E-cigarettes, Cigarettes, and the Prevalence of Adolescent Tobacco Use

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abstract

BACKGROUND: Adolescent e-cigarette use has increased rapidly in recent years, but it is unclear whether e-cigarettes are merely substituting for cigarettes or whether e-cigarettes are being used by those who would not otherwise have smoked. To understand the role of e-cigarettes in overall tobacco product use, we examine prevalence rates from Southern California adolescents over 2 decades.

METHODS: The Children's Health Study is a longitudinal study of cohorts reaching 12th grade in 1995, 1998, 2001, 2004, and 2014. Cohorts were enrolled from entire classrooms in schools in selected communities and followed prospectively through completion of secondary school. Analyses used data from grades 11 and 12 of each cohort (N = 5490).

RESULTS: Among 12th-grade students, the combined adjusted prevalence of current cigarette or e-cigarette use in 2014 was 13.7%. This was substantially greater than the 9.0% adjusted prevalence of current cigarette use in 2004, before e-cigarettes were available (P = .003) and only slightly less than the 14.7% adjusted prevalence of smoking in 2001 (P = .54). Similar patterns were observed for prevalence rates in 11th grade, for rates of ever use, and among both male and female adolescents and both Hispanic and Non-Hispanic White adolescents.

CONCLUSIONS: Smoking prevalence among Southern California adolescents has declined over 2 decades, but the high prevalence of combined e-cigarette or cigarette use in 2014, compared with historical Southern California smoking prevalence, suggests that e-cigarettes are not merely substituting for cigarettes and indicates that e-cigarette use is occurring in adolescents who would not otherwise have used tobacco products.

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WHAT'S KNOWN ON THIS SUBJECT: E-cigarette use has increased rapidly in recent years among adolescents. It is unknown whether e-cigarettes are merely substituting for cigarettes or whether e-cigarettes are increasing total adolescent tobacco product use via initiation by those who would not otherwise have smoked.

WHAT THIS STUDY ADDS: The high prevalence of combined e-cigarette or cigarette use in 2014, compared with historical Southern California smoking prevalence, suggests that e-cigarette use is occurring in adolescents who would not otherwise have used tobacco products.

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Since the introduction of electronic cigarettes into the US market in 2007,[1] adolescent use has increased rapidly, particularly in the past several years. Data from the National Youth Tobacco Survey (NYTS), a nationally representative cross-sectional survey of adolescents in the United States, show that current (past 30-day) use of e-cigarettes increased exponentially from 1.1% in 2011 to 16.0% in 2015 among high school students.[2–6] While the prevalence of e-cigarette use is increasing, cigarette use is generally declining among adolescents; in the NYTS, current cigarette use among high school students fell from 15.8% in 2011 to 9.2% in 2014,[2,3,5,6] continuing the decline in prevalence of cigarette use among adolescents from its most recent peak in the mid-1990s when the prevalence of current smoking reached 35%.[7] Of note, the prevalence of cigarette smoking did not continue to decline from 2014 (9.2%) to 2015 (9.3%).[6] In 2014, current use of e-cigarettes surpassed current cigarette use for the first time in several national studies (including the NYTS[2] and the Monitoring the Future Study[8]), as well as in a number of local and state-level studies,[9–11] including our study of Southern California adolescents.[12]

There are multiple interpretations of recent trends in e-cigarette and cigarette use among adolescents. Adolescents who otherwise would have smoked may be using e-cigarettes instead of cigarettes. Alternatively, e-cigarettes may be recruiting new users who otherwise would not have initiated cigarette use (or perhaps any other tobacco product) if e-cigarettes were not available. Recent data from the 2015 NYTS found a small, nonsignificant increase in the use of any tobacco product from 2013 to 2015 (from 22.9% to 25.3%).[2,6] The increase in overall tobacco product use appears to be largely driven by increases in e-cigarette and hookah use in 2013 and 2014, and continued increases in e-cigarette use in 2015, along with no decline in cigarette smoking from 2014 to 2015.[2,3] Although these data provide insight into trends over the preceding 3 years, adolescent tobacco use has declined for >20 years.[7] The impact of e-cigarettes on adolescent tobacco use trends that have evolved over longer periods is unknown.

We analyzed data from the Southern California Children's Health Study (CHS), a prospective study of 5 cohorts reaching 12th grade in 1995, 1998, 2001, 2004, and 2014, to describe patterns of smoking among adolescents across these years. On the basis of historical data on smoking initiation over the course of adolescence in these cohorts, we compared the rate of total e-cigarette or cigarette use in 2014 to the rate of cigarette use in 2004 before e-cigarettes were available; we hypothesized that an increase from this benchmark may indicate that e-cigarettes are currently being used by adolescents who would not otherwise have smoked if e-cigarettes were not available.

METHODS

Study Sample

The CHS is a prospective cohort study (1993–present), originally designed to study the effects of childhood air pollution exposure.[13–15] It comprises 5 cohorts of adolescents (Cohorts A–E) who were recruited and followed through 12th grade (Table 1). Recruitment methods and data collection procedures have been described previously.[12–15] Briefly, participants were enrolled from entire classrooms in schools in selected communities in Southern California[12,14] in 10th grade (Cohort A, 1993), seventh grade (Cohort B, 1993), fourth grade (Cohort C, 1993 and Cohort D, 1996), kindergarten (Cohort E1, 2003), or first grade (Cohort E2, 2003). The current analysis uses available data from grades 11 and 12 of each cohort from participants who answered questions about tobacco product use (N = 5490; 11th grade: mean age [SD] = 16.9 [0.4]; 12th grade: mean age [SD] = 17.9 [0.4]. In Cohorts A through D, history of cigarette use was collected by in-person interview every year at schools as they were followed over time.[15,16] Among participants in Cohorts A through D with data available from 11th or 12th grade, 85.7% of the sample provided information on smoking history in both 11th and 12th grades and therefore contributed to prevalence estimates in both years; 10.6% contributed to 11th grade analyses only and 3.7% contributed to 12th grade analyses only. In Cohorts E1 and E2, who were separated by 1 grade, smoking history was collected every other year, so both 11th- and 12th-grade subjects were included in the 2014 survey. In 2014, smoking history in Cohorts E1 and E2 was collected by self-administered questionnaires under study staff supervision. Cohort A through D subjects were all recruited from the same 12 communities; Cohorts E1 and E2 were recruited from 13 communities, of which 12 participated in the 2014 data collection and 8 were the same as Cohorts A through D.

Ethics Statement

The study was approved by the University of Southern California Institutional Review Board. Written informed consent was obtained before data collection.

Cigarette and E-Cigarette Use

In all CHS cohorts, participants were asked the number of cigarettes or packs of cigarettes that they had smoked in the past 24 hours, past week, past month, past year, and in their lifetime. In each year, participants were classified as current users if they reported smoking ≥1 cigarettes in the past

TABLE 1 Grade of Adolescents Included in Each Cohort in Each Year of the CHS, 1994–2014

Cohort	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2012	2014
A	11[a]	12[a]	—	—	—	—	—	—	—	—	—	—	—
B	8	9	10	11[a]	12[a]	—	—	—	—	—	—	—	—
C	5	6	7	8	9	10	11[a]	12[a]	—	—	—	—	—
D	—	—	4	5	6	7	8	9	10	11[a]	12[a]	—	—
E1	—	—	—	—	—	—	—	—	—	K	1	9	11[a]
E2	—	—	—	—	—	—	—	—	—	1	2	10	12[a]

—, no data collected.
[a] Data included in analysis

24 hours, past week, or past month; participants were classified as ever users if they reported either (1) use in the past year or in their lifetime or (2) listed an age at which they had first smoked. This classification was used for all prevalence estimates of cigarette use alone, across all cohorts.

In 2014, smoking history was assessed in Cohort E participants (in grades 11 and 12) using the same question as in Cohorts A through D, along with 2 additional questions that asked about the age at which each participant had first used a cigarette ("even 1 or 2 puffs") and the number of days smoked in the past 30 days. In addition, use of e-cigarettes was assessed for the first time using the new questions. Adolescents who had used cigarettes or e-cigarettes on at least 1 of the past 30 days were classified as "current users" of that product. "Ever users" were adolescents who reported having ever tried a product. Analyses evaluating combined product use of cigarettes or e-cigarettes in Cohorts E1 and E2 were based on responses to the new questions. The prevalence rates both for current and ever cigarette use were quite similar using either set of questions, differing by 0.1% for current use and 1.6% for prevalence of ever smoking, and the results of analyses were not substantively different using either set of questions. Therefore, in Cohort E we used the prevalence rates derived from the new questions about cigarette use, which we have reported previously[12] and which were common to those used to assess e-cigarette prevalence rates.

Statistical Analysis

Prevalence estimates for ever and current cigarette use were calculated by cohort and grade, using the questionnaire items assessed across all cohorts. In Cohort E (in 2014), we calculated the combined prevalence of cigarette or e-cigarette use (ever or current), which included adolescents who reported use of either product or dual use of both products. Logistic regression models were used to estimate smoking prevalence for each cohort by grade, with adjustment for self-reported sex, ethnicity (Hispanic, non-Hispanic white, or other), and parental education (less than high school education, high school graduate, some college, college degree, some graduate school or higher, unknown/missing). Adjusted models were used to account for the different distribution across cohorts of socioeconomic factors known to be associated with cigarette use. These models were applied separately to current smoking and ever smoking. The distributions of sex, ethnicity, and parental education in Cohort E were used as the reference for calculating the adjusted prevalence estimates from the logistic model. Logistic regression models were also used to evaluate trends in the prevalence of cigarette use (ever or current) over calendar time, by including year of data collection as a continuous predictor variable in separate analyses by grade. Logistic regression models with an interaction term were used to evaluate whether the pattern of cigarette use across cohorts varied by ethnicity or sex. In analyses to assess the sensitivity of results to the participation of different Southern California communities in different cohorts, we additionally restricted analyses to the 8 communities common to all years of all cohorts and adjusted for community. The Statistical Analysis System (SAS, version 9.4) was used for analyses, and figures were created using Stata, version 13.1. All hypothesis testing was conducted assuming a .05 significance level.

RESULTS

Demographic characteristics for each cohort are shown in Table 2. The earlier cohorts (A–D) included a

TABLE 2 Demographic Characteristics of Participants Enrolled in the CHS, by Cohort, 1994–2014, $N = 5490$

	Cohort A[a]	Cohort B[a]	Cohort C[a]	Cohort D[a]	Cohort E1[b]	Cohort E2[b]
	N (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)	*N* (%)
Total (*N* = 5490)	759	615	1076	985	1159	896
Grade[c,d,e]						
11	713	565	1016	916	1159	—
12	627	520	880	774	—	896
Sex						
Male	402 (53.0)	328 (53.3)	570 (53.0)	520 (52.8)	555 (47.9)	468 (52.2)
Female	357 (47.0)	287 (46.7)	506 (47.0)	465 (47.2)	604 (52.1)	428 (47.8)
Race/ethnicity[d]						
Hispanic White	193 (25.4)	143 (23.3)	297 (27.6)	290 (29.4)	612 (52.8)	443 (49.4)
Non-Hispanic White	436 (57.4)	362 (58.9)	625 (58.1)	530 (53.8)	384 (33.1)	346 (38.6)
Other	130 (17.1)	110 (17.9)	154 (14.3)	165 (16.8)	163 (14.1)	107 (11.9)
Highest parental education[d,f]						
<12th grade	111 (15.2)	70 (11.8)	130 (12.5)	89 (9.5)	228 (21.2)	154 (18.6)
12th grade	157 (21.5)	122 (20.6)	189 (18.2)	172 (18.3)	177 (16.5)	127 (15.4)
Some college	288 (39.5)	249 (42.1)	451 (43.5)	447 (47.6)	393 (36.6)	318 (38.5)
College degree	93 (12.7)	55 (9.3)	115 (11.1)	114 (12.1)	137 (12.8)	118 (14.3)
Some graduate school	81 (11.1)	95 (16.1)	151 (14.6)	117 (12.5)	139 (12.9)	110 (13.3)

—, no data collected.

[a] Cohort A–D communities: Alpine, Lake Elsinore, Lake Gregory, Lancaster, Lompoc, Long Beach, Mira Loma, Riverside, San Dimas, Atascadero, Santa Maria, and Upland.

[b] Cohort E communities: Alpine, Lake Elsinore, Lake Gregory, Mira Loma, Riverside, San Dimas, Santa Maria, Upland, Glendora, Anaheim, San Bernadino, and Santa Barbara.

[c] Some participants contributed to both grades 11 and 12 for Cohorts A–D.

[d] $P < .05$ for test of difference across cohorts.

[e] Years in grade 11–12: Cohort A, 1994–1995; Cohort B, 1997–1998; Cohort C, 2000–2001; Cohort D, 2003–2004; Cohort E1, 11th: 2014; Cohort E2, 12th: 2014.

[f] Frequencies do not add to total because of missing values.

greater proportion of non-Hispanic white adolescents (54%–59%), whereas Cohorts E1 and E2 included more Hispanic adolescents (49%–53%). The distributions of the highest level of parental education differed among the cohorts.

The adjusted prevalence of current smoking among high school students decreased over time from 1995 to 2014 in both 11th and 12th grades ($P_{trend} < .0001$; Fig 1 A and B). Among 12th-grade students in Cohort A (1995), the adjusted prevalence of current smoking was 19.1%; prevalence of use decreased to 17.1% in Cohort B (1998), 14.7% in Cohort C (2001), 9.0% in Cohort D (2004), and 7.8% in Cohort E (2014). Although the prevalence of current cigarette use was lowest among students in both grades in 2014, the combined prevalence of current cigarette and/or e-cigarette use was similar to or greater than that for cigarette use alone 10 to 15 years ago, before e-cigarettes were available (Fig 1 A and B). For example, among 12th-grade students, the adjusted prevalence of combined use of either product in 2014 was 13.7% (3.8% dual users of cigarettes and e-cigarettes, 3.9% cigarette only users, and 6.0% e-cigarette only users), which was similar to the 14.7% prevalence of cigarette use in 2001 ($P = .54$), and nearly 5 percentage points higher than the adjusted prevalence of current cigarette use in 2004 (9.0%; $P = .003$).

The prevalence of ever cigarette use followed similar patterns of an overall decrease over time across Cohort A (1994–1995) to Cohort E (2014) for both 11th- and 12th-grade students ($P_{trend} < .0001$; Fig 1 C and D). However, the 11th- and 12th-grade prevalence rates for ever cigarette use in 2014 were not statistically significantly lower than the prevalence in Cohort D 10 years earlier in 2003–2004 ($P = .59$, 0.56, respectively). The prevalence of

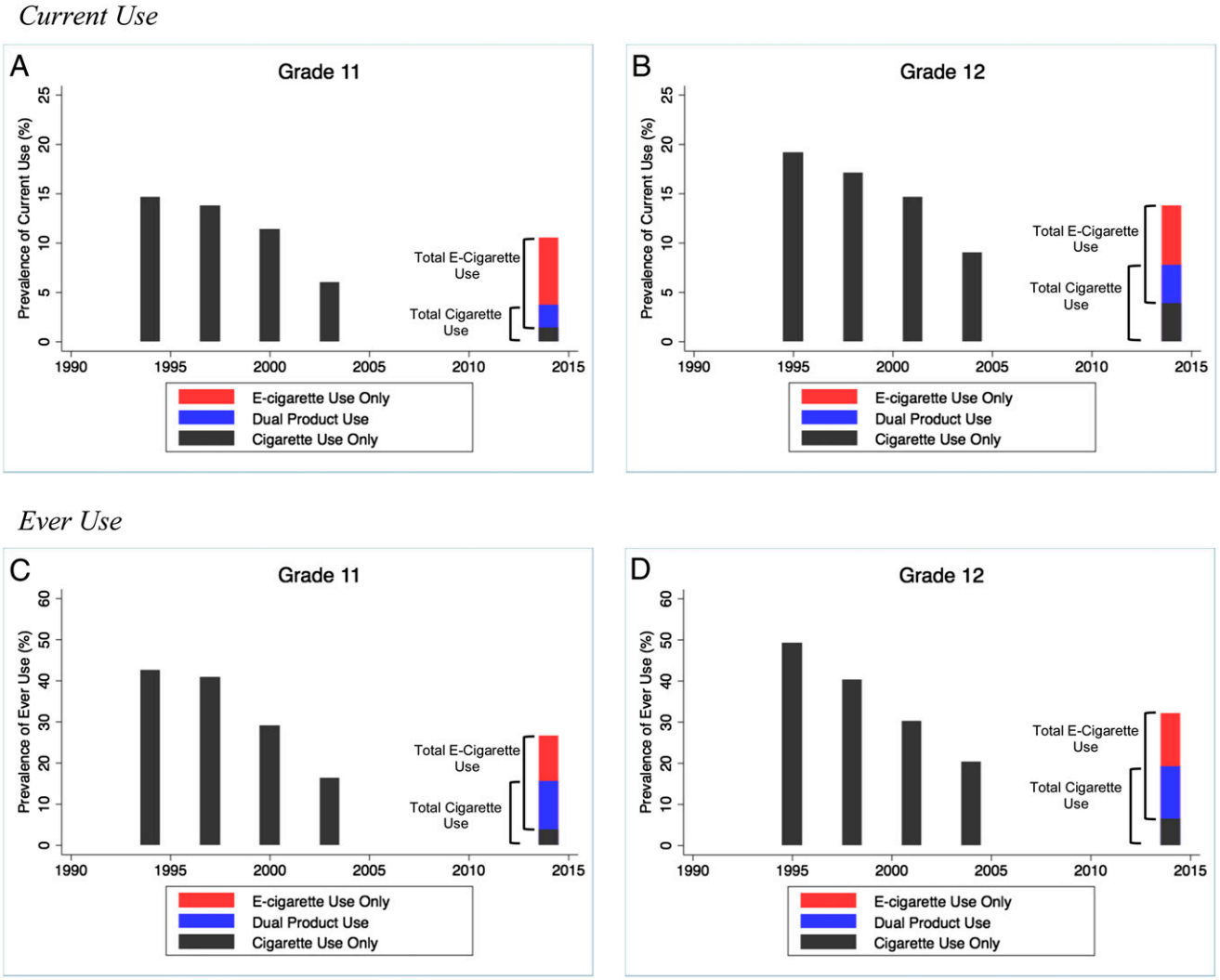

FIGURE 1

Adjusted prevalence estimates among adolescents in the CHS by cohort for current cigarette use (all cohorts), and current cigarette or e-cigarette use (Cohort E) in (A) grade 11 and (B) grade 12 and for ever cigarette use (all cohorts) and ever cigarette or e-cigarette use (Cohort E) in (C) grade 11 and (D) grade 12, 1994–2014.

combined ever use of cigarettes or e-cigarettes also surpassed rates of ever cigarette use more than a decade ago. Among 12th-grade students, the adjusted prevalence of ever use of either cigarettes or e-cigarettes in 2014 was 32.1%, substantially higher than the adjusted prevalence of ever cigarette use in 2004 (20.4%; $P < .0001$), and slightly higher than the adjusted prevalence in 2001 (30.2%; $P = .41$).

