to initiate cigarette smoking in the following year.^{3,10–13} Consistent with these longitudinal data, 2014 to 2015 was the first time in at least 10 years that cigarette smoking did not decline among high school students in the United States.^{6,33}

Limitations

We did not adjust for baseline differences in cigarette smoking or e-cigarette use in this analysis because of the small number of data points available. As a result, some of the observed differences in trend may be due to differential rates of uptake of e-cigarettes in the two countries. In addition, definitions of current cigarette and e-cigarette use (past 30 days) are similar but not identical in the KYRBS and NYTS. We attempted to perform formal hypothesis testing of interaction terms (country by time), but unfortunately, the inclusion of the interaction term induced collinearity, and we had too few time points to test for interactions using year as a categorical variable. In addition, we were unable to control statistically for many differences between Korea and the United States that likely contributed to our results, including culture, differences in the governing of the two countries beyond the regulation of e-cigarettes, social norms, tobacco control policy, tobacco industry activity, and knowledge, attitudes, and beliefs (KAB) towards tobacco and health, including the influence of industry activity on KAB and the reciprocal relationship between KAB and policy. The wording of the e-cigarette question in the NYTS (but not in the KYRBS) changed slightly between 2013 and 2014. Between 2011 and 2013, the question asked was "In the past 30 days, which [tobacco products] have you used on at least 1 day?" with the answer choice "Electronic Cigarettes or E-cigarettes, such as Ruyan or NJOY". In 2014, the question asked was "During the past 30 days, on how many days did you use e-cigarettes such as Blu, 21st Century Smoke, or NJOY?" The change in format and the more expansive list of e-cigarette brands in 2014 may have contributed to some of the reported increase in e-cigarette use between 2013 and 2014. In addition, the age range for the two samples did not match perfectly. So, we conducted sensitivity tests restricting the NYTS data to 12- to 18-year-olds to match KYRBS

data; this analysis produced estimates of prevalence and significance almost identical to those that obtained for the full NYTS sample. Future research should examine trajectories of e-cigarette use, which may differ for the two countries.

Conclusion

In the context of strong e-cigarette regulation in Korea, e-cigarette use has plateaued or declined among smokers and never smokers. In the context of lax regulation in the United States, e-cigarette use increased rapidly. While combined e-cigarette and cigarette use dropped in Korea, it increased in the United States. Strong, comprehensive e-cigarette regulations should be implemented in a way that will not jeopardize the impacts of tobacco control policies on cigarette use.

Supplementary Material

Supplementary data is available at *Nicotine & Tobacco Research* online.

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Declaration of Interests

None declared.

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