



# Adolescents' attitudes towards e-cigarette ingredients, safety, addictive properties, social norms, and regulation



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## ABSTRACT

E-cigarette use has dramatically increased. While studies have examined adolescents' attitudes towards smoking, few have extended this research to adolescents' attitudes towards e-cigarettes. The goal of this study was to examine adolescents' attitudes regarding e-cigarette ingredients, safety, addictive properties, social norms, accessibility, price, and regulation; and determine whether attitudes differ by past cigarette/e-cigarette use. Participants were 786 9th and 12th graders from California (63.21% females; mean age = 16.10 years [SD = 1.6]; 26.61% White, 21.98% Asian/Pacific Islander, 29.82% Hispanic, and 21.59% other). Results indicated that 19.05% of participants believed smoke from e-cigarettes is water; 23.03% believed e-cigarettes aren't a tobacco product; 40.36% considered e-cigarettes to be for cessation, and 43.13% felt they were safer than cigarettes. Participants felt it was more acceptable to use e-cigarettes indoors and outdoors compared to cigarettes ( $p < 0.0001$ ), 23.13% felt raising e-cigarette taxes is a bad idea, 63.95% thought e-cigarettes were easier to get than cigarettes, 54.42% felt e-cigarettes cost too much, 64.33% felt the age for buying e-cigarettes should be raised, and 64.37% favored e-cigarette regulation. Adolescents who used e-cigarettes and/or cigarettes had significantly more favorable e-cigarette attitudes than non-users. This study indicates that adolescents are aware of some of the risks of e-cigarettes, although many harbor misperceptions and hold more favorable attitudes towards e-cigarettes than cigarettes. Of concern is the relationship between favorable e-cigarette attitudes and use. Findings suggest the need to provide adolescents with correct information about e-cigarette ingredients, risks, and the insufficient evidence of their role in cigarette cessation.

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## 1. Introduction

Electronic cigarettes (also known as vapes, vaporizers, or vape pens) were introduced into the US market in 2007. They are generally battery-powered products that heat liquid into an aerosol that is inhaled by the user. These devices are designed to deliver nicotine and flavors; they also contain chemicals such as propylene glycol, glycerin, and many other constituents. Use of e-cigarettes has dramatically increased over the past 4 years, tripling among high school students from a rate of 4.5% in 2011 to 27.4% in 2014 (CDC, 2015, 2016). Further, 27.4% of adolescents in the U.S. have ever used e-cigarettes (CDC, 2015), with 30% of California youth reporting ever using an e-cigarette (California Department of Public Health, 2015).

Although research on the health effects of e-cigarettes is nascent, studies show that use of e-cigarettes likely increases lung inflammatory markers (Lerner et al., 2015; Wu et al., 2014) and impacts cardiovascular health (Dwyer et al., 2009; Lippi et al., 2014). Certain flavorants in e-cigarettes, when inhaled, cause toxicity, respiratory disease, and respiratory flow resistance (Barrington-Trimis et al., 2014; Behar et al., 2014; Farsalinos et al., 2015; Gardiner, 2013; Wu et al., 2014); and there are concerns about the impact of nicotine on the developing adolescent brain (Dwyer et al., 2009; England et al., 2015). There are also broader public health implications concerning adolescent e-cigarette use, with several studies showing that adolescents who use e-cigarettes are more susceptible to smoking combustible cigarettes (Barrington-Trimis et al., 2016; Bunnell et al., 2015; Leventhal et al., 2015; Moore et al., 2016; Primack et al., 2015; Wills et al., 2015, in press).

Despite studies showing the health effects of e-cigarettes, adolescents harbor misperceptions, including that e-cigarettes are safer than cigarettes, help people quit smoking conventional cigarettes, and do not contain any or just limited amounts of nicotine. Adolescents also

Abbreviations: SD, Standard Deviation; n, number.

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consider e-cigarettes to be trendier, more prevalent, and more acceptable than conventional cigarettes (Anand et al., 2015; Hammal and Finegan, 2016; Roditis and Halpern-Felsher, 2015; Trumbo and Harper, 2013). The lowest perceptions of harm and most positive attitudes regarding e-cigarettes have been reported by adolescents who have used e-cigarettes (Ambrose et al., 2014; 2015; Anand et al., 2015; Chaffee et al., 2015; Kong et al., 2015; Roditis and Halpern-Felsher, 2015; Roditis and Halpern-Felsher, 2015; Roditis et al., 2016; Trumbo and Harper, 2013).

The literature on e-cigarette attitudes thus far has predominantly focused on harm perceptions and general acceptability of and attitudes towards e-cigarettes and cigarettes. To our knowledge, there are few studies that have more comprehensively examined adolescents' specific attitudes towards and knowledge about e-cigarettes, and/or whether such attitudes differ between those who have and have not used e-cigarettes or other tobacco. Data on these more specific e-cigarette attitudes will guide public health officials, healthcare providers, and educators to develop more detailed, salient health messages and prevention efforts to address adolescents' misperceptions and ultimately deter e-cigarette use.