Among both male and female adolescents, the prevalence of cigarette or e-cigarette use (ever or current) in both 11th and 12th grades in 2014 was higher than the prevalence of smoking in 2003–2004 and was generally similar to the prevalence of smoking in 2000–2001 (Fig 2 A–D). There was no difference between sexes in these patterns of decline in smoking over time (interaction $P > .05$). The prevalence of current and ever use of cigarettes within cohorts was higher among male than among female adolescents, with more pronounced differences observed among 12th-grade students; combined rates of e-cigarette or cigarette use in 2014 were also larger in male than female adolescents.

The prevalence of current and ever smoking also decreased over time from 1994 to 2014 among both non-Hispanic white adolescents and Hispanic adolescents ($P < .0001$; Fig 3 A–D; interaction P for ethnicity >.05). In both ethnic groups, the combined prevalence of current cigarette or e-cigarette use in 2014 exceeded the rate of current cigarette use in 2003 (11th grade) or 2004 (12th grade). For example, among non-Hispanic white 12th-grade students, the combined rate of current cigarette or e-cigarette use in 2014 in Cohort E was identical to the rate of smoking in 2001 (17.2%;

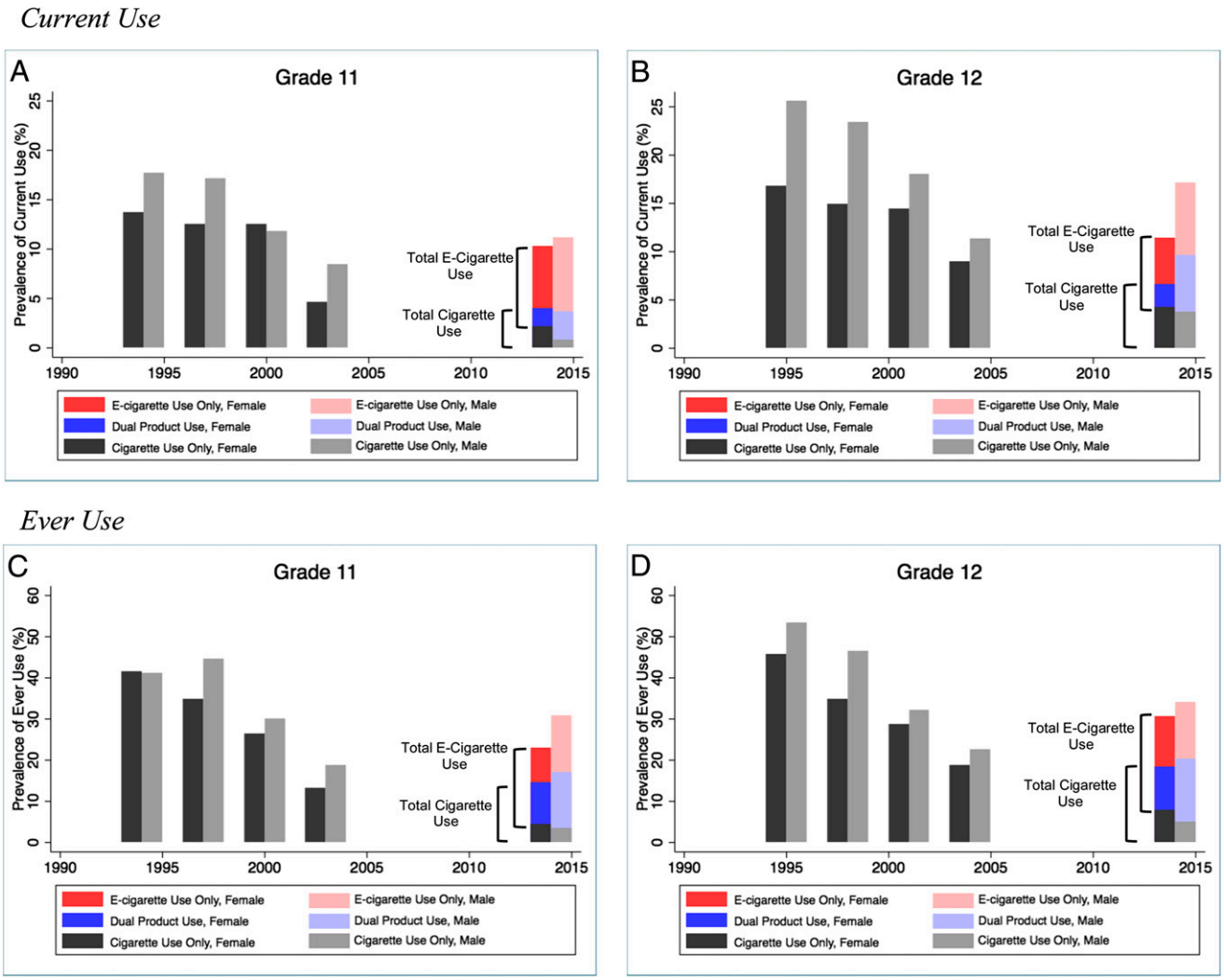

FIGURE 2

Prevalence estimates among adolescents in the CHS by cohort and sex for current cigarette use (all cohorts) and current cigarette or e-cigarette use (Cohort E) in (A) grade 11 and (B) grade 12 and for ever cigarette use (all cohorts) and ever cigarette or e-cigarette use (Cohort E) in (C) grade 11 and (D) grade 12, 1994–2014.

5.0% dual use, 4.4% cigarette only use, 7.8% e-cigarette only use); the rate of combined use among Hispanic white adolescents in 2014 (12.0%; 2.9% dual use, 5.0% cigarette only use, 4.1% e-cigarette only use) was >3 percentage points higher than the rate of smoking in 2004 (8.8%) and only slightly less than the rate of smoking in 2001 (13.8%). Similar patterns were observed for ever use in both ethnicities; the combined rate of cigarette or e-cigarette use in 2014 in 11th- and 12th-grade students was higher than the rates of smoking 10 years earlier in both ethnic groups. We did observe differences in rates of smoking within cohorts between Hispanic and non-Hispanic white study participants. Current smoking prevalence was consistently higher among non-Hispanic white adolescents than among Hispanic white adolescents (Fig 3 A and B), but ever use was generally similar or modestly higher among Hispanic white adolescents than among non-Hispanic white adolescents (Fig 3 C and D). In 2014 the combined prevalence of e-cigarette or cigarette use (both current and ever) was greater in Hispanic whites than non-Hispanic whites in 11th grade, which appears to result from higher prevalence of cigarette only use (dual and e-cigarette only use was similar across both groups). In 12th grade, the combined prevalence of e-cigarette or cigarette use was greater in non-Hispanic whites than Hispanic white youth, largely resulting from greater levels of e-cigarette and dual product use.

In analyses restricted to the 8 communities with data available across all cohorts, trends in prevalence across cohorts and across grades within cohorts, as well as the ethnic- and sex-specific patterns, were similar to those observed in the entire sample (data not shown).

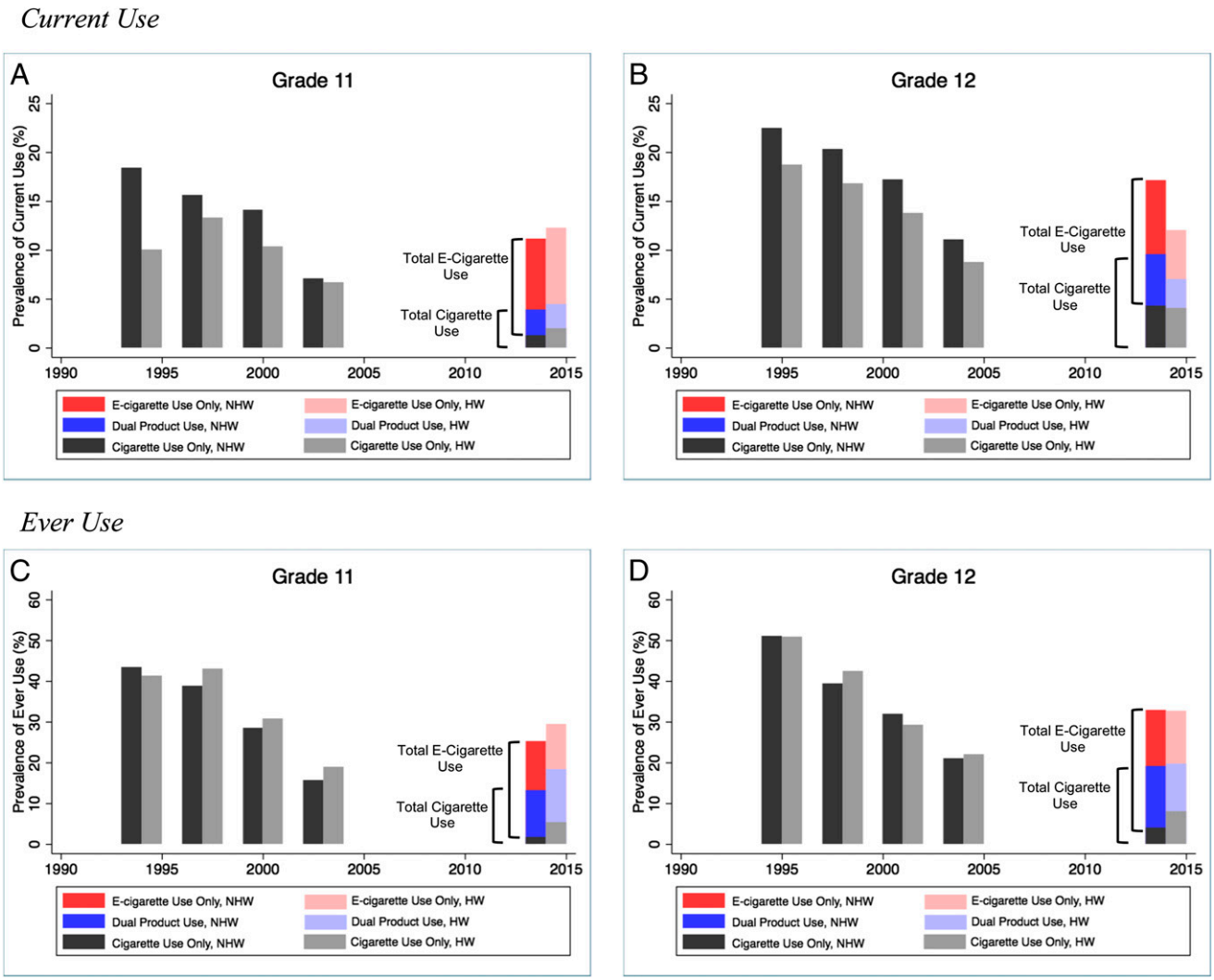

FIGURE 3

Prevalence estimates among adolescents in the CHS by cohort and by ethnicity for current cigarette use (all cohorts), and current cigarette or e-cigarette use (Cohort E) in (A) grade 11 and (B) grade 12 and for ever cigarette use (all cohorts) and ever cigarette or e-cigarette use (Cohort E) in (C) grade 11 and (D) grade 12, 1994–2014. HW, Hispanic white; NHW, non-Hispanic white.

DISCUSSION

These Southern California communities have experienced a marked decrease in adolescent cigarette use over the past 2 decades. However, among both 11th- and 12th-grade students, the combined prevalence of current cigarette or e-cigarette use in 2014 was substantially greater than the prevalence of smoking in 2004 (among 12th graders, eg, 13.7% and 9.0%, respectively) and was almost as high as the prevalence of smoking in 2001 (14.7% for 12th graders).

This substantially increased combined prevalence of cigarette smoking or e-cigarette use in 2014, compared with smoking rates a decade earlier, when e-cigarettes were not available, suggests that e-cigarettes are not used only by adolescents who would otherwise be smoking cigarettes. If, for example, the current rates of smoking would not have changed from 2004 to 2014 in the absence of e-cigarettes, then 1.2% of adolescents in Southern California, the difference between the 7.8% adjusted prevalence of cigarette use in 2014 and 9.0% in 2004, may be substituting e-cigarettes for cigarettes. An additional 4.7% of e-cigarette users, the difference between the 13.7% combined prevalence of e-cigarette or cigarette use in 2014 and the 9.0% prevalence of cigarette use in 2004 likely would not have used cigarettes if e-cigarettes were not available, under the assumption that the rate of smoking from 2004 to 2014 would not have changed. The assumption that smoking rates would not have decreased in the absence of e-cigarettes likely makes this estimate of the proportion of

e-cigarette users who would not otherwise have used cigarettes conservative.

The general prevalence patterns and the findings compared with the 2004 data were similar among Hispanic and non-Hispanic white participants and in male and female participants; thus, tobacco control interventions geared toward youth are equally needed for youth of both sexes and ethnicities. The prevalence of cigarette use or combined use (Cohort E only) did differ by gender and ethnicity within each cohort. Hispanic adolescents were less likely to report cigarette use in each cohort among both 11th- and 12th-grade students but as likely to report ever use, a pattern consistent with historically reported ethnic comparisons.[3,7,17,18] Male respondents were generally more likely to report use of cigarettes, e-cigarettes, or combined use of cigarettes or e-cigarettes, which is also consistent with previous literature.[2,7,12,19]

A major strength of this study is the use of >20 years of data collected across 5 cohorts drawn from the same CHS communities to assess patterns of change in cigarette use in Southern California. Because all results were adjusted for the Cohort E distribution of race/ethnicity, sex, and parental education, it is unlikely that differences across cohorts were influenced by changes in sociodemographic characteristics of the population over time. The study is also subject to some limitations. Data on use of tobacco products other than cigarettes were not collected from earlier cohorts. Thus, the contribution of hookah, cigar/cigarillo, pipe, or smokeless tobacco use to the prevalence of all tobacco product use in earlier cohorts is not known. Data from the NYTS have shown relatively stable prevalence of use of cigars and smokeless tobacco from 2000 to 2012,[20] followed by a decrease in cigar and pipe use and in smokeless tobacco use from 2011 to 2014.[2] Although national results may not be generalizable to Southern California (and vice versa), we cannot exclude the possibility that e-cigarette use is substituting for these combustible tobacco products. No data are available on trends in hookah use across the periods of interest in this study, but prevalence of hookah use increased in the NYTS from 2011 to 2014,[2] so it seems unlikely that the increase in prevalence of e-cigarette use during this period reflects substitution of e-cigarettes for hookah use among participants who otherwise would have smoked hookah use in previous cohorts. Analyses were restricted to Hispanic youth (historically an underrepresented population in tobacco regulatory science research) and non-Hispanic white youth, who comprise the majority of the Southern California population; the prevalence estimates were imprecise in other racial/ethnic groups in our study, which made up <20% of the sample. Additional research is needed to determine whether similar patterns of product use over time occurred in other racial groups and in other geographic regions.

E-cigarettes have gained popularity in recent years, in part because of availability in a wide variety of flavorings[21] that may be appealing to adolescents and young adults,[22] the perception that e-cigarettes are less harmful than smoking,[23] absence or poor enforcement of regulations on indoor use,[24] and the recent popularity of product-specific venues that encourage use of these products in social situations, such as vape shops.[25] Such characteristics of e-cigarettes may be recruiting new users who are deterred from initiating cigarettes because of concerns about the health hazards of smoking and social stigmatization of cigarette use.[7] There is concern that the increasing prevalence of e-cigarette use could even lead to initiation of smoking among previously nonsmoking adolescent e-cigarette users in what has been described as a "gateway effect," either as a result of social normalization of alternative product use and smoking behaviors more generally, leading to renormalization of smoking or by directly increasing use of cigarettes through establishment of reward seeking behaviors (eg, nicotine dependence).[26–30] Although our results demonstrated a decline in cigarette use in the past decade, we also have observed a markedly increased likelihood of intention to use cigarettes[31] among e-cigarette users in the CHS in 2014 who had never smoked, results which are consistent with 2 recent studies examining the association of e-cigarette use with susceptibility to smoking,[28,30] and recent longitudinal studies that have found that never-smoking e-cigarette users were more likely to report use of cigarettes a year later than never e-cigarette users.[32–34]

The use of e-cigarettes by nonsmoking adolescents poses several potential public health problems. First, use of e-cigarettes containing nicotine may directly contribute to nicotine dependence in late adolescence or early adulthood, putting adolescents at risk for lifelong nicotine dependence.[35,36] Use of e-cigarettes, even without nicotine, may normalize tobacco product use behaviors more generally, which could then lead to increased rates of addiction via use of other nicotine-containing products, including cigarettes and other harmful combustible tobacco products.[35–37] Second, in addition to lifelong problems associated with nicotine dependence, exposure to nicotine in adolescence adversely affects cognitive function and development.[19] There is also evidence that e-cigarettes may generate aldehydes and other toxic chemicals and that flavoring additives

may induce adverse respiratory health effects in e-cigarette users.[38] Although the adverse health effects of e-cigarettes may be less than those of cigarettes, the long-term consequences of e-cigarette use are not known because these products have been on the market for less than a decade.

CONCLUSIONS

Longitudinal data on emerging adolescent tobacco and alternative tobacco product use, including detailed information on topography of e-cigarette use and dose of nicotine, are needed to understand the role of e-cigarettes in nicotine addiction and whether e-cigarette users who have not used combustible cigarettes will, in the future, continue using e-cigarettes only, quit using tobacco products altogether, or progress to combustible cigarette users or dual users of both products. However, the high combined prevalence of e-cigarette use or cigarette use in 2014, compared with historical Southern California smoking prevalence, suggests that adolescents are not merely substituting e-cigarettes for cigarettes but that e-cigarettes are instead recruiting a new group of users who would not likely have initiated combustible tobacco product use in the absence of e-cigarettes, which poses a potential threat to the public health of adolescent populations.

ABBREVIATIONS

CHS: Southern California Children's Health Study
NYTS: National Youth Tobacco Survey

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REFERENCES

1. Grana R, Benowitz N, Glantz SA. E-cigarettes: a scientific review. *Circulation*. 2014;129(19):1972–1986
2. Arrazola RA, Singh T, Corey CG, et al; Centers for Disease Control and Prevention (CDC). Tobacco use among middle and high school students—United States, 2011–2014. *MMWR Morb Mortal Wkly Rep*. 2015;64(14):381–385
3. Arrazola RA, Neff LJ, Kennedy SM, Holder-Hayes E, Jones CD; Centers for Disease Control and Prevention (CDC). Tobacco use among middle and high school students—United States, 2013. *MMWR Morb Mortal Wkly Rep*. 2014;63(45):1021–1026
4. Centers for Disease Control and Prevention (CDC). Notes from the field: electronic cigarette use among middle and high school students—United States, 2011–2012. *MMWR Morb Mortal Wkly Rep*. 2013;62(35):729–730
5. Centers for Disease Control and Prevention (CDC). Tobacco product use among middle and high school students—United States, 2011 and 2012. *MMWR Morb Mortal Wkly Rep*. 2013;62(45):893–897
6. Singh T, Arrazola RA, Corey CG, et al. Tobacco Use Among Middle and High School Students - United States, 2011-2015. *MMWR Morb Mortal Wkly Rep*. 2016;65(14):361–367
7. *Preventing Tobacco Use Among Youth and Young Adults: A Report of the Surgeon General*. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2012
8. Johnston LD, O'Malley PM, Miech RA, Bachman JG, Schulenberg JE. *Monitoring the Future National Survey Results on Drug Use 1975–2014: Overview: Key Findings on Adolescent Drug Use*. Ann Arbor, MI: Institute for Social Research, The University of Michigan; 2015
9. Krishnan-Sarin S, Morean ME, Camenga DR, Cavallo DA, Kong G. E-cigarette use among high school and middle school adolescents in Connecticut. *Nicotine Tob Res*. 2015;17(7):810–818
10. Wills TA, Knight R, Williams RJ, Pagano I, Sargent JD. Risk factors for exclusive e-cigarette use and dual e-cigarette use and tobacco use in adolescents. *Pediatrics*. 2015;135(1). Available at: www.pediatrics.org/cgi/content/full/135/1/e43
11. *State Health Officer's Report on E-Cigarettes: A Community Health Threat*. Sacramento, CA: California Department of Public Health, California Tobacco Control Program; 2015
12. Barrington-Trimis JL, Berhane K, Unger JB, et al. Psychosocial factors associated with adolescent electronic cigarette and cigarette use. *Pediatrics*. 2015;136(2):308–317
13. Peters JM, Avol E, Navidi W, et al. A study of twelve Southern California communities with differing levels and types of air pollution. I. Prevalence of respiratory morbidity. *Am J Respir Crit Care Med*. 1999;159(3):760–767

14. McConnell R, Berhane K, Yao L, et al. Traffic, susceptibility, and childhood asthma. *Environ Health Perspect*. 2006;114(5):766–772

15. Gauderman WJ, Gilliland GF, Vora H, et al. Association between air pollution and lung function growth in southern California children: results from a second cohort. *Am J Respir Crit Care Med*. 2002;166(1):76–84

16. Gauderman WJ, Avol E, Gilliland F, et al. The effect of air pollution on lung development from 10 to 18 years of age. *N Engl J Med*. 2004;351(11):1057–1067

17. Kann L, Kinchen S, Shanklin SL, et al; Centers for Disease Control and Prevention (CDC). Youth risk behavior surveillance—United States, 2013. *MMWR Suppl*. 2014;63(4):1–168

18. Centers for Disease Control and Prevention (CDC). Cigarette use among high school students—United States, 1991–2009. *MMWR Morb Mortal Wkly Rep*. 2010;59(26):797–801

19. *The Health Consequences of Smoking—50 Years of Progress. A Report of the Surgeon General*. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health; 2014

20. Arrazola RA, Kuiper NM, Dube SR. Patterns of current use of tobacco products among U.S. high school students for 2000–2012—findings from the National Youth Tobacco Survey. *J Adolesc Health*. 2014;54(1): 54–60.e9

21. Zhu SH, Sun JY, Bonnevie E, et al. Four hundred and sixty brands of e-cigarettes and counting: implications for product regulation. *Tob Control*. 2014;23(suppl 3):iii3–iii9

22. Kong G, Morean ME, Cavallo DA, Camenga DR, Krishnan-Sarin S. Reasons for electronic cigarette experimentation and discontinuation among adolescents and young adults. *Nicotine Tob Res*. 2015;17(7):847–854

23. Latimer LA, Batanova M, Loukas A. Prevalence and harm perceptions of various tobacco products among college students. *Nicotine Tob Res*. 2014;16(5):519–526

24. American Nonsmokers' Rights Foundation. States and municipalities with laws regulating use of electronic cigarettes. Available at: www.no-smoke.org/pdf/ecigslaws.pdf. Accessed October 1, 2015

25. Lee YO, Kim AE. "Vape shops" and "E-cigarette lounges" open across the USA to promote ENDS. *Tob Control*. 2015;24(4):410–412

26. Stanwick R. E-cigarettes: Are we renormalizing public smoking? Reversing five decades of tobacco control and revitalizing nicotine dependency in children and youth in Canada. *Paediatr Child Health*. 2015;20(2):101–105

27. Moore GF, Littlecott HJ, Moore L, Ahmed N, Holliday J. E-cigarette use and intentions to smoke among 10-11-year-old never-smokers in Wales. *Tob Control*. 2016;25:147–152

28. Bunnell RE, Agaku IT, Arrazola RA, et al. Intentions to smoke cigarettes among never-smoking U.S. middle and high school electronic cigarette users, National Youth Tobacco Survey, 2011–2013. *Nicotine Tob Res*. 2015;17(2):228–235

29. Coleman BN, Apelberg BJ, Ambrose BK, et al. Association between electronic cigarette use and openness to cigarette smoking among US young adults. *Nicotine Tob Res*. 2015;17(2):212–218

30. Wills TA, Sargent JD, Knight R, Pagano I, Gibbons FX. E-cigarette use and willingness to smoke: a sample of adolescent non-smokers. *Tob Control*. 2016;25(E1):e52–e59

31. Barrington-Trimis J, Berhane K, Unger J, et al. The e-cigarette psychosocial environment, e-cigarette use, and susceptibility to cigarette smoking [published online ahead of print May 6, 2016]. *J Adolesc Health*

32. Leventhal AM, Strong DR, Kirkpatrick MG, et al. Association of electronic cigarette use with initiation of combustible tobacco product smoking in early adolescence. *JAMA*. 2015;314(7):700–707

33. Primack BA, Soneji S, Stoolmiller M, Fine MJ, Sargent JD. Progression to traditional cigarette smoking after electronic cigarette use among US adolescents and young adults. *JAMA Pediatr*. 2015;169(11):1018–1023

34. Wills TA, Knight R, Sargent JD, Gibbons FX, Pagano I, Williams RJ. Longitudinal study of e-cigarette use and onset of cigarette smoking among high school students in Hawaii [published online ahead of print January 25, 2016]. *Tob Control*. 10.1136/tobaccocontrol-2015-052705

35. Kandel DB, Kandel ER. A molecular basis for nicotine as a gateway drug. *N Engl J Med*. 2014;371(21):2038–2039

36. Bell K, Keane H. All gates lead to smoking: the "gateway theory," e-cigarettes and the remaking of nicotine. *Soc Sci Med*. 2014;119:45–52

37. Schneider S, Diehl K. Vaping as a catalyst for smoking? An initial model on the initiation of electronic cigarette use and the transition to tobacco smoking among adolescents. *Nicotine Tob Res*. 2015

38. Barrington-Trimis JL, Samet JM, McConnell R. Flavorings in electronic cigarettes: an unrecognized respiratory health hazard? *JAMA*. 2014;312(23):2493–2494

The Truth About
Menthol Cigarettes

Menthol is a flavoring that can be derived naturally from mint plants or synthetically produced.[1] This cool, minty and fresh flavor is often used in products like lip balm, cough medicine, mouth wash, and candy.[2] Menthol is also used in cigarettes and **makes smoking more appealing to young and beginning smokers**.[1]

A Public Health Threat

Easier to Inhale

The menthol flavor in cigarettes **masks the harsh taste of tobacco** and makes the smoke feel smoother and easier to inhale.[1]

This **makes it easier for new smokers to start**.[1]

Menthol also allows smokers to inhale more deeply, which causes harmful particles to settle **deeper inside the lungs**.[2]

Harder to Quit

Scientific studies show that the sensory effects and flavor of menthol can **make cigarettes more addictive**.[3]

Menthol smokers show greater signs of nicotine dependence and are **less likely to successfully quit smoking** than other smokers.[4,5]

Increasing Menthol Use

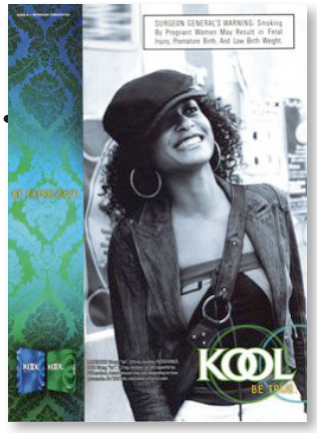
Although cigarette use is declining in the U.S., use of menthol cigarettes has increased in recent years, especially among young people and new smokers.[6]

Approximately **19 million** Americans smoke menthol cigarettes, including over 1 million adolescents.[6]

While only 25% of all cigarettes sold in the U.S. are labeled as menthol, **90%** of all tobacco cigarettes actually contain some menthol.[7,8]

Disproportionate Marketing and Use

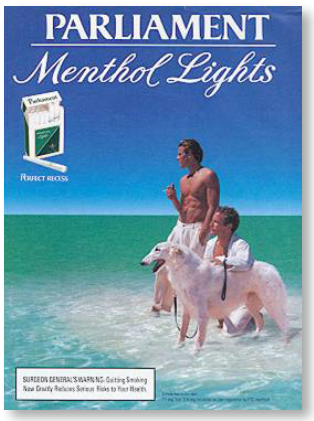
African American Communities



Tobacco industry documents reveal **aggressive menthol tobacco product marketing** and higher rates of discounts and promotions on menthol cigarette brands in African American neighborhoods.[9]

In California, **70%** of African American adult cigarette smokers smoke menthol cigarettes, compared to only 18% of white adult cigarette smokers.[10]

LGB Communities



The tobacco industry has also targeted the lesbian, gay and bisexual (LGB) community.

Nearly 50% of all LGB adult cigarette smokers in California smoke menthol cigarettes, compared to only 28% of straight adult cigarette smokers.[10]

Youth

57% of smokers in the U.S. age 12–17 smoke menthol cigarettes.[11]

Protecting our Communities

A National study found that **44.5%** of African Americans and **44%** of women would quit smoking if menthol cigarettes were banned.[12]

Prohibiting the sale of menthol cigarettes is a critical step to preventing a new generation of Californians from becoming addicted to tobacco.

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California Department of
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References

1. Kreslake, J.M., et al., *Tobacco industry control of menthol in cigarettes and targeting of adolescents and young adults.* American Journal of Public Health, 2008. 98(9): p. 1685.
2. Kreslake, J.M. and V.B. Yerger, *Tobacco industry knowledge of the role of menthol in chemosensory perception of tobacco smoke.* Nicotine & Tobacco Research, 2010. 12: p. 98-101.
3. Henningfield, J.E., et al., *Does menthol enhance the addictiveness of cigarettes? An agenda for research.* Nicotine & Tobacco Research, 2003.
4. Levy, D.T., et al., *Quit attempts and quit rates among menthol and nonmenthol smokers in the United States.* 2011.
5. U.S. Food and Drug Administration, *Preliminary scientific evaluation of the possible public health effects of menthol versus nonmenthol cigarettes.* July 2013.
6. Substance Abuse and Mental Health Services Administration, *The NSDU Report: Use of Menthol Cigarettes.* 2009: Rockville, MD.
7. Giovino, G.A., et al., *Epidemiology of menthol cigarette use.* Nicotine & Tobacco Research, 2004. 6: p. 67-81.
8. Wickham, R., Focus: Addiction: *How Menthol Alters Tobacco- Smoking Behavior: A Biological Perspective.* The Yale Journal of Biology and Medicine, 2015. 88(3): p. 279.
9. Cruz, T.B., L.T. Wright, and G. Crawford, *The menthol marketing mix: targeted promotions for focus communities in the United States.* Nicotine & Tobacco Research, 2010. 12(suppl 2): p. S147-S153.
10. *Behavioral Risk Factor Surveillance System 2013-2015.* Sacramento, CA: California Department of Public Health.
11. Giovino, G.A., et al., *Differential trends in cigarette smoking in the USA: is menthol slowing progress?* Tobacco Control, 2013.
12. Tobacco Control Legal Consortium et al., *Citizen Petition to Food and Drug Administration, Prohibiting Menthol As A Characterizing Flavor in Cigarettes* (April 12, 2013).

The Truth About Flavored Tobacco

The use of flavored tobacco products such as cigars, cigarillos, smokeless tobacco, hookah tobacco, and e-liquids (used in e-cigarettes) has increased in recent years.[1] These products use **enticing flavors, colorful packaging and lower prices** to hook a new generation of tobacco users.

A Public Health Threat

Enticing Fruit and Candy Flavors

Sweet flavors like watermelon, cherry, chocolate, mint, and gummy bear **appeal to kids and teens.**[2]

Flavorings **mask the harsh taste of tobacco** which make it easier for youth to initiate tobacco use.[2]

Marketed to Young People

Flavored tobacco products often use the same flavoring chemicals as **popular brands** like Jolly Rancher, Kool-Aid, and Life Savers.[3]

Little cigars are often sold in small packages for **less than a dollar** and promoted as a low-cost alternative to cigarettes.[4,5]

Colorful packaging and placement near the register makes them highly visible and attractive to kids.[4]

Growing Teen Use

A majority of youth report flavoring as a leading reason for using tobacco products.[6] This includes:

- **82%** of e-cigarette users
- **79%** of hookah users
- **74%** of cigar users
- **69%** of smokeless users

80% of young people who have ever used tobacco **started with a flavored tobacco product.**[6]

Consequences for Our Youth

Long term addiction

The U.S. Surgeon General has warned that flavored tobacco products help new users establish habits that can **lead to long-term addiction.**[7]

Flavors like menthol in tobacco products make it **harder for users to quit.**[8]

Smokers who start at a younger age, are more likely to develop a **severe nicotine addiction.**[7]

Serious health risks

All nicotine products are addictive and increase the risk of developing **serious health problems.**[9]

The chemical Diacetyl, found in 75% of flavored e-liquids, is linked to bronchiolitis obliterans ("popcorn lung") which causes **irreversible lung damage.**[10,11]

Protecting Our Communities

The FDA has banned the sale of flavored cigarettes (other than menthol) because they appeal to youth. But flavored e-cigarettes, e-liquid, cigars, hookah, and chewing tobacco continue to be sold.

Prohibiting the sale of all flavored tobacco products is a critical step to preventing another generation of young people from living with a lifetime of addiction.

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References

1. Corey, C.G., et al., *Flavored tobacco product use among middle and high school students—United States, 2014.* MMWR Morbitity and Mortality Weekly Report, 2015. 64(38): p. 1066-1070.
2. King, B.A., S.R. Dube, and M.A. Tynan, Flavored cigar smoking among US adults: findings from the 2009–2010 National Adult Tobacco Survey. Nicotine & Tobacco Research, 2013. 15(2): p.608-614.
3. Brown, J.E., et al., Candy flavorings in tobacco. New England Journal of Medicine, 2014. 370(23): p. 2250-2252.
4. Oregon Public Health Division, *Flavored Tobacco: Sweet, Cheap, and Within Kids' Reach, in CD Summary.* 2014, Oregon Health Authority: Oregon.
5. Delnevo, C.D. and M. Hrywna, "A whole 'nother smoke" or a cigarette in disguise: How RJ Reynolds reframed the image of littlecigars. American Journal of Public Health, 2007. 97(8): p. 1368.
6. Ambrose, B.K., et al., *Flavored Tobacco Product Use Among US Youth Aged 12-17 Years, 2013-2014.* JAMA, 2015: p. 1-3.
7. U.S. Department of Health and Human Services, *Preventing tobacco use among youth and young adults: a report of the Surgeon General.* Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2012. 3.
8. Delnevo, C.D., et al., *Smoking-cessation prevalence among US smokers of menthol versus non-menthol cigarettes.* American Journal of Preventive Medicine, 2011. 41(4): p. 357-365.
9. U.S. Food and Drug Administration, *Flavored Tobacco Product Fact Sheet.* 2011, U.S. Food and Drug Administration.
10. Joseph G. Allen, et al., Flavoring Chemicals in E-Cigarettes: Diacetyl, 2,3-Pentanedione, and Acetoin in a Sample of 51 Products, Including Fruit-, Candy-, and Cocktail-Flavored E-Cigarettes. Environmental Health Perspectives, 2015.
11. Farsalinos, K.E., et al., *Evaluation of electronic cigarette liquids and aerosol for the presence of selected inhalation toxins.* Nicotine & Tobacco Research, 2015. 17(2): p. 168-174.

HOOKAH TOBACCO IS UNSAFE

What Are Hookahs?

- Hookahs are glass or metal waterpipes that originated in India. They are shaped somewhat like a bottle and have long, flexible hoses with tips that people put into their mouths to inhale tobacco smoke. In most hookahs, hot charcoal is placed on top of tobacco in a bowl to heat it.[1] The tobacco, or shisha, is typically flavored, and contains the same chemicals found in all tobacco, including nicotine.[2]

- In recent years, there has been tremendous growth in the number of hookah bars and lounges in California.[3, 4, 5] Hookah smoking is **increasingly popular among underage youth and young adults**, exposing them to both tobacco use and secondhand smoke.[6] Many of these young people do not think that hookah smoke is as harmful and addictive as cigarette smoke.[7]

Why Are Hookahs Harmful?