We thus examined a broad array of adolescents' knowledge and attitudes regarding e-cigarette ingredients, addictive properties, safety, cessation, perceived prevalence, accessibility, price, and regulation. We also examined whether these attitudes differ between adolescents who have and have not used cigarettes and/or e-cigarettes. Based on the small body of literature on e-cigarette attitudes, the larger set of literature on adolescents' attitudes towards cigarettes, and the relationship between such attitudes and tobacco use (e.g., Halpern-Felsher et al., 2004; Krosnick et al., 2006; Song et al., 2009; Roditis et al., 2016), we hypothesized that: (1) adolescents will believe that a greater number of parents, siblings, and peers are using e-cigarettes compared to cigarettes; (2) adolescents will hold more favorable attitudes towards e-cigarettes compared to cigarettes; (3) adolescents lack knowledge about the ingredients and harms associated with e-cigarettes; (4) adolescents will not support e-cigarette regulation; and (5) adolescents who have used e-cigarettes or cigarettes in the past will harbor more favorable attitudes and greater misperceptions about e-cigarettes compared to non-users.

## 2. Methods

### 2.1. Participants

Researchers visited school classes or assemblies, introducing the study and inviting 9th and 12th graders to participate. Consent forms and project information sheets were provided to students to take home and discuss with parents or guardians. An assent form signed by the prospective participant and a consent form signed by the parent or guardian was returned to school. Students >18 years old provided their own consent.

Approximately 4000 students learned about the study, of whom 1299 returned signed forms. Of these, 405 (31.1%) students were withdrawn from the study due to invalid contact information, ineligibility (wrong grade) or did not respond to subsequent contact by the researchers. Overall, 786 (87.9%) of eligible consented students completed the survey. The sample had fewer males and more females and a higher percentage of Asian students than schools from which we recruited. However, mother's education did not vary between those who did and did not complete the survey, and neither sex nor race/ethnicity had a significant main effect on the study outcomes. Further, rates of tobacco use among study participants were consistent with rates of use for California youth (Gilreath et al., 2016).

The sample size was designed to allow sufficient power (80%) to detect the contrasts of interest. The sample included 63.21% females and 36.67% males; mean age = 16.1 (SD = 1.6). Participants came from diverse ethnic backgrounds with 207 (26.61%) White, 171 (21.98%)

Asian/Pacific Islander, 232 (29.82%) Hispanic, and 168 (21.59%) other. Demographics of the students who participated in the study reflected the demographic make-up of their respective schools. Of the participants in this study, 4.9% had used cigarettes only, 11.08% had used e-cigarettes only, 7.73% had used both e-cigarettes and cigarettes, and 76.29% had used neither product (see Table 1).

### 2.2. Procedures

Participants were e-mailed a link to the survey administered through Qualtrics. To ensure privacy, participants were advised to complete the survey at one time, and at no point were their responses and names linked. Participants received a \$10 gift card for completing the survey. Participants took the survey from 07/2014 to 10/2015. All procedures were approved by our institutional review board.

### 2.3. Measures

Below describes the measures used for this study. Many items were derived from past surveys on adolescents' attitudes towards tobacco (e.g., Chaffee et al., 2015; Halpern-Felsher et al., 2004; Roditis and Halpern-Felsher, 2015; Song et al., 2009). All measures were pilot tested with adolescents of the same age and demographics of our sample; adolescents identified any items that were unclear. Through this process, we made adjustments to measures, and re-piloted the entire survey until all measures were clear.

#### 2.3.1. Demographics

Race/ethnicity was categorized into: Latino, white, Asian, and other. Age groups were combined into ages 13–15 and 16–19.

#### 2.3.2. Cigarette and e-cigarette use

Participants were asked, "During your entire life, how many times have you EVER used [e-cigarettes/cigarettes], even 1 or 2 puffs." Response choices included: never, 1–2 times, 3–10 times, 11–19 times, 20–30 times, 31–99 times, 100 or more times.

#### 2.3.3. Perceived prevalence of use of cigarettes and e-cigarettes

Participants were asked: (a) if their mother/female guardian, father/male guardian, siblings, or closest friends had ever used e-cigarettes or cigarettes; and (b) to evaluate how many teens out of 100 who were the same age, gender, and race-ethnicity were using e-cigarettes/cigarettes. See Table 2 for specific items asked. Similar questions have been asked in other studies on tobacco use and perceived prevalence (Lazuras et al., 2011; Pedersen et al., 2013; Sussman et al., 1988).