- Smoking hookah for 45-60 minutes can be equivalent to smoking 100 or more cigarettes.[8]

- Secondhand hookah smoke contains the same cancer-causing chemicals found in secondhand smoke from cigarettes.

- In addition, the charcoal used in the tobacco heating process produces the toxin carbon monoxide.[9]

- In 2005, the World Health Organization (WHO) issued an Advisory Note about hookah use, stating that people who smoke hookah pipes or who are exposed to secondhand hookah smoke are at risk for the same diseases that are caused by smoking cigarettes, including:
  - Cancer
  - Heart disease
  - Respiratory disease
  - Adverse effects during pregnancy

- The WHO Advisory Note also warned that sharing a waterpipe mouthpiece poses a serious risk of transmission of communicable diseases, including tuberculosis and hepatitis.[10]

- The proliferation of hookah bars and lounges in California is leading to a growing public acceptance of smoking. This threatens to setback twenty years of progress in reducing tobacco-related death and disease.

How Can Hookah Bars and Lounges Allow Indoor Smoking?

- While smoking inside restaurants and bars has been banned since 1998 in California, the Smoke-Free Workplace law (Labor Code Section 6404.5) includes twelve exemptions that allow smoking in certain indoor workplaces.

- Hookah bars and lounges typically claim they operate as tobacco shops and private smokers' lounges, which are among the businesses that can allow indoor smoking under exemptions in California's Smoke-Free Workplace law.

  - The California Smoke-free Workplace law defines a tobacco shop as a business establishment whose "main purpose" is to sell tobacco products. Unfortunately, the definition of "main purpose" is unclear.

California's Winnable Battle
Finish the Fight Against Tobacco

California Department of Public Health
California Tobacco Control Program
P.O. Box 997377, MS7206
Sacramento, CA 95899-7377
www. www.cdph.ca.gov/programs/tobacco

California Department of PublicHealth

- For example, some hookah bars and lounges have obtained licenses to sell alcohol, serve food and nonalcoholic beverages, and provide entertainment –operating more like a bar or restaurant where smoking inside is prohibited under state law. The assertion that the "main purpose" of these businesses is the sale of tobacco is questionable.

- Other hookah bars and lounges assert that the business is owner-operated and has no employees and is therefore exempt from the state labor law.

- It is unfair that hookah bars and lounges are trying to take advantage of ambiguities in the law to allow indoor smoking, while other similar businesses (bars and restaurants) are following the law.

- The ambiguity and contradictions in state law make enforcement by cities and counties throughout California difficult. Investigating claims that hookah bars and lounges are violating the state Smoke-Free Workplace law can be time-consuming and challenging because of these seemingly contradictory interpretations of business classifications and permitting and licensing requirements and standards.

All California workers deserve to be protected from secondhand smoke. All businesses should be on a level playing field, required to abide by the same rules when it comes to protecting California's workers from secondhand smoke exposure. It's time to close the loophole on hookah bars and lounges.

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1. California's Clean Air Project. *Hookah – In Your Community: Ideas for Action*. ETR Associates, 2005.
2. Shihadeh, A. and Saleh, R. Polycyclic aromatic hydrocarbons, carbon monoxide, "tar", and nicotine in the mainstream smoke aerosol of the narghile water pipe. *Food and Chemical Toxicology*, 2005, 43, 655–661.
3. Asotra, K.and Kiser, D. Policies Needed to Regulate Hookah Smoking and Hookah Bars in California. *Burning Issues* 9(2): 4-5, 9, 2007. Available at: http://www.trdrp.org/publications/newsletters/2007/407nwsltr.pdf
4. American Lung Association. *Tobacco Policy Trend Alert: An Emerging Deadly Trend: Waterpipe Tobacco Use*, 2007. Available at: http://www.lungusa2.org/embargo/slati/Trendalert_Waterpipes.pdf
5. BACCHUS Network. *Reducing Hookah Use: A Public Health Challenge for the 21st Century*. 2007. Available at: http://www.tobaccofreeu.org/pdf/HookahWhitePaper.pdf
6. Eissenberg T., Ward K.D., Smith-Simone S., Maziak, W. Waterpipe tobacco smoking on a U.S. college campus: prevalence and predictors. *Journal of Adolescent Health*, 42(5), 2008, 526-529. Available at: http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2362063/pdf/nihms46743.pdf
7. Aljarrah, K., Ababneh, Z. Q. and Al-Delaimy, W.K. Perceptions of hookah smoking harmfulness: predictors and characteristics among current hookah users. *Tobacco Induced Diseases*, 2009, 5:16. Available at: http://www.tobaccoinduceddiseases.com/content/5/1/16
8. World Health Organization Study Group on Tobacco Product Regulation (TobReg). *Advisory Note: Waterpipe Tobacco Smoking: Health Effects, Research Needs and Recommended Actions by Regulators*. 2005. Available at: http://www.who.int/tobacco/global_interaction/tobreg/Waterpipe%20recommendation_Final.pdf
9. Shihadeh, A. and Saleh, R. Polycyclic aromatic hydrocarbons, carbon monoxide, "tar", and nicotine in the mainstream smoke aerosol of the narghile water pipe. *Food and Chemical Toxicology*, 2005, 43, 655–661.
10. World Health Organization Study Group on Tobacco Product Regulation (TobReg). *Advisory Note: Waterpipe Tobacco Smoking: Health Effects, Research Needs and Recommended Actions by Regulators*. 2005. Available at: http://www.who.int/tobacco/global_interaction/tobreg/Waterpipe%20recommendation_Final.pdf

***No Menthol Sunday* Schedule of Events** **Dates: 5/15 – 5/19, 2019**	
Staff Leads: Carol Magruder, Dr. Phil, Susan Bradshaw Contact Person: Tanishia Wright (310) 295-8141	
Agenda for the Day	
Wednesday, May 15th 2019	**Location**
The Green Believers Podcast Show **2pm – 3pm (PST)** ***arrive by 1:45pm***	Accelerated Radio 1119 South La Brea Avenue Inglewood, CA 90301 **Primary contact: Cheryl Branch (323) 273-4586**
Saturday, May 18th 2019	**Location**
Valley Crossroads Seventh Day Adventist Church ***arrive by 10:50. Service starts at 11am. ask for Dr. Weekes upon arrival***	11350 Glenoaks Boulevard Pacoima, CA 91331 **Primary Contact: Saely Butler: (310) 488-5738**
Sunday, May 19th 2019 **1. WARD AME Church** ***arrive by 9:45 am. Presentation starts at 10am. Church staff on-hand to distribute materials and flyers.**	1177 West 25th Street Los Angeles, CA 90007 **Primary Contact: Linda (213) 747-1367/Pastor Cager**
2. Fellowship Baptist Church ***arrive by 11am* Services start at 11am**	11901 South Willowbrook Avenue Los Angeles, CA 90059 **Primary Contact: Reverenced Torrence**

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Psychiatric comorbidity in Adolescent Electronic and Conventional Cigarette Use

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Abstract

The popularity of electronic (e-) cigarettes has greatly increased recently, particularly in adolescents. However, the extent of psychiatric comorbidity with adolescent e-cigarette use and dual use of conventional (combustible) and e-cigarettes is unknown. This study characterized psychiatric comorbidity in adolescent conventional and e-cigarette use. Ninth grade students attending high schools in Los Angeles, CA (*M* age=14) completed self-report measures of conventional/e-cigarette use, emotional disorders, substance use/problems, and transdiagnostic psychiatric phenotypes consistent with the NIMH-Research Domain Criteria Initiative. Outcomes were compared by lifetime use of: (1) neither conventional nor e-cigarettes (non-use; N=2557, 77.3%); (2) e-cigarettes only (N=412, 12.4%); (3) conventional cigarettes only (N=152, 4.6%); and (4) conventional and e-cigarettes (dual use; N=189, 5.6%). In comparison to adolescents who used conventional cigarettes only, e-cigarette only users reported lower levels of internalizing syndromes (depression, generalized anxiety, panic, social phobia, and obsessive-compulsive disorder) and transdiagnostic phenotypes (i.e., distress intolerance, anxiety sensitivity, rash action during negative affect). Depression, panic disorder, and anhedonia were higher in e-cigarette only vs. non-users. For several externalizing outcomes (mania, rash action during positive affect, alcohol drug use/abuse) and anhedonia, an ordered pattern was observed, whereby comorbidity was lowest in non-users, moderate in single product users (conventional or e-cigarette), and

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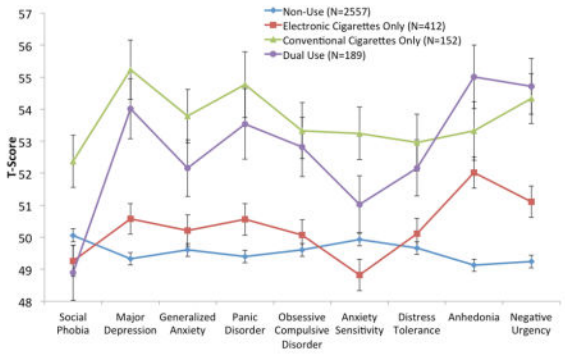
Author contributions: AML conducting the analyses and oversaw data collection. AML and JAM conceptualized and wrote the majority of the manuscript text. DRS, MGK, SS, JBU, and JBT aided in study conceptualization and provided feedback on drafts.

highest in dual users. These findings: (1) raise question of whether emotionally-healthier ('lower-risk') adolescents who are not interested in conventional cigarettes are being attracted to e-cigarettes; (2) indicate that research, intervention, and policy dedicated to adolescent tobacco-psychiatric comorbidity should distinguish conventional cigarette, e-cigarette, and dual use.

Graphical Abstract



Keywords

adolescents; electronic cigarettes; smoking; mental health; comorbidity

INTRODUCTION

Mid-adolescence is a vulnerable developmental period for cigarette smoking uptake, the onset of mental health conditions, and the emergence of comorbid tobacco use and mental health problems (Upadhyaya, Deas, Brady, & Kruesi, 2002). The over-representation of smoking among adolescents with mental health problems generalizes across various conditions (e.g., depressive, mania, anxiety, alcohol/drug use disorders), remains robust after controlling for confounders, and is mediated by theoretically-relevant factors suggesting a causal relation (e.g., beliefs that smoking has mood-modulating effects) (Audrain-McGovern et al., 2012; Upadhyaya et al., 2002). The rapid emergence and appeal of novel tobacco and nicotine products such as electronic (e-) cigarettes raises the question as to whether the same adolescent subgroup with mental health problems is at risk for using these products (Cummins, Zhu, Tedeschi, Gamst, & Myers, 2014). This is important to address because this population may be particularly vulnerable to nicotine addiction, given that neural plasticity during adolescence and neuropathology in psychiatric conditions can enhance the brain's sensitivity to nicotine (Balfour & Ridley, 2000; Counotte, Smit, Pattij, & Spijker, 2011; Sinha, 2008).

E-cigarettes—electronic devices that deliver inhaled nicotine emulate the sensorimotor properties of conventional (combustible) cigarettes—are gaining popularity among adolescents. According to 2014 estimates, past 30 day use of e-cigarettes is more common than conventional cigarettes among U.S. 8th- (9% vs. 4%) and 10th- (16% vs. 7%) graders, and many adolescent e-cigarette users have never tried conventional cigarettes (Johnston, O'Malley, Miech, Bachman, & Schulenberg, 2015). E-cigarettes may be an attractive

alternative to conventional cigarettes among youth because of beliefs that they are less harmful, addictive, malodorous, and costly than conventional cigarettes (Peters, Meshack, Lin, Hill, & Abughosh, 2013). Furthermore, e-cigarettes come in flavors appealing to youth and may be easier to obtain than conventional cigarettes because of inconsistent enforcement of restrictions against sales to minors (Collaco, Drummond, & McGrath-Morrow, 2015). Such factors may facilitate e-cigarette initiation in adolescents who would not otherwise smoke conventional cigarettes and may perhaps have fewer risk factors for smoking (Wills, Knight, Williams, Pagano, & Sargent, 2015)—including mental health problems.

Dual use of conventional and e-cigarettes is also common in adolescents (Johnston et al., 2015; Wills et al., 2015), raising the possibility that some adolescents may use e-cigarettes to substitute for conventional cigarettes in situations where smoking is restricted. Indeed, school bathrooms and staircases are among the most common places adolescents report using e-cigarettes (Peters et al., 2013). Given that adolescents with (vs. without) mental health symptoms are more prone to nicotine dependence (Upadhyaya et al., 2002), these populations could be more likely to initiate use of e-cigarettes to bridge situations when they are not able to smoke, which ultimately could perpetuate the over-representation of smoking among individuals with mental health problems.

While research has yet to characterize the psychiatric comorbidity with patterns of conventional and e-cigarette use in adolescents, a recent study of Hawaiian adolescents found that alcohol/marijuana use and other psychosocial risk factors (e.g., sensation seeking, rebelliousness, emotional/behavioral dysregulation) were highest in dual users, moderate in e-cigarette only users, and lowest in non-users (Wills et al., 2015). Most pairwise comparisons involving conventional cigarette only users were not significant in that study, perhaps limited by reduced statistical power due to the smaller size of this group (N=53) (Wills et al., 2015). Given these findings, stratification of psychiatric comorbidity across dual use, single-product use, and non-use in adolescents is plausible.

The current study characterized the mental health of adolescents who reported ever using e-cigarettes, conventional cigarettes, both, or neither. To provide a wide-ranging picture of psychiatric comorbidity, traditional syndrome-based indices of various depressive, manic, anxiety, and substance use disorders were administered. Consistent with NIMH's Research Domain Criteria Initiative (Insel et al., 2010), we also assessed several transdiagnostic phenotypes implicated in multiple internalizing and externalizing psychopathologies and conventional cigarette use (e.g., impulsivity, anhedonia, distress tolerance) (Leventhal & Zvolensky, 2015b). Up to this point, data on the psychiatric comorbidity associated with e-cigarette and dual use is virtually absent, leaving unclear as to how the mental health of these two groups compare to conventional cigarette users and non-users. Given that conventional cigarettes and e-cigarettes have both similarities (e.g., the experience of inhaling aerosol/smoke, nicotine intake) and differences (e.g., e-cigarettes are perceived as less harmful than conventional cigarettes; (Ambrose et al., 2014)), whether the patterns of psychiatric comorbidity are similar or different between e-cigarette only users and conventional cigarette users is unclear. As the first study to comprehensively characterize psychiatric comorbidity in adolescent e-cigarette and dual use, this study may yield data that

is important to tobacco policy by identifying adolescent populations that are psychiatrically vulnerable and potentially at risk for use of traditional and emerging tobacco products. Such data could highlight the need to protect psychiatrically vulnerable adolescents from tobacco product use take via targeted tobacco product regulation and behavioral health prevention programming for this populations.

METHODS

Participants and Procedure

This report is based on a cross-sectional survey of substance use and mental health among 9th grade students enrolled in ten public high schools surrounding Los Angeles, CA, USA. The schools were recruited based on their adequate representation of diverse demographic characteristics. The percentage of students eligible for free lunch within each school (i.e., student's parental income ≤ 185% of the national poverty level) on average across the ten schools was 31.1% (*SD*=19.7, range: 8.0% – 62.4%). Students not in special education (e.g., severe learning disabilities) or English as a Second Language programs were eligible (N=4100). Of the students who assented to participate (N=3,874; 94.5%), 3,383 (82.5%) provided active parental consent and enrolled in the study. In-classroom paper-and-pencil surveys were administered across two 60-minute data collections during the fall of 2013, conducted less than two weeks apart. Some students did not complete all questionnaires within the time allotted or were absent for data collections (n=73), leaving a final sample of 3310. The University of Southern California Institutional Review Board approved the protocol.

Measures

Each study measure described below has shown good psychometric properties in previous adolescent samples (Audrain-McGovern et al., 2004; Bastiani et al., 2013; Eaton et al., 2010; Johnston et al., 2015; Leventhal et al., 2015 *in press;* Martino, Grilo, & Fehon, 2000; Muris & Meesters, 2008; Pang, Farrahi, Glazier, Sussman, & Leventhal, 2015 *in press;* Wagner et al., 2006; White & Labouvie, 1989). Unless otherwise specified, a mean score per item composite was calculated and composites were scored such that higher scores reflect higher psychopathology.

Electronic Cigarettes, Conventional Cigarettes, and other Substance Use— Using items derived from the Youth Behavior Risk Surveillance (Eaton et al., 2010) and Monitoring the Future (Johnston et al., 2015) Surveys, lifetime use of e-cigarettes (described as "electronic cigarettes, personal vaporizers; prevalence in this sample = 18.2%) and conventional cigarettes (10.3%) was measured, as well as these additional substances: marijuana (15.1%), one full drink of alcohol (26.5%), inhalants (6.0%), cocaine (1.0%), methamphetamines (0.71%), ecstasy (1.5%), LSD/mushrooms/psychedelics (1.7%), salvia (1.0%), heroin (0.5%), prescription pain killers (2.3%), tranquilizers or sedatives (3.3%), diet pills (1.7%), prescription stimulant pills (0.82%), and other drugs (1.2%). Only substances with lifetime prevalence greater than 5% were analyzed as individual outcomes.

Clinical Syndromes

Revised Children's Anxiety and Depression Scale (RCADS) (Chorpita, Yim, Moffitt, Umemoto, & Francis, 2000): The RCADS instructs respondents to report the frequency of 40 different *DSM-IV* symptoms from 1=never to 4=always. Subscales yield scores for major depression, generalized anxiety disorder, obsessive-compulsive disorder, panic disorder, and social phobia.

Mood Disorder Questionnaire (MDQ) (Hirschfeld et al., 2000): The MDQ instructs respondents to indicate whether they experienced 13 *DSM-IV* mania symptoms in the past year (yes=1, no=0). A symptom count sum score was utilized for analyses, per prior work (Boschloo et al., 2014). (Supplemental analyses utilizing the cutoff for probable *DSM-IV* hypomanic/manic episode yielded the same findings with the continuous score.)

Transdiagnostic Phenotypes—Each of the transdiagnostic phenotype measures described below has been consistently associated with multiple psychopathologies (Audrain-McGovern et al., 2009; Audrain-McGovern et al., 2004; Cyders et al., 2007; Ellis & Rothbart, 2001; Isolan, Salum, Menezes Flores, de Carvalho, & Gus Manfro, 2012; Leventhal et al., 2015 *in press;* Leyro, Zvolensky, & Bernstein, 2010; Muris et al., 2008; Muris, Schmidt, Merckelbach, & Schouten, 2001; Pang et al., 2015 *in press;* Smith et al., 2007).

Distress Tolerance Scale (DTS) (Simons & Gaher, 2005): The 14-item DTS measures capacity to tolerate affective distress (e.g., "I'll do anything to avoid feeling distressed or upset") using 5-point ratings (1=strongly disagree, 5=strongly agree).

Childhood Anxiety Sensitivity Index (CASI) (Silverman, Fleisig, Rabian, & Peterson, 1991): The 18-item CASI measures fear of and concerns about anxiety-related sensations and consequences (e.g., "It scares me when my heart beats fast"; none=0, some=1, a lot=2).

Snaith-Hamilton Pleasure Scale (SHAPS) (Snaith et al., 1995): The SHAPS assesses anhedonia using 14 self-statements regarding pleasure response to common pleasant experiences (e.g., "I would enjoy seeing others' smiling faces"; 1=strongly agree, 4=strongly disagree).

Temperament and Character Inventory (TCI)-Impulsivity Scale (Cloninger, Przybeck, Syrakic, & Wetzel, 1994): The 5-item TCI Impulsivity subscale assesses tendency towards acting on instinct without conscious deliberation (e.g., "I often do things based on how I feel at the moment"). It uses a sum across items (True=1, False=0; range: 0–5).

UPPS-P Impulsive Behavior Scale-Positive and Negative Urgency Subscales (Whiteside & Lynam, 2001): The UPPS-P Impulsive Behavior Scale(Whiteside et al., 2001) has subscales tapping the tendency towards rash action during states of negative affect (negative urgency; 12 items, e.g., "When I'm upset I often act without thinking") and positive affect (positive urgency; 14 items, e.g., "I tend to lose control when I am in a great mood"). Items are rated from 1=disagree strongly to 4=agree strongly.

The Early Adolescent Temperament Questionnaire – Revised (EATQ-R)-Inhibitory Control Scale (Ellis et al., 2001): The 5-item EATQ-R Inhibitory Control scale assesses ability to inhibit reflexive responses (e.g., "When someone tells me to stop doing something, it is easy for me to stop"; 1=almost always true to 5=almost always untrue).

Substance Abuse and Problems

Drug Abuse Screening Test-Adolescent Version (DAST) (Martino et al., 2000): The 10-item DAST assesses problems associated with use and abuse of drugs other than alcohol (e.g., blackouts, family problems, withdrawal symptoms, legal problems; yes/no). A total sum score (0 – 10) is calculated.

Cannabis Abuse Screening Test (CAST) (LEGLEYE, KARILA, BECK, & REYNAUD, 2007): The 6-item CAST measures problems experienced from cannabis use (e.g., failed attempts to stop use, social or academic consequences). Participants rate frequency from never (=0) to often (=4) and a sum score is calculated.

Rutgers Alcohol Problem Index (RAPI) (White et al., 1989): The 23-item RAPI measures the frequency of negative consequences associated with drinking within the last 12 months. Responses to items (0=never to 4=10 or more times) are summed.

Data Analysis

Based on patterns of lifetime use, the sample was divided into: (1) use of neither electronic nor conventional cigarettes (non-use; N=2557); (2) use of conventional cigarettes only (N=152); (3) use of electronic cigarettes only (N=412); (4) use of electronic and conventional cigarettes (dual use; N=189). Primary analyses used generalized linear mixed models (GLMMs) that accounted for clustering of data within school, in which the 4-level cigarette use group variable was a categorical regressor variable and a mental health indicator was the outcome variable, with separate models for each outcome. GLMM specified binary and continuous distributions for the lifetime substance use status and mental health quantitative outcomes, respectively. Because of skewed distributions on the three substance use problems measures, Poisson distributions were specified for these outcomes. For outcomes with omnibus groups differences, we conducted follow up pairwise contrasts using an adjusted p-value, correcting for study-wise false discovery rate of 0.05. GLMMs were adjusted for gender, age, ethnicity, and highest parental education; missing data on covariates were accounted for by dummy coding a 'missingness' variable to allow inclusion in analyses. Results are reported as standardized effect size estimates (*r*s).

RESULTS

Use of e-cigarettes only (12.4%) was more common than conventional cigarettes only (4.6%) and dual (5.7%) use, *p*s < .0001. Dual use was more common than conventional cigarette use only, $p = .04$. Demographic characteristics by group are reported in Table 1. Cronbach αs for continuous outcomes are reported in Table 2. The correlations between all of the continuous mental health measures can be found in Supplementary Table 1, which

showed a wide range correlations across each pair of constructs (M[SD] r-statistic between two measures = 0.27 [0.20], range: −0.25, 0.77).

As illustrated in Table 2, there were omnibus differences across the four groups for all outcomes. Pairwise contrasts indicated that adolescents who used conventional cigarettes only reported worse mental health than non-users and e-cigarette only users on multiple internalizing emotional syndromes (i.e., major depression, generalized anxiety, panic, social phobia, and obsessive compulsive disorder) and transdiagnostic phenotypes (i.e., distress tolerance, anxiety sensitivity, negative urgency; see Table 2). On these internalizing-emotional outcomes, the conventional cigarettes only and dual use groups did not significantly differ. For some internalizing outcomes (i.e., anhedonia, major depression, panic disorder), e-cigarette only users had higher elevations than non-users, but lower problem levels than conventional only or dual users. Relative to non-users, use of either product (e-cigarettes only, conventional cigarettes only, or dual use) was related to the externalizing phenotypes of poorer inhibitory control and impulsivity. An ordered effect of dual use vs. e-cigarette use only vs. non-use was found for elevations in mania, positive urgency, and anhedonia. An ordered effect of dual use vs. either single product use (e-cigarettes only or conventional cigarettes only) vs. non-use was also found for lifetime use status and level of abuse/problems for all substances.

Given the differences in patterns across internalizing (i.e., negative emotion-related) and externalizing and positive-emotion seeking (i.e., mania, behavioral dyscontrol, substance use) behaviors, syndromes, and traits, we plotted standardized T-scores of the outcomes by conventional/e-cigarette use status separately in the two domains. These figures respectively illustrate general trends of: (a) differentiation of conventional and dual cigarette use from never and e-cigarette use on most internalizing outcomes (Figure 1), and (b) tri-level ordered differentiation of never vs. single product vs. dual use on externalizing outcomes (Figure 2).

Analyses of the substance problem outcomes utilizing the overall sample cannot distinguish between substance ever-users who report zero drug/alcohol-related problems and substance never-users. To identify whether e- and conventional-cigarette use status differentiates level of substance problems among substance ever-users, a supplementary analysis of the three substance problem outcomes was conducted that limited each analysis to ever-users of the respective substance using the same GLMM analytic strategy and covariates as the primary analyses with a continuous outcome distribution specified. As in the analysis in the primary sample, these analyses of substance ever-users generally showed an ordered pattern whereby dual tobacco product users reported the highest levels of alcohol, cannabis, and drug problems, followed by single tobacco product users (either conventional- or e-cigarette use), and then never-users of either tobacco product, respectively (see supplementary table 2).

DISCUSSION

This study is the first to comprehensively examine differences in psychiatric profiles between four different groups based on typologies of tobacco product use: (1) non-users; (2) e-cigarette only users; (3) conventional cigarette only users; and (4) dual users. This novel 4-group comparison is a critical innovation; with changes in the pattern of tobacco product use

in the past several years, new typologies of adolescent tobacco product use have emerged, including both e-cigarette and dual use (Arrazola et al., 2015; Dutra & Glantz, 2014). Given the relative lack of data to suggest that additional psychiatric problems would be associated with e-cigarette vs. conventional cigarette or dual use, it was unclear whether e-cigarette only users would differ from the other user groups in psychiatric comorbidity.

This study's main findings were that: (1) e-cigarette only users reported a level of internalizing mental health problems midway between non-use and conventional cigarette use; and (2) externalizing/substance use comorbidity was extensive and followed an ordered pattern with dual users having the most severe and pervasive comorbidity, followed by single-product users and non-users, respectively. These results are novel and raise an important question as to whether e-cigarette use may be common in 'lower-risk' subgroups of the adolescent population (including those with better mental health) who otherwise are not attracted to other tobacco products, like conventional cigarettes. These results are broadly consistent with recent data in adults (Cummins et al., 2014) as well as Wills et al.'s study of psychosocial risk factors and alcohol/marijuana use in Hawaiian $9^{th}/10^{th}$ graders, which found that e-cigarette users were at an intermediate risk status in between non-users and dual users (Wills et al., 2015). In the current sample of Los Angeles 9^{th} graders, a similar pattern of differentiation by dual vs. e-cigarette only vs. non-use is seen that extends across a number of mental health syndromes and transdiangostic phenotypes. The current study also found that conventional cigarette only users have worse internalizing mental health problems than e-cigarette only users. Overall, it is clear that future research and intervention dedicated to comorbidity between use of tobacco (or tobacco-like) products and mental health problems in adolescents should assess and distinguish between use of conventional cigarettes only, e-cigarettes only, and dual use.

For eight internalizing emotional disorder symptoms and phenotypes, adolescents who used e-cigarettes only reported an intermediate level of problems which was lower than conventional cigarette only users on seven outcomes and higher than never-users on three outcomes. Prior research suggests that adolescents with better (vs. worse) emotional health are more strongly deterred from initiating smoking due to concerns about smoking's negative effects on health and social acceptability (Stone & Leventhal, 2014). Thus, emotionally-healthier adolescents may be more willing to use e-cigarettes, which are generally perceived to be more socially acceptable and less harmful than conventional cigarettes (Wills et al., 2015). The availability of tobacco products that are perceived as less harmful and more socially acceptable, like e-cigarettes, may lower the threshold of risk for tobacco product experimentation associated with certain mental health problems.

Externalizing behavioral comorbidities (i.e., substance use and abuse, impulsivity, poor inhibitory control, tendency toward rash action during positive affect) and mania were elevated in adolescents who used e-cigarettes only versus those who use never used either tobacco product. Adolescents who used conventional cigarettes only also showed this pattern relative to those who never used either tobacco product, which extends prior research on tobacco-psychiatric comorbidity (Upadhyaya et al., 2002). Moreover, this study provides novel data indicating use of e-cigarettes per se is not universally linked with all types of

mental health comorbidities; rather use of e-cigarettes alone (vs. non-use) is associated more prominently with externalizing problems and less prominently with internalizing problems.

A clear gradient was observed in which substance use/problems, mania, and positive urgency that successively increased with the number of tobacco products used (dual vs. single vs. never users). One explanation for these findings is that adolescent cigarette smokers with these comorbidities may be more nicotine dependent and may therefore be motivated to also use e-cigarettes to alleviate withdrawal during times when they cannot smoke (Peters et al., 2013). Indeed, these disorders are linked with more severe conventional cigarette dependence (Griesler, Hu, Schaffran, & Kandel, 2011). Another explanation is that adolescents with substance use and mania comorbidity who have experimented with e-cigarette use may not derive enough reinforcement from e-cigarettes, which may be an important factor given prior evidence that conventional cigarette smokers with these comorbidities report stronger motivation to smoke for positive reinforcement (Kahler et al., 2010). Because e-cigarettes have provided less reliable nicotine delivery and reinforcement than conventional cigarettes in novice users (Evans & Hoffman, 2014), adolescents with substance use and mania comorbidities who have tried e-cigarettes may be motivated to subsequently experiment with conventional cigarettes in an effort to find a product that provides stronger and more consistent rewarding effects. An additional perspective is that substance experimentation is driven by a drive for pleasure and means for rebelling against norms (Wills et al., 2015), and that teens with externalizing mental health problems are motivated to experiment with a wider array of multiple substances, including e-cigarettes, conventional cigarettes, and other drugs. Further longitudinal evaluation of these hypotheses is necessary and future research should explore whether there is a gradient in the intensity of intervention needed in preventing conventional cigarette smoking and dual use.

This study had several strengths, including a comprehensive four-group comparison strategy that distinguished four unique patterns of tobacco product use, broad sampling of mental health syndromes and cross-cutting traits, and utilization of a large, diverse sample. The cross-sectional design does not permit an assessment of the temporal precedence of the mental health problems and the use of conventional/e-cigarettes. Accordingly, this study cannot speak to etiological mechanisms underpinning the link between mental health and tobacco product use. Because the survey did not assess past 30-day e-cigarette use, use frequency and progression in use, persistence of use, and nicotine strength (i.e., whether products contain nicotine and at what level), several aspects regarding the quality and profile of e-cigarette and conventional cigarette use are not addressed in this study. Furthermore, the focus on lifetime use leaves unclear whether findings generalize to brief experimentation or more persistent use patterns. To limit burden on students and class time, brief self-report measures were used. As such, these results reflect self-reported symptoms, and the extent to which they generalize to psychiatric diagnoses is unclear. Future work utilizing structured clinical interviews are warranted to identify diagnoses associated with conventional and e-cigarette use.

This is first the investigation to characterize adolescent psychiatric comorbidity in an era when the extensive popularity of e-cigarettes in youth is now clearly established. The current data are of use for policy and tobacco and mental illness intervention by elucidating

a subpopulation based on mental health status that may be at higher risk for use of traditional and emerging tobacco products. Describing patterns of psychiatric comorbidity between different forms of tobacco product use in teens provides clues to practitioners on assessment and intervention. For instance, these findings suggest that if a teen is a dual user or conventional cigarette smoker, she or he may be more likely to have comorbid mental health problems than teens who use e-cigarettes only; practitioners should thus make mental health assessment a priority such populations. Similarly, these findings suggest that teens with mild levels of emotional pathology may nonetheless be at elevated likelihood of e-cigarette use and should be asked by practitioners about their e-cigarette use patterns, particularly given recent evidence that teens who use e-cigarettes are more likely to initiate combustible tobacco product use.(Leventhal et al., 2015a; Primack, Soneji, Stoolmiller, Fine, & Sargent, 2015). These results also raise the possibility that adolescents with more severe and pervasive mental health problems could be more vulnerable to factors that increase risk of initiation of e-cigarettes and dual use in teen populations. Some of these risk factors could be targeted via regulation (e.g., youth exposure to e-cigarette advertising, restrictions on ability for minors to purchase e-cigarettes, flavorings and other elements of e-cigarettes and conventional cigarettes that could attract youths) or intervention (e.g., tobacco prevention media campaigns that tailor message characteristics to sufficiently resonate with youth with certain behavioral tendencies; Allen, Vallone, Vargyas, & Healton, 2009). The current results may also have implications for patterns of comorbidity that are likely to arise in the future. Namely, emotionally-healthier individuals who previously might be deterred from using any tobacco products may now be at risk for uptake of e-cigarettes or other emerging products. Furthermore, individuals with certain behavioral comorbidities may be more prone to use multiple products, which may alter the trajectory of future conventional cigarette smoking in patterns that remain to be seen.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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References

Allen, JA.; Vallone, D.; Vargyas, E.; Healton, CG. The truth campaign: Using counter marketing to reduce youth smoking. In: Zimmerman, BHR., editor. The new world of health promotion, New program development, implementation and evaluation. Sudbury, MA: Jones and Bartlett; 2009. p. 195-215.

Ambrose BK, Rostron BL, Johnson SE, Portnoy DB, Apelberg BJ, Kaufman AR, Choiniere CJ. Perceptions of the relative harm of cigarettes and e-cigarettes among U.S. youth. Am J Prev Med. 2014; 47:S53–60. [PubMed: 25044196]

Arrazola RA, Singh T, Corey CG, Husten CG, Neff LJ, Apelberg BJ, Bunnell RE, Choiniere CJ, King BA, Cox S, McAfee T, Caraballo RS. Tobacco use among middle and high school students - United States, 2011–2014. MMWR Morb Mortal Wkly Rep. 2015; 64:381–385. [PubMed: 25879896]

Audrain-McGovern J, Rodriguez D, Epstein LH, Cuevas J, Rodgers K, Wileyto EP. Does delay discounting play an etiological role in smoking or is it a consequence of smoking? Drug Alcohol Depend. 2009; 103:99–106. [PubMed: 19443136]

Audrain-McGovern J, Rodriguez D, Rodgers K, Cuevas J, Sass J, Riley T. Reward expectations lead to smoking uptake among depressed adolescents. Drug Alcohol Depend. 2012; 120:181–189. [PubMed: 21855235]

Audrain-McGovern J, Rodriguez D, Tercyak KP, Cuevas J, Rodgers K, Patterson F. Identifying and characterizing adolescent smoking trajectories. Cancer Epidemiol Biomarkers Prev. 2004; 13:2023–2034. [PubMed: 15598757]

Balfour DJ, Ridley DL. The effects of nicotine on neural pathways implicated in depression: a factor in nicotine addiction? Pharmacology, biochemistry, and behavior. 2000; 66:79–85.

Bastiani L, Siciliano V, Curzio O, Luppi C, Gori M, Grassi M, Molinaro S. Optimal scaling of the CAST and of SDS Scale in a national sample of adolescents. Addict Behav. 2013; 38:2060–2067. [PubMed: 23396173]

Boschloo L, Spijker AT, Hoencamp E, Kupka R, Nolen WA, Schoevers RA, Penninx BW. Predictors of the onset of manic symptoms and a (hypo)manic episode in patients with major depressive disorder. PLoS One. 2014; 9:e106871. [PubMed: 25259889]

Chorpita BF, Yim L, Moffitt C, Umemoto LA, Francis SE. Assessment of symptoms of DSM-IV anxiety and depression in children: a revised child anxiety and depression scale. Behaviour research and therapy. 2000; 38:835–855. [PubMed: 10937431]

Cloninger, C.; Przybeck, T.; Syrakic, D.; Wetzel, R. The Temperament and Character Inventory (TCI): A guide to its development and use. St. Louis, MO: Center for Psychobiology of Personality, Washington University; 1994.