#### 2.3.4. Knowledge and attitudes regarding e-cigarette ingredients, safety, and addictive properties

Participants were asked if they agree or disagree with specific statements about e-cigarette ingredients, safety, and addictive properties (see Table 3). Response options were: strongly disagree (1), disagree, agree, and strongly agree (4). The content of these items were derived from qualitative interviews (Roditis and Halpern-Felsher, 2015) and pilot studies in which we elicited adolescents' knowledge and perceptions about e-cigarettes.

#### 2.3.5. E-cigarette and cigarette acceptability

Participants were asked about their perceived acceptability of e-cigarettes and cigarettes (Kong et al., 2015; Roditis and Halpern-Felsher, 2015). See Table 4 for specific items asked. Response options again ranged from strongly disagree (1) to strongly agree (4).

#### 2.3.6. Attitudes towards e-cigarette and cigarette price and government regulation

Participants responded to statements such as: e-cigarettes and cigarettes cost too much; raising taxes on e-cigarettes or cigarettes is a bad

**Table 1**  
Rates of e-cigarette and cigarette use, overall and by gender, age and race/ethnicity.

	Used neither (n; %)	Used cigarettes only (n; %)	Used e-cigarettes only (n; %)	Used both cigarettes and e-cigarettes (n; %)
Total sample (n = 786)	592; 76.29	38; 4.90	86; 11.08	60; 7.73
Males (n = 284)	203; 71.48	14; 4.93	39; 13.73	28; 9.86
Females (n = 491)	388; 79.02	24; 4.89	47; 9.57	32; 6.52
13–15 Year olds (n = 311)	271; 87.14	8; 2.57	22; 7.07	10; 3.22
16–19 Year olds (n = 465)	321; 69.03	30; 6.45	64; 13.76	50; 10.75
White (n = 207)	159; 76.81	7; 3.38	21; 10.14	20; 9.66
Asian (n = 168)	134; 79.76	3; 1.79	21; 12.50	10; 5.95
Latino (n = 228)	166; 72.81	18; 7.89	26; 11.40	18; 7.89
Other (n = 165)	128; 77.58	10; 6.06	17; 10.30	10; 6.06

idea; e-cigarettes or cigarettes should be regulated by the federal government; and raising the age at which you can use e-cigarettes or cigarettes is a good idea. Response options ranged from strongly disagree (1) to strongly agree (4). See Table 5 for specific items asked.

### 3. Analysis

Descriptive statistics including means, standard deviations, and percentages were used to describe the data. Within and between participant comparisons were tested by a generalized linear model using Proc Genmod in SAS 9.4. A linear regression model was used for continuously distributed dependent measures, and a logistic model was used for dichotomous measures. For analyses concerning tobacco use, given that few participants only used e-cigarettes or cigarettes (see Table 1), we collapsed the data as follows: individuals who had ever used an e-cigarette or cigarette were labeled as “ever users,” and those who had never used either e-cigarettes or cigarettes were labeled as “never users.” Covariates in the models included age category (13–15, 16–19), race (White, Asian, Latino, Other) and sex. All models accounted for clustering by school. Missing data, which varied item to item, were left as missing.

### 4. Results

#### 4.1. Perceived prevalence of e-cigarette compared to cigarette use among parents and youth

A greater number of participants reported that their parents were using cigarettes (33.00% of moms and 44.58% of dads) compared to e-cigarettes (8.16% for moms and 7.87% for dads;  $p < 0.001$ ). Participants reported a similar number of siblings who used cigarettes (18.17%) and e-cigarettes (15.43%), and similar numbers of close friends who used e-cigarettes and cigarettes, 32.28% and 31.80%, respectively ( $p > 0.05$ ). See Table 2 for specific numbers and statistics.

Adolescents who had ever used an e-cigarette and/or a cigarette reported a greater prevalence of both e-cigarette and cigarette use among parents, siblings, and closest friends, compared to those who hadn't used either product. Specifically, among users, 14.05% reported that their mom/female guardian used e-cigarettes, and 13.14% reported that their dad/male guardian used e-cigarettes, compared to 5.45% and 5.56% of non-users who reported their mom/female guardian and dad/male guardian used e-cigarettes, respectively ( $p < 0.002$  and  $p < 0.001$ , respectively). With respect to cigarettes, among users, 45.50% reported their mom and 51.56% reported their dad used

**Table 2**  
Adolescents' perception of friends' and family use of e-cigarettes and cigarettes, total and by past e-cigarette and cigarette use.