Collaco JM, Drummond MB, McGrath-Morrow SA. Electronic cigarette use and exposure in the pediatric population. JAMA Pediatr. 2015; 169:177–182. [PubMed: 25546699]

Counotte DS, Smit AB, Pattij T, Spijker S. Development of the motivational system during adolescence, and its sensitivity to disruption by nicotine. Developmental cognitive neuroscience. 2011; 1:430–443. [PubMed: 22436565]

Cummins SE, Zhu SH, Tedeschi GJ, Gamst AC, Myers MG. Use of e-cigarettes by individuals with mental health conditions. Tobacco control. 2014; 23(Suppl 3):iii48–53. [PubMed: 24824516]

Cyders MA, Smith GT, Spillane NS, Fischer S, Annus AM, Peterson C. Integration of impulsivity and positive mood to predict risky behavior: development and validation of a measure of positive urgency. Psychol Assess. 2007; 19:107–118. [PubMed: 17371126]

Dutra LM, Glantz SA. Electronic cigarettes and conventional cigarette use among U.S. adolescents: a cross-sectional study. JAMA Pediatr. 2014; 168:610–617. [PubMed: 24604023]

Eaton DK, Kann L, Kinchen S, Shanklin S, Ross J, Hawkins J, Harris WA, Lowry R, McManus T, Chyen D, Lim C, Whittle L, Brener ND, Wechsler H. Youth risk behavior surveillance - United States, 2009. Morbidity and mortality weekly report. Surveillance summaries. 2010; 59:1–142. [PubMed: 20520591]

Ellis, L.; Rothbart, M. Revision of the Early Adolescent Temperament Questionnaire. Poster presented at the Biennial Meeting of the Society for Research in Child Development; Minneapolis, MN. 2001.

Evans SE, Hoffman AC. Electronic cigarettes: abuse liability, topography and subjective effects. Tobacco control. 2014; 23(Suppl 2):ii23–29. [PubMed: 24732159]

Griesler PC, Hu MC, Schaffran C, Kandel DB. Comorbid psychiatric disorders and nicotine dependence in adolescence. Addiction. 2011; 106:1010–1020. [PubMed: 21320229]

Hirschfeld RM, Williams JB, Spitzer RL, Calabrese JR, Flynn L, Keck PE, Lewis L, McElroy SL, Post RM, Rapport DJ, Russell JM, Sachs GS, Zajecka J. Development and validation of a screening instrument for bipolar spectrum disorder: the Mood Disorder Questionnaire. Am J Psychiatry. 2000; 157:1873–1875. [PubMed: 11058490]

Insel T, Cuthbert B, Garvey M, Heinssen R, Pine DS, Quinn K, Sanislow C, Wang P. Research domain criteria (RDoC): toward a new classification framework for research on mental disorders. Am J Psychiatry. 2010; 167:748–751. [PubMed: 20595427]

Isolan L, Salum G, Menezes Flores S, de Carvalho HW, Gus Manfro G. Reliability and convergent validity of the Childhood Anxiety Sensitivity Index in children and adolescents. Jornal Brasileiro de Psiquiatria. 2012; 61

Johnston, LD.; O'Malley, PM.; Miech, RA.; Bachman, JG.; Schulenberg, JE. Monitoring the Future National Survey Results on Drug Use 1975–2014: Overview: Key Findings on Adolescent Drug Use. Ann Arbor, MI: Institute for Social Research, The University of Michigan; 2015.

Kahler CW, Leventhal AM, Daughters SB, Clark MA, Colby SM, Ramsey SE, Boergers J, Abrams DB, Niaura R, Buka SL. Relationships of personality and psychiatric disorders to multiple domains of smoking motives and dependence in middle-aged adults. Nicotine Tob Res. 2010; 12:381–389. [PubMed: 20167635]

LEGLEYE S, KARILA L, BECK F, REYNAUD M. Validation of the CAST, a general population Cannabis Abuse Screening Test. Journal of Substance Use. 2007; 12:233–242.

Leventhal A, Unger J, Audrain-McGovern J, Sussman S, Volk H, Strong D. Measuring anhedonia in adolescents: A psychometric analysis. Journal of Personality Assessment. 2015 in press.

Leventhal AM, Strong DR, Kirkpatrick MG, Unger JB, Sussman S, Riggs NR, Stone MD, Khoddam R, Samet JM, Audrain-McGovern J. Association of Electronic Cigarette Use With Initiation of Combustible Tobacco Product Smoking in Early Adolescence. JAMA. 2015a; 314:700–707. [PubMed: 26284721]

Leventhal AM, Zvolensky MJ. Anxiety, depression, and cigarette smoking: a transdiagnostic vulnerability framework to understanding emotion-smoking comorbidity. Psychological bulletin. 2015b; 141:176–212. [PubMed: 25365764]

Leyro TM, Zvolensky MJ, Bernstein A. Distress tolerance and psychopathological symptoms and disorders: a review of the empirical literature among adults. Psychol Bull. 2010; 136:576–600. [PubMed: 20565169]

Martino S, Grilo CM, Fehon DC. Development of the drug abuse screening test for adolescents (DAST-A). Addict Behav. 2000; 25:57–70. [PubMed: 10708319]

Muris P, Meesters C. Reactive and Regulative Temperament in Youths: Psychometric Evaluation of the Early Adolescent Temperament Questionnaire-Revised. Journal of Psychopathology and Behavioral Assessment. 2008; 31:7–19.

Muris P, Schmidt H, Merckelbach H, Schouten E. Anxiety sensitivity in adolescents: factor structure and relationships to trait anxiety and symptoms of anxiety disorders and depression. Behaviour research and therapy. 2001; 39:89–100. [PubMed: 11125726]

Pang R, Farrahi L, Glazier S, Sussman S, Leventhal A. Depressive symptoms, negative urgency and substance use initiation in adolescents. Drug and Alcohol Dependence. 2015 in press.

Peters RJ, Meshack A, Lin MT, Hill M, Abughosh S. The social norms and beliefs of teenage male electronic cigarette use. J Ethn Subst Abuse. 2013; 12:300–307. [PubMed: 24215223]

Primack BA, Soneji S, Stoolmiller M, Fine MJ, Sargent JD. Progression to Traditional Cigarette Smoking After Electronic Cigarette Use Among US Adolescents and Young Adults. JAMA Pediatr. 2015:1–7.

Silverman WK, Fleisig W, Rabian B, Peterson RA. Childhood Anxiety Sensitivity Index. Journal of Clinical Child Psychology. 1991; 20:162–168.

Simons J, Gaher R. The Distress Tolerance Scale: Development and Validation of a Self-Report Measure. Motivation and Emotion. 2005; 29:83–102.

Sinha R. Chronic stress, drug use, and vulnerability to addiction. Ann N Y Acad Sci. 2008; 1141:105–130. [PubMed: 18991954]

Smith GT, Fischer S, Cyders MA, Annus AM, Spillane NS, McCarthy DM. On the validity and utility of discriminating among impulsivity-like traits. Assessment. 2007; 14:155–170. [PubMed: 17504888]

Snaith RP, Hamilton M, Morley S, Humayan A, Hargreaves D, Trigwell P. A scale for the assessment of hedonic tone the Snaith-Hamilton Pleasure Scale. The British journal of psychiatry: the journal of mental science. 1995; 167:99–103. [PubMed: 7551619]

Stone, M.; Leventhal, A. Associations between Anhedonia and Risk Factors for Smoking Initiation among Adolescent Never Smokers. Poster presented at the 20th annual meeting of the Society for Research on Nicotine and Tobacco; Seattle, WA. 2014.

Upadhyaya HP, Deas D, Brady KT, Kruesi M. Cigarette smoking and psychiatric comorbidity in children and adolescents. J Am Acad Child Adolesc Psychiatry. 2002; 41:1294–1305. [PubMed: 12410071]

Wagner KD, Hirschfeld RM, Emslie GJ, Findling RL, Gracious BL, Reed ML. Validation of the Mood Disorder Questionnaire for bipolar disorders in adolescents. J Clin Psychiatry. 2006; 67:827–830. [PubMed: 16841633]

White HR, Labouvie EW. Towards the assessment of adolescent problem drinking. J Stud Alcohol. 1989; 50:30–37. [PubMed: 2927120]

Whiteside SP, Lynam DR. The five factor model and impulsivity: Using a structural model of personality to understand impulsivity. Pers Individ Dif. 2001; 30:669–689.

Wills TA, Knight R, Williams RJ, Pagano I, Sargent JD. Risk factors for exclusive e-cigarette use and dual e-cigarette use and tobacco use in adolescents. Pediatrics. 2015; 135:e43–51. [PubMed: 25511118]

HIGHLIGHTS

- Relative to conventional cigarette only users, e-cigarette only users reported lower levels of internalizing mental health syndromes (depression, generalized anxiety, panic disorder, social phobia, and obsessive-compulsive disorder) and traits (i.e., distress intolerance, fear of anxiety-related sensations, rash action during negative affect).
- Depression, panic disorder, and inability to experience pleasure (i.e., anhedonia) were higher in e-cigarette only users vs. non-users.
- For externalizing mental health (mania, rash action during positive affect, alcohol/drug use/abuse) and anhedonia, comorbidity was lowest in non-users, moderate in single-product users (conventional or e-cigarette), and highest in dual users.
- Adolescent e-cigarette use is characterized by emotional problems midway between non-use and conventional cigarette use. Dual use is associated with pervasive psychiatric comorbidity.

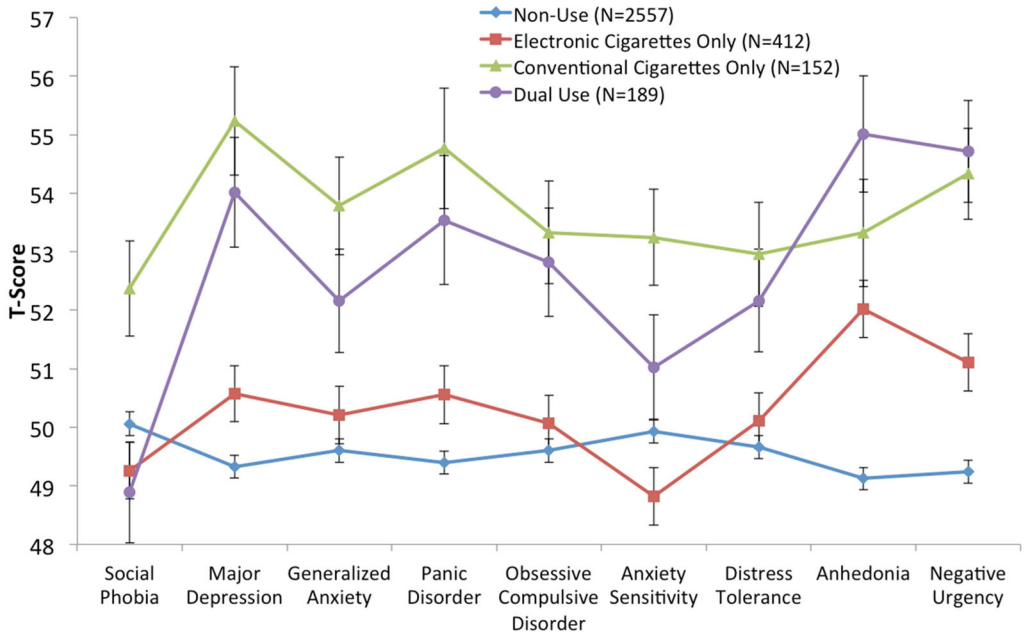

Figure 1.

Mean (±SE) of Internalizing Type Syndromes and Traits by Lifetime Conventional/E-Cigarette Use. Reported as Standardized T-Scores (M=50, SD=15).

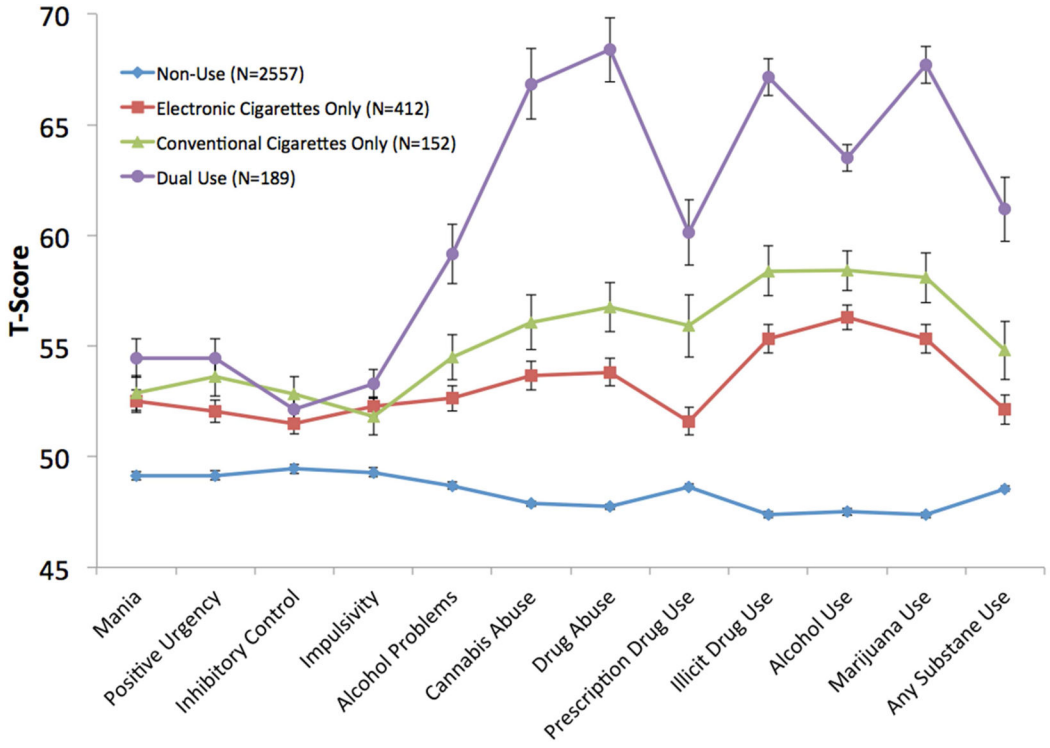

Figure 2.

Mean (±SE) of Externalizing Type Syndromes and Traits by Lifetime Conventional/E-Cigarette Use. Reported as Standardized T-Scores (M=50, SD=15).

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Table 1

Demographic Characteristics by Lifetime Electronic and Conventional Cigarette Use Status

	Lifetime Conventional and Electronic Cigarette Use Status: Descriptive Statistics					Omnibus Test	
Outcome	**Non-Use (*N*=2557)**	**Electronic Cigarettes Only (*N*=412)**	**Conventional Cigarettes Only (*N*=152)**	**Dual Use (*N*=189)**	**Entire Sample**	***r***	***p***
Female, %	54.4%[a]	44.6%[b]	59.2%[a]	53.2%[ab]	53.4%	.07	.001
Age, *M*(*SD*)	14.07 (0.42)[a]	14.10 (0.38)[a]	14.18 (0.48)[b]	14.17 (0.43)[b]	14.08 (0.42)	.08	.0003
Race/Ethnicity, %	-	-	-	-	-	.03	.52
American Indian/Alaska Native	0.9%	0.5%	2.0%	1.6%	0.9%		
Asian	17.6%	14.6%	9.3%	5.5%	16.2%		
Black/African American	4.5%	5.0%	6.0%	2.7%	4.9%		
Hispanic/Latino	45.0%	50.5%	54.7%	59.0%	46.9%		
Native Hawaiian/Pacific Islander	3.1%	5.3%	2.0%	3.3%	3.4%		
White	16.7%	12.6%	12.7%	15.3%	15.6%		
Other	5.9%	4.0%	6.8%	7.1%	5.6%		
Multi-ethnic/Multi-Racial	5.8%	7.5%	6.8%	5.5%	6.0%		
Highest Parental Education, %	-[a]	-[ac]	-[bc]	-[b]		.10	<.0001
Unknown	13.4%	11.4%	13.8%	14.3%	13.2%		
8th grade or less	3.1%	2.2%	5.9%	9.0%	3.5%		
Some high school	6.8%	10.7%	12.5%	13.8%	7.9%		
High school graduate	13.4%	18.2%	21.1%	14.9%	14.5%		
Some college	17.0%	17.0%	11.8%	22.2%	17.1%		
College graduate	28.4%	28.6%	21.1%	15.3%	27.3%		
Graduate degree	17.9%	11.9%	13.8%	9.5%	16.5%		

Note. *N*s range from 2873 to 3310 for each analysis due to different patterns of missing data or reporting “unknown” as a response. across outcomes. Results from omnibus and pairwise tests for group differences in psychiatric and substance use variables using generalized linear mixed models accounting for data nested by school. Groups that share superscripts are not significantly different from one another in pairwise contrasts using unadjusted p-values ($p < .05$).

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Table 2

Psychiatric and Substance Use by Lifetime Electronic and Conventional Cigarette Use Status

		Lifetime Conventional and Electronic Cigarette Use Status: Descriptive Statistics				Omnibus Test	
Outcome	**Cronbach α[1]**	**Non-Use (*N*=2557)**	**Electronic Cigarettes Only (*N*=412)**	**Conventional Cigarettes Only (*N*=152)**	**Dual Use (*N*=189)**	***r***	***p***
Clinical Syndromes, *M*(*SD*)							
Mania	.77	5.15 (3.07)[a]	6.22 (3.28)[b]	6.34 (2.97)[bc]	6.84 (3.58)[c]	.18	<.0001
Major Depression	.93	0.73 (0.68)[a]	0.82 (0.67)[c]	1.14 (0.60)[b]	1.05 (0.84)[b]	.16	<.0001
Generalized Anxiety	.89	1.32 (0.77)[a]	1.36 (0.76)[a]	1.64 (0.81)[b]	1.51 (0.84)[b]	.10	<.0001
Panic	.90	0.45 (0.56)[a]	0.52 (0.57)[c]	0.77 (0.77)[b]	0.69 (0.78)[b]	.14	<.0001
Social Phobia	.92	1.33 (0.81)[a]	1.27 (0.78)[a]	1.52 (0.82)[b]	1.24 (0.85)[a]	.05	.03
Obsessive Compulsive	.82	0.71 (0.63)[a]	0.74 (0.61)[a]	0.95 (0.70)[b]	0.92 (0.73)[b]	.10	<.0001
Transdiagnostic Phenotypes, *M*(*SD*)							
Anxiety Sensitivity	.88	1.69 (0.39)[ac]	1.64 (0.38)[a]	1.82 (0.42)[bd]	1.73 (0.42)[cd]	.08	.0003
Distress Tolerance	.84	2.53 (0.84)[a]	2.58 (0.79)[a]	2.82 (0.88)[b]	2.75 (0.98)[b]	.09	<.0001
Anhedonia	.90	1.65 (0.47)[a]	1.79 (0.49)[b]	1.86 (0.60)[bc]	1.94 (0.61)[c]	.15	<.0001
Negative Urgency	.89	1.90 (0.64)[a]	2.02 (0.62)[c]	2.23 (0.67)[b]	2.26 (0.66)[b]	.16	<.0001
Positive Urgency	.94	1.58 (0.61)[a]	1.77 (0.63)[c]	1.86 (0.65)[bc]	1.92 (0.68)[b]	.16	<.0001
Impulsivity	.57	0.48 (0.30)[a]	0.56 (0.26)[b]	0.55 (0.29)[b]	0.59 (0.26)[b]	.13	<.0001
Inhibitory Control	.38	2.36 (0.63)[a]	2.49 (0.58)[b]	2.57 (0.58)[b]	2.52 (0.60)[b]	.10	<.0001
Lifetime Substance Use, %							
Any prescription drug		2.2%[a]	8.8%[c]	18.4%[b]	27.8%[b]	.23	<.0001
Any illicit drug		6.1%[a]	35.0%[b]	46.1%[b]	77.8%[c]	.38	<.0001
Alcohol		15.0%[a]	53.5%[b]	62.3%[b]	84.9%[c]	.37	<.0001
Marijuana		5.7%[a]	34.2%[b]	44.1%[b]	78.5%[c]	.38	<.0001
Inhalants		2.6%[a]	11.1%[b]	17.5%[b]	32.6%[c]	.26	<.0001
Substance Use Problems, *M*(*SD*)							
Alcohol Problems	.91	2.25 (4.17)[a]	4.24 (5.62)[b]	5.18 (6.24)[bc]	7.52 (0.83)[c]	.19	<.0001
Cannabis Abuse	.92	0.27 (1.55)[a]	1.94 (3.73)[b]	2.62 (4.28)[b]	5.70 (5.97)[c]	.27	<.0001

		Lifetime Conventional and Electronic Cigarette Use Status: Descriptive Statistics				Omnibus Test	
Outcome	**Cronbach α[1]**	**Non-Use (*N*=2557)**	**Electronic Cigarettes Only (*N*=412)**	**Conventional Cigarettes Only (*N*=152)**	**Dual Use (*N*=189)**	***r***	***p***
Drug Abuse	.82	0.20 (0.79)[a]	1.00 (1.66)[b]	1.39 (1.76)[b]	2.92 (2.50)[c]	.32	<.0001

Note. *N*s range from 3121 to 3310 for each analysis due to different patterns of missing data across outcomes. All outcomes are coded such that higher scores reflect more severe pathology. Results from omnibus and pairwise tests for group differences in psychiatric and substance use variables after adjusting for gender, age, ethnicity, and highest parental education using generalized linear mixed models accounting for data nested by school. Groups that share superscripts are not significantly different from one another in pairwise contrasts using an adjusted p-value, corrected for study-wise false discovery rate of .05.

Tobacco Retail Licensing and Youth Product Use

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abstract

BACKGROUND: Restricting youth access to tobacco is a central feature of US tobacco regulatory policy, but impact of local tobacco retail licensing (TRL) regulation on cigarette smoking rates remains uncertain. Effects of TRL on other tobacco product use and use as adolescents reach the age to legally purchase tobacco products has not been investigated.

METHODS: Prevalences of ever and past 30-day cigarette, electronic cigarette (e-cigarette), cigar, and hookah use were assessed in a survey of a cohort of 1553 11th- and 12th-grade adolescents (mean age: 17.3 years); rates of initiation were evaluated 1.5 years later. An American Lung Association (2014) youth access grade was assigned to each of 14 political jurisdictions in which participants lived on the basis of the strength of the local TRL ordinance.

RESULTS: At baseline, participants living in 4 jurisdictions with "A" grades (ie, with most restrictive ordinances) had lower odds of ever cigarette use (odds ratio [OR] 0.61; 95% confidence interval [CI] 0.41–0.90) and of past 30-day use (OR 0.51; 95% CI 0.29–0.89) than participants in 10 D- to F-grade jurisdictions. At follow-up at legal age of purchase, lower odds of cigarette use initiation (OR 0.67; 95% CI 0.45–0.99) occurred in jurisdictions with stronger TRL policy. Lower odds of e-cigarette initiation at follow-up (OR 0.74; 95% CI 0.55–0.99) and of initiation with past 30-day use (OR 0.45; 95% CI 0.23–0.90) were also associated with better regulation.

CONCLUSIONS: Strong local TRL ordinance may lower rates of cigarette and e-cigarette use among youth and young adults.

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Dr McConnell conceptualized and designed the study and reviewed and revised the manuscript; Mr Astor collected data on tobacco retail licensing in study communities, conducted a literature review, and drafted the manuscript; Dr Urman conducted all data analyses; Drs Barrington-Trimis, Berhane, Steinberg, Cousineau, Leventhal, Unger, Cruz, Pentz, and Samet provided advice on the analysis and interpretation of results and reviewed and provided guidance on the development of the manuscript; and all authors approved the final manuscript as submitted.

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

WHAT'S KNOWN ON THIS SUBJECT: Restricting youth access to tobacco has long been a central feature of US tobacco regulatory policy, but the impact of local tobacco retail licensing regulation on electronic cigarette use rates remains uncertain.

WHAT THIS STUDY ADDS: Strong local tobacco retail licensing ordinances may lower rates of cigarette and electronic cigarette use among youth and young adults. Success of regulations restricting youth access to cigarettes and alternative tobacco products may depend on ensuring a robust enforcement scheme.

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Most US states have had laws to restrict the sale of cigarettes to minors for decades.[1] Because there was widespread violation of these laws by tobacco vendors,[2] Congress passed the Synar Amendment to the Public Health Service Act in 1993,[3] which required that states enact laws banning cigarette sales to minors and that they enforce such laws with compliance checks using undercover "decoys" posing as underage customers.[4,5]

Enforcement of these youth access regulations is a central feature of US tobacco control programs. However, although compliance checks of vendors have been shown to reduce sales to minors, their effectiveness in reducing youth smoking rates is less certain, for example, because they may obtain cigarettes legally purchased by older friends.[6,7] Key regulatory features that are reported to reduce both compliance violations and youth cigarette use include a mandatory tobacco retailer licensing fee to provide sustainable funding of undercover decoys to make at least 1 annual visit to each vendor and fines or penalties for violations.[7,8] Low rates of vendor compliance checks, which occur annually at only a small fraction of tobacco vendors under existing state and federal enforcement programs,[9,10] and inadequate penalties may explain why associations with youth smoking rates have not consistently been observed.[7] Within states, compliance enforcement may vary markedly on the basis of local ordinances that provide funding to do so. Given the expense involved in enforcement and the lack of expert consensus on its benefits, additional studies are warranted to assess the effectiveness in reducing youth cigarette use.

The impact of youth access restriction on the initiation of alternative tobacco products, such as electronic cigarettes (e-cigarettes), hookah, and cigars, has not been studied, although prevalence of ever using these products is high.[11] An additional gap in understanding the effectiveness of youth tobacco access restriction is during the transition to the legal age of purchase. Most adult smokers historically have initiated cigarette use by age 18,[12] which is the legal age of purchase in most states. There have been few prospective studies examining the effect of tobacco licensing and youth access restriction on cigarette and alternative tobacco product use during this transition to adult life.

Among participants in the Southern California Children's Health Study, we evaluated whether youth living in jurisdictions with a strong tobacco retail licensing (TRL) ordinance had reduced prevalence of cigarette and other tobacco use, compared with participants in jurisdictions with a poor TRL ordinance. In addition, using prospectively collected data, we assessed the association of local ordinances with the initiation of tobacco product use during a cohort follow-up as youth reached 18 years of age, the age at which the sale of tobacco products was legal in California at the time of the study.

METHODS

Study Population

Between January and June of 2014, a total of 2097 11th- and 12th-grade participants in the Southern California Children's Health Study (mean age: 17.3; SD: 0.6) completed self-administered questionnaires collecting detailed information about cigarette and alternative tobacco product use. Follow-up online questionnaire data were collected on 1553 participants (74% of the 2097 at baseline) as they reached 18 years of age, between January 2015 and June 2016 (mean age: 18.8; SD: 0.6). Additional characteristics of the study sample have been described previously.[13,14]

Ethics Statement

The study was approved by the University of Southern California Institutional Review Board. Parental written informed consent and child assent were obtained for all Children's Health Study participants <18 years of age. Participants age 18 or older provided written informed consent.

Tobacco and Alternative Tobacco Product Use

At each survey, participants were asked whether they had ever tried e-cigarettes, cigarettes, cigars, or hookah and the number of days each product was used in the past 30 days.[12] Participants who had "never tried" a product (not "even 1 or 2 puffs") were classified as never users. Those reporting an age at first use of each tobacco product were classified as ever (lifetime prevalent) users of that product at baseline. Rates of initiation were calculated on the basis of a new report of use of a tobacco product at follow-up among participants not reporting use of that product at baseline. Both prevalent users and initiators of each tobacco product were further characterized on the basis of past 30-day use.

Evaluation of Local Tobacco Regulatory Licensing to Reduce Youth Access

There were 14 political jurisdictions with corresponding tobacco product ordinances across the 12 participating Children's Health Study communities. Four study jurisdictions were assigned an A grade on the basis of the 2014 American Lung Association (ALA) "Reducing Sales of Tobacco Products" to youth scale, which is used to evaluate the strength of the local TRL ordinance across California.[15] An A grade required adequate annual retail license fees, which were paid by all tobacco retailers (including gas stations, convenience stores, larger grocery stores, and pharmacies),

to cover the administration of an enforcement program and regular compliance checks in each store. An A grade also required (1) an annual renewal of this local license; (2) a provision that any violation of local, state, or federal law is a violation of the license; and (3) a graduated penalty system for violators, including financial deterrents such as fines or other penalties, including license revocation or suspension.[15]

The remaining study jurisdictions were assigned an F grade (8) or a D grade (1). An F grade indicated either (1) no local ordinance mandating a license fee or (2) a fee insufficient to fund administrative and compliance checks as well as none of the 3 other provisions for an A grade. The jurisdiction with the D grade had a licensing fee that was insufficient to cover administration and compliance checks, but it had at least 1 of the other 3 provisions listed above that were needed for an A grade. The D and F communities were collapsed for data analysis, because the insufficient annual fee is a central feature of regulation to reduce youth access.[7,15] No study jurisdiction in this sample had B or C grades corresponding to TRL policies of intermediate quality.[15]

ALA assigned grades to other categories of tobacco policy (smoke-free housing policy, smoke-free outdoor policy, and overall tobacco policy).[15] These policies, which are not specific to youth tobacco product access, were not associated with tobacco product use in this study, and results are not presented.

Covariates

Self-administered questionnaires completed by parents of participants were used to assess sociodemographic characteristics, including sex, ethnicity (Hispanic, non-Hispanic white, other), age at baseline, and parental education (completed high school or less, some college, or completed college or more).

Statistical Analysis

Unconditional logistic regression models were used to evaluate the associations of living in a jurisdiction with an ALA grade A versus D or F TRL ordinance with baseline ever and past 30-day use of cigarettes, e-cigarettes, hookah, cigars, or use of any of these tobacco products in separate models. Models were also fit to evaluate associations of ALA grade with the initiation of each product, with or without past 30-day use. In models used to evaluate the initiation of use of each tobacco product between baseline and follow-up, the sample was restricted to baseline never users of that product. Odds ratios (ORs) and 95% confidence intervals (CIs) were used to estimate the association of each tobacco product use with an ALA grade. All models were adjusted for sex, ethnicity, highest parental education, and baseline age, factors that have been associated both with e-cigarette use and cigarette use in previous studies.[13,14] Each tobacco product–specific model was also adjusted for a baseline history of use of any other tobacco product, because there was clustering of the tobacco product outcomes.[13] A missing indicator category for covariates and any other tobacco product use was included where appropriate. Additionally, all models included a random effect for community to account for similarities among subjects within jurisdictions. In a sensitivity analysis, models were further adjusted for time between baseline and follow-up questionnaire completion. Statistical analyses were based on 2-sided hypotheses tested at a 0.05 level of significance, using SAS 9.4 (SAS Institute, Inc, Cary, NC).

RESULTS

Of the 2097 participants, 31.1% (652) lived in a jurisdiction with an ALA 2014 TRL A grade, and 68.9% (1445) students lived in jurisdictions with D or F grades. Sex and ethnic distributions were similar in A and D or F jurisdictions, but students in A jurisdictions were more likely to come from less-educated households (Table 1). Unadjusted prevalence and initiation rates for each tobacco product were lower in jurisdictions with A than with D or F grades, with the exception of new initiation of hookah with past 30-day use. Initiation rates were substantial among never tobacco product users at baseline, in particular for e-cigarette use. Both prevalence and initiation rates of past 30-day tobacco product use generally did not exceed 10% for any product.

For baseline prevalence of ever and past 30-day use of cigarette and e-cigarette ever use, and to a lesser degree for prevalence of cigar use, jurisdictions with A grades had generally lower use rates than D or F jurisdictions (Supplemental Fig 3). However, within both grade groups, there was considerable variability in prevalence rates across jurisdictions for all tobacco products. Rates in individual jurisdictions had wide CIs (results not shown) because of small sample size. Rates of tobacco product initiation at follow-up were also generally quite variable across the jurisdictions within both A and D or F grades (Supplemental Fig 4).

At baseline, participants living in the 4 jurisdictions with A grades had lower odds of ever using a cigarette (OR 0.61; 95% CI 0.41–0.90) and of past 30-day use (OR 0.51; 95% CI 0.29–0.89) than participants in 10 D- to F-grade jurisdictions, after adjusting for sociodemographic covariates and other tobacco product use at baseline (Fig 1).

Living in A-grade jurisdictions was associated with lower odds of initiation of cigarette use between baseline and the follow-up questionnaire (OR 0.67; 95% CI 0.45–0.99 [Fig 2]). The risks of

TABLE 1 Prevalence of Sociodemographic Characteristics, Lifetime, and Current (Last 30-Day) Use of Each Tobacco Product at Baseline and Rates of Product Initiation at Follow-up Among Youth Residing in a Jurisdiction With ALA Reduced Tobacco Sales, Grade A or D or F

	Grade A	Grade D or F
	N (%[a])	*N* (%[a])
Sex		
Male	324 (49.7)	735 (50.9)
Female	328 (50.3)	710 (49.1)
Ethnicity		
Hispanic white	349 (53.5)	736 (50.9)
Non-Hispanic white	230 (35.3)	504 (34.9)
Other	73 (11.2)	205 (14.2)
Parent education		
Less than or equal to high school	245 (41.3)	460 (34.3)
Some college	219 (36.9)	502 (37.4)
College or more	129 (21.8)	379 (28.3)
Prevalent ever tobacco product use at baseline		
Cigarette	89 (13.7)	302 (21.0)
E-cigarette	123 (19.0)	379 (26.4)
Hookah	158 (24.3)	411 (28.6)
Cigars	69 (10.6)	204 (14.2)
Any tobacco product	214 (32.9)	564 (39.2)
Prevalent past 30-d tobacco product use at baseline		
Cigarette	24 (3.7)	95 (6.6)
E-cigarette	56 (8.6)	145 (10.1)
Hookah	62 (9.5)	162 (11.3)
Cigars	21 (3.2)	55 (3.8)
Any tobacco product	107 (16.5)	267 (18.6)
Initiation of tobacco product use (between baseline and follow-up)[b]		
Cigarette	52 (13.1)	156 (18.0)
E-cigarette	92 (24.7)	235 (29.7)
Hookah	55 (15.9)	146 (18.9)
Cigars	49 (12.0)	158 (17.1)
Any tobacco product	85 (27.7)	198 (30)
Initiation with past 30-d tobacco product use at follow-up[b]		
Cigarette	17 (4.3)	52 (6.0)
E-cigarette	17 (4.7)	69 (8.9)
Hookah	16 (4.7)	32 (4.2)
Cigars	12 (2.9)	36 (3.9)
Any tobacco product	24 (7.9)	78 (12.1)

[a] The denominator (652 in grade A; 1445 in grade D or F) varies because of missing values in covariates.
[b] Restricted to nonusers of each product (or of any tobacco product) at baseline.

initiation of e-cigarettes (OR 0.74; 95% CI 0.55–0.99) and of initiation with past 30-day use (OR 0.45; 95% CI 0.23–0.90) were also lower in A-grade than D- or F-grade jurisdictions. In sensitivity analyses adjusting for time since turning 18 at follow-up, there was no change in the protective effect estimate of living in a well-regulated (A-grade) jurisdiction (results not shown). Participants still living in their jurisdiction of origin at follow-up evaluation would have had consistent exposure to the same regulatory environment. In this sample, there were stronger protective A-grade compared with D- or F-grade associations with cigarette and e-cigarette initiation at follow-up (and of initiation of e-cigarettes with past 30-day use) than in the entire sample (results not shown). The protective association of A-grade residence with initiation of cigar use was similar in magnitude to the association with cigarette and e-cigarette use but was not statistically significant.

DISCUSSION

Central features of the ALA TRL grade include a licensing fee sufficient to fund compliance checks and enforcement of regulations prohibiting tobacco sales to minors and penalties for violating the law, features of TRL that have been reported to be necessary to reduce sales to and use by youth.[7] Compared with living in a jurisdiction with poor TRL policy, youth in a jurisdiction satisfying these criteria were less likely to smoke in high school. In a prospective follow-up of the cohort, the odds of initiation of e-cigarette use, with or without past 30-day use, and of initiation of cigarette use were also lower in well-regulated jurisdictions. Stronger associations among participants still living in their jurisdiction of origin at follow-up evaluation, with consistent exposure to the same regulatory environment throughout, also suggest that the benefits of good TRL policy extended both beyond cigarette use to e-cigarette use and into early adult life at age 18 when the sale of tobacco products was legal at the time of the study. The protective associations were large, with risk lower by one-third to a half in the strong compared with weak TRL jurisdictions (depending on the outcome).

There has been uncertainty regarding the effects of youth access restrictions on cigarette use.[6,7,16] Some authors of prospective studies in which age-specific prevalence of tobacco use was assessed before and after regulatory intervention to restrict youth access found reductions in cigarette use,[17–20] but others found no benefit.[21,22] Authors of 1 review of studies that reported changes in smoking associated with youth access restrictions found no relationship of vendor compliance or of changes in vendor compliance, with smoking prevalence in a meta-analysis of available studies,[6] perhaps because the restriction of commercial access resulted in a shift to social sources of cigarettes such as older friends or siblings. Authors of other observational studies have

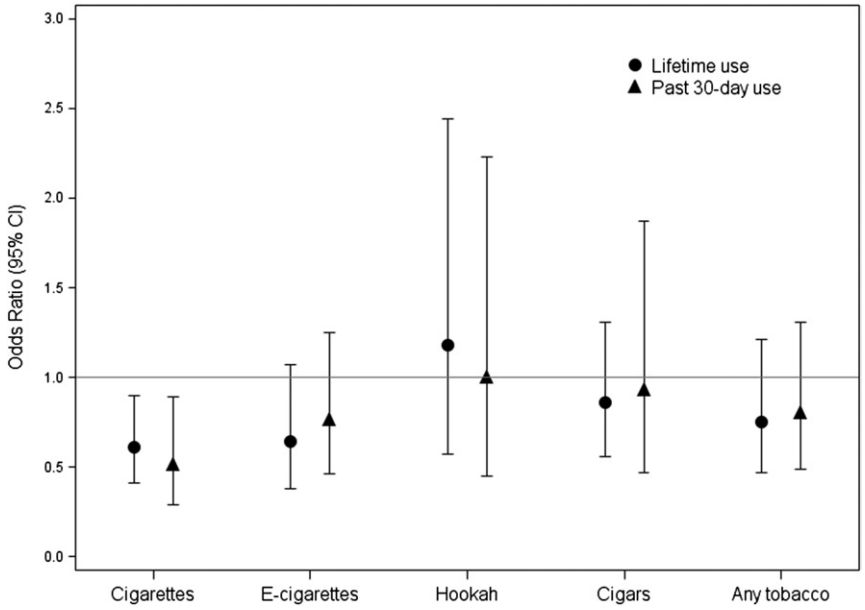

FIGURE 1

Associations of prevalent lifetime and current (last 30-day) use of each tobacco product at baseline with residence in ALA Reduced Tobacco Sales grade A jurisdictions, compared with residence in grade D or F jurisdictions. Models were adjusted for sex, ethnicity, parental education, age at baseline, and for any other tobacco product use at baseline (except for any tobacco product use prevalence, which was compared with never users of any tobacco product) and included a random effect for jurisdiction.

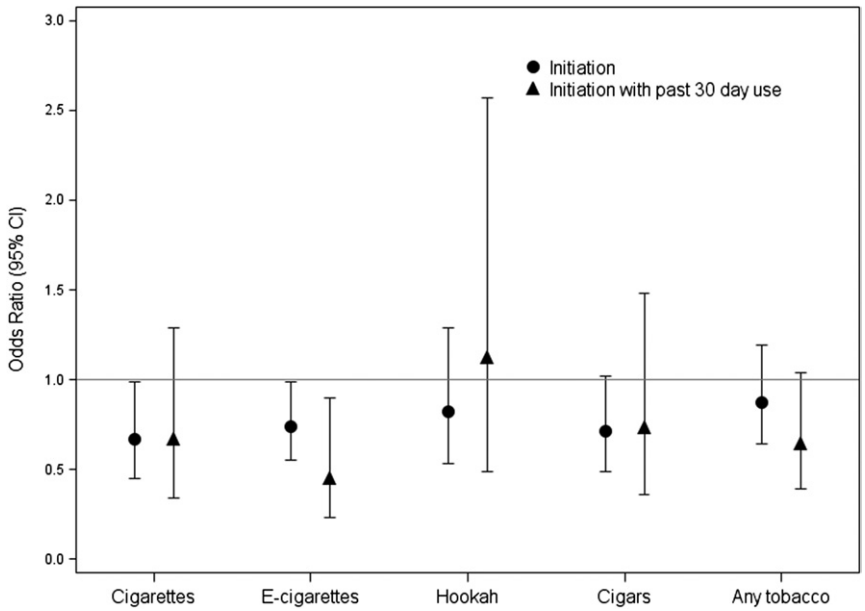

FIGURE 2

Associations of initiation of use of each tobacco product between baseline and follow-up and of initiation and current (last 30-day) use, with residence in ALA Reduced Tobacco Sales grade A jurisdictions, compared with residence in grade D or F jurisdictions. Each model was restricted to nonusers of product at baseline. Models were adjusted for sex, ethnicity, parental education, age at baseline, and for any other tobacco product use at baseline (except for any tobacco product use initiation, which was compared with never users of any tobacco product at either baseline or follow-up) and included a random effect for jurisdiction.

found reduced smoking rates in communities with youth access restrictions, but it was not clear that reduced access mediated the reduction in smoking rates.[19,23] For example, sustained reductions in adolescent daily smoking rates were observed in Minnesota communities that were randomly assigned to intervention supporting community organizers to develop and promote good TLR ordinances, compared with nonintervention communities.[20] However, it was not clear whether the observed reductions in smoking rates were due to youth access restrictions and improved vendor compliance or to other regulatory features resulting from the intervention, such as bans on vending machines and requirements for posted signs reporting age of sale policies, or for storing cigarettes behind the sales counter.[17]

Our results are broadly consistent with findings of a comprehensive review in which authors concluded that lower smoking rates occur if local TRL requires yearly compliance checks with effective enforcement.[7] Our study is 1 of the few that assessed associations of TRL with both prevalence and initiation rates in a prospective assessment of the same participants during an adolescent period of known high incidence of initiation. The prospective cohort design of the study also provided the opportunity to examine the impact of TRL on legal tobacco product use by young adults. The reduced risk of initiation of cigarette and e-cigarette use at follow-up in jurisdictions with better TRL regulation (with effect estimates that were unaffected by adjusting for time since turning 18 at follow-up) suggests that regulation may have lowered initiation rates even after participants reached the age for legal purchase. Although most adult smokers historically first use cigarettes before age 18,[12] in our cohort, rates of initiation of tobacco

product use were substantial, even in well-regulated jurisdictions. For example, in jurisdictions with an A grade, rates of initiation of cigarette and e-cigarette use during the follow-up period were 13.1% and 24.7%, respectively (from Table 1); these high rates of experimentation indicate a need for interventions to reduce initiation in this susceptible age window.

An alternative explanation for the protective effects of better TRL policy is that the associations reflected broadly unfavorable community attitudes toward cigarette use, including other tobacco regulations that affected the use of cigarettes and e-cigarettes to minors. If this were the explanation, we might expect to have seen associations with the other ALA tobacco grades relating to, for example, smoke-free housing, smoke-free outdoor air, or the overall tobacco grade in a jurisdiction. However, protective effects only of the TRL grade were observed.

Lower odds of cigar use initiation associated with better TRL regulation, although not statistically significant, were similar in magnitude to reductions in odds of the initiation of cigarettes and e-cigarettes. However, living in a jurisdiction with stronger regulation was not protective for baseline prevalence or subsequent initiation of hookah use. Sales of hookah paraphernalia often occur in specialty shops and hookah bars where cigarettes may not have been sold[24] and therefore may not consistently have been subjected to the same rigorous compliance checks as traditional cigarette vendors. E-cigarettes are commonly sold at locations that also sell cigarettes that would have been subject to TRL regulation, and a state law passed in 2010 made it illegal to sell e-cigarettes to minors.[25] However, e-cigarettes are also sold in specialty "vape" shops,[26] and at the time of the study, e-cigarettes were not specifically categorized as a tobacco product.[27] Therefore, vape shops were not required by state law to obtain a tobacco vendor license if they were not selling other tobacco products. If strong TRL regulation was responsible for the lower rates of e-cigarette use in A-grade jurisdictions, it is possible that similar TRL requirements for vape shops would have resulted in larger protective effects.

The US Food and Drug Administration (FDA) has contracts with regulators in most states to restrict youth tobacco access and also conducts its own inspections and hires third parties to conduct compliance checks.[28] However, the frequency of compliance checks is generally low, because of resource limitations, and penalties for violation of the law vary widely between states. California, for example, which has been a leader in tobacco control, annually inspected, on average, only 7% of tobacco retailers in 2016.[9,10] If a high rate of compliance checks, accompanied by enforcement, is necessary to reduce youth smoking as our results suggest, then strong local TRL ordinances may be an important option to reduce teen tobacco product use through access restriction.[10,29,30]

The study has some limitations. The ALA criteria for an A grade covered a relatively broad spectrum of TRL policy relevant to youth access, including larger fees, compliance access, and penalties if vendors violated the law. Identifying the possible effects of specific features of the TRL policy was not possible. A minimum proportion of vendors actually undergoing compliance checks was not specified, and it was not possible to assess the effect of the proportion of vendors visited. In addition, the "deeming rule" that defined e-cigarettes and hookah as tobacco products means that TRL will be required of all vendors of these products.[31] The recent increase in the legal age of tobacco product purchase to 21 years in California, passed after data collection for this study was completed, means that the associations of TRL policy with use during the transition to legal age of purchase may no longer be applicable to California. However, the results may broadly be generalizable to local jurisdictions in states with a legal purchase age of 18 years, with the exception of a few states that have prohibited local jurisdictions from enacting more stringent local regulation.[32] The increase of poorly regulated e-cigarette Internet vendors, a relatively new way for minors to obtain tobacco products illegally at the time of data collection, may limit the future impact of TRL as a regulatory tool.[33] Future follow-up of this cohort is warranted to determine the persistence of associations with strong youth TRL and to examine longitudinally potential mediating factors, such as social characteristics of neighborhoods and communities and individuals' changing tobacco social environment over time. There were also other potential confounders or mediators of TRL effects, such as differences in school-level tobacco prevention programs or number of tobacco outlets by jurisdiction, that were not available to study.

CONCLUSIONS

The results suggest that a strong local TRL ordinance that provides adequate resources to fund regular compliance checks and enforcement may result in large reductions in the use of cigarettes and may also result in reduced e-cigarette use. The benefits of these policies may extend into early adult life. The study also suggests that the success of future FDA regulation to reduce youth cigarette and alternative tobacco product access and use, under rules

deeming these products to be subject to FDA regulation,[31] may depend on the availability of resources for universal annual compliance checks and enforcement targeted to both traditional and alternative tobacco product vendors. Continued monitoring is needed to assess the impact on the effectiveness of TRL policy within the rapidly evolving tobacco product patterns of use, new national regulation, and poorly regulated Internet sales.

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ABBREVIATIONS

ALA: American Lung Association
CI: confidence interval
e-cigarette: electronic cigarette
FDA: US Food and Drug Administration
OR: odds ratio
TRL: tobacco retail licensing

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REFERENCES

1. Centers for Disease Control (CDC). State laws restricting minors' access to tobacco. *MMWR Morb Mortal Wkly Rep*. 1990;39(21):349–353
2. Preventing tobacco use among young people. A report of the surgeon general. Executive summary. *MMWR Recomm Rep*. 1994;43(RR-4):1–10
3. United States Department of Health and Human Services. Substance abuse prevention and treatment block grants: sale or distribution of tobacco products to individuals under 18 years of age. *Fed Regist*. 1993;58(164):45156–45174
4. United States Department of Health and Human Services Office of the Inspector General. State oversight of tobacco sales to minors. 1995. Available at: https://oig.hhs.gov/oei/reports/oei-02-94-00270.pdf. Accessed August 17, 2016
5. Forster JL, Widome R, Bernat DH. Policy interventions and surveillance as strategies to prevent tobacco use in adolescents and young adults. *Am J Prev Med*. 2007;33(suppl 6):S335–S339
6. Fichtenberg CM, Glantz SA. Youth access interventions do not affect youth smoking. *Pediatrics*. 2002;109(6):1088–1092
7. DiFranza JR. Which interventions against the sale of tobacco to minors can be expected to reduce smoking? *Tob Control*. 2012;21(4):436–442
8. Center for Tobacco Policy & Organizing; American Lung Association in California. Tobacco retailer licensing is effective. 2013. Available at: http://center4tobaccopolicy.org/wp-content/uploads/2016/10/Tobacco-Retailer-Licensing-is-Effective-September-2013.pdf. Accessed February 25, 2017
9. California Department of Health Care Services. State of California; 42 U.S.C. 300x-26, OMB No 0930-0222. FFY 2017. Available at: https://www.dhcs.ca.gov/provgovpart/Documents/Substance Use Disorder-PPFD/SYNAR_2017_Report.pdf. Accessed December 8, 2018
10. American Lung Association in California; The Center for Tobacco Policy and Organizing. Becoming a policy wonk on local tobacco retailer licensing: answers to tough questions from opponents and elected officials. June 2018. Available at: https://center4tobaccopolicy.org/wp-content/uploads/2018/06/Becoming-a-Policy-Wonk-on-TRL-2018-06-20.pdf. Accessed December 8, 2018
11. Singh T, Arrazola RA, Corey CG, et al. Tobacco use among middle and high school students–United States, 2011-2015. *MMWR Morb Mortal Wkly Rep*. 2016;65(14):361–367
12. Alberg AJ, Shopland DR, Cummings KM. The 2014 surgeon general's report: commemorating the 50th anniversary of the 1964 report of the advisory committee to the US surgeon general and updating the evidence on the health consequences of cigarette smoking. *Am J Epidemiol*. 2014;179(4):403–412
13. Barrington-Trimis JL, Berhane K, Unger JB, et al. Psychosocial factors associated with adolescent electronic cigarette and cigarette use. *Pediatrics*. 2015;136(2):308–317
14. Barrington-Trimis JL, Urman R, Berhane K, et al. E-cigarettes and future cigarette use. *Pediatrics*. 2016;138(1):e20160379
15. American Lung Association in California. State of tobacco control 2014 – California local grades. 2015. Available at: http://tobaccocontrol.usc.edu/files/SOTC_2014_CA_REPORT_and_GRADES_3_7.pdf. Accessed August 11, 2017
16. Etter JF. Laws prohibiting the sale of tobacco to minors: impact and adverse consequences. *Am J Prev Med*. 2006;31(1):47–51
17. Forster JL, Murray DM, Wolfson M, Blaine TM, Wagenaar AC, Hennrikus DJ. The effects of community policies to reduce youth access to tobacco. *Am J Public Health*. 1998;88(8):1193–1198

18. Jason LA, Ji PY, Anes MD, Birkhead SH. Active enforcement of cigarette control laws in the prevention of cigarette sales to minors. *JAMA*. 1991;266(22):3159–3161

19. Cummings KM, Hyland A, Perla J, Giovino GA. Is the prevalence of youth smoking affected by efforts to increase retailer compliance with a minors' access law? *Nicotine Tob Res*. 2003;5(4):465–471

20. Chen V, Forster JL. The long-term effect of local policies to restrict retail sale of tobacco to youth. *Nicotine Tob Res*. 2006;8(3):371–377

21. Rigotti NA, DiFranza JR, Chang Y, Tisdale T, Kemp B, Singer DE. The effect of enforcing tobacco-sales laws on adolescents' access to tobacco and smoking behavior. *N Engl J Med*. 1997;337(15):1044–1051

22. Bagott M, Jordan C, Wright C, Jarvis S. How easy is it for young people to obtain cigarettes, and do test sales by trading standards have any effect? A survey of two schools in Gateshead. *Child Care Health Dev*. 1998;24(3):207–216

23. Siegel M, Biener L, Rigotti NA. The effect of local tobacco sales laws on adolescent smoking initiation. *Prev Med*. 1999;29(5):334–342

24. Cawkwell PB, Lee L, Weitzman M, Sherman SE. Tracking hookah bars in New York: utilizing yelp as a powerful public health tool. *JMIR Public Health Surveill*. 2015;1(2):e19

25. California Legislative Information. Electronic Cigarettes, California State Senate Bill 882. 2009-2010 regular session. (Ca 2010). 2010. Available at: http://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200920100SB882. Accessed February 25, 2017

26. Lee YO, Kim AE. 'Vape shops' and 'e-cigarette lounges' open across the USA to promote ENDS. *Tob Control*. 2015;24(4):410–412

27. Legislative Counsel's Digest. Amendment to the stop tobacco access to kids enforcement (STAKE) act, Assembly Bill 1301. 2011-2012 regular session. (Ca 2012). 2012. Available at: www.leginfo.ca.gov/pub/11-12/bill/asm/ab_1301-1350/ab_1301_bill_20120618_amended_sen_v92.html. Accessed February 25, 2017

28. US Food and Drug Administration. FDA tobacco retail inspection contracts. 2016. Available at: www.fda.gov/TobaccoProducts/GuidanceComplianceRegulatoryInformation/Retail/ucm228914.htm. Accessed January 10, 2016

29. U.S. Food and Drug Administration; Tobacco Control Legal Consortium. State and local tobacco regulation in a post-deeming world. 2016. Available at: http://publichealthlawcenter.org/sites/default/files/resources/tclc-fda-deemingreg-state-and-local-regulation-2016.pdf. Accessed February 13, 2017

30. McLaughlin I. License to kill?: tobacco retailer licensing as an effective enforcement tool. 2010. Available at: http://publichealthlawcenter.org/sites/default/files/resources/tclc-syn-retailer-2010.pdf. Accessed February 25, 2017

31. Food and Drug Administration, HHS. Deeming tobacco products to be subject to the federal food, drug, and cosmetic act, as amended by the family smoking prevention and tobacco control act; restrictions on the sale and distribution of tobacco products and required warning statements for tobacco products. Final rule. *Fed Regist*. 2016;81(90):28973–29106

32. Lempert LK, Grana R, Glantz SA. The importance of product definitions in US e-cigarette laws and regulations. *Tob Control*. 2016;25(e1):e44–e51

33. Mackey TK, Miner A, Cuomo RE. Exploring the e-cigarette e-commerce marketplace: identifying Internet e-cigarette marketing characteristics and regulatory gaps. *Drug Alcohol Depend*. 2015;156:97–103

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