	E-cigarette (n; %) <sup>a</sup>			Cigarette (n; %) <sup>a</sup>			p-Value	Total sample: perceived prevalence of e-cigarette vs. cigarette use (a vs. d)	Users vs non-users: perceived prevalence of e-cigarette use (b vs. c)	Users vs. non-users: perceived prevalence of cigarette use (e vs. f)
	Total sample (a)	Users <sup>b</sup> (b)	Non-Users <sup>b</sup> (c)	Total sample (d)	Users <sup>b</sup> (e)	Non-Users <sup>b</sup> (f)				
As far as you know, has your <b>mother/female guardian</b> ever used any of the following products?	48; 8.16	26; 14.05	22 5.45	200; 33.00	91; 45.50	109; 26.98	<0.001	0.0002	<0.0001	
As far as you know, has your <b>dad/male guardian</b> ever used any of the following products?	43; 7.87	23; 13.14	20; 5.56	248; 44.58	94; 51.56	154; 41.29	<0.001	<0.0001	0.0007	
As far as you know, have your <b>siblings</b> ever used any of the following products?	84; 15.43	54; 30.17	30; 8.33	100; 18.17	54; 29.67	146; 12.64	NS	<0.0001	<0.0001	
As far as you know, have your <b>closest friends</b> ever used any of the following products?	195; 32.28	118; 55.40	77; 19.64	193; 31.80	119; 56.13	74; 18.69	NS (0.86)	<0.0001	<0.0001	

<sup>a</sup> n = number of participants who responded “yes” to the question; % = percentage of participants who responded “yes” to the question.

<sup>b</sup> “Users” were those who had ever used an e-cigarette and/or a cigarette; “non-users” were those who had never used either an e-cigarette or a cigarette.

**Table 3**  
Knowledge and attitudes regarding e-cigarette ingredients, addictive properties, safety, and cessation.

	Total sample Mean (SD)	Users <sup>a</sup> Mean (SD)	Non-Users <sup>a</sup> Mean (SD)	Users vs. non-users <sup>a</sup> : knowledge and attitudes towards e-cigarettes p value
Smoke from e-cigarettes is just water	1.82 (0.79)	2.06 (0.82)	1.68(0.73)	<0.0001
E-cigarettes don't contain tar	1.96 (0.83)	2.18 (0.83)	1.85 (0.80)	<0.0001
E-cigarettes aren't addictive	1.82 (0.81)	2.08 (0.88)	1.68 (0.72)	<0.0001
E-cigarettes aren't a tobacco product	1.88 (0.82)	2.02 (0.83)	1.80 (0.80)	<0.0001
E-cigarettes don't produce smoke	1.85 (0.76)	1.95 (0.79)	1.80 (0.74)	0.0022
Using e-cigarettes feels cleaner than smoking	2.27 (0.86)	2.43 (0.88)	2.19 (0.84)	<0.0001
E-cigarettes are safer than smoking	2.24 (0.90)	2.36 (0.89)	2.18 (0.89)	0.0002
Teens use e-cigarettes to get the same buzz they get from tobacco cigarettes	2.37 (0.86)	2.24 (0.85)	2.44 (0.85)	Ns (0.11)
E-cigarettes help people quit using cigarettes	2.22 (0.86)	2.41 (0.84)	2.12 (0.85)	<0.0001
E-cigarette vapor is dangerous to babies and kids	2.82 (1.01)	2.69 (0.93)	2.88 (1.03)	(0.019)

Response scale ranged from strongly agree (4) to strongly disagree (1).

<sup>a</sup> "Users" were those who had ever used an e-cigarette and/or a cigarette; "non-users" were those who had never used either an e-cigarette or a cigarette.

cigarettes ( $p < 0.0001$ ), whereas non-users reported that 26.98% of their mom/female guardians and 41.29% of their dad/male guardians used. Among users, 30.17% and 29.67% believed their siblings had used e-cigarettes or cigarettes, compared to 8.33% and 12.64% of non-users respectively ( $p < 0.0001$ ). Among users, 55.40% perceived a close friend used e-cigarettes, and 56.13% believed a close friend used cigarettes, compared to 19.64% and 18.69%, respectively, of non-users ( $p < 0.0001$ ). See Table 2 for more details.

Adolescents on average thought that 32.5 out of 100 (SD = 27.40) teens their age, gender, and ethnicity were using e-cigarettes, compared to 34.7 out of 100 (SD = 25.09) teens who were using cigarettes, with significant differences between users and non-users ( $p = 0.043$ ;  $p < 0.001$ ). Users believed more peers were using e-cigarettes than did non-users (36.20%, SD = 27.99, versus 30.55%, SD = 26.88, respectively;  $p < 0.01$ ). In contrast, users perceived fewer teens use cigarettes than did non-users (32.30%, SD = 24.68 versus 35.47%, SD = 24.99, respectively;  $p < 0.01$ ).

#### 4.2. Knowledge and attitudes regarding e-cigarette ingredients, addictive properties, and, safety

Almost one out of five participants (19.05%) agreed or strongly agreed that smoke from e-cigarettes is water, 23.03% felt e-cigarettes aren't a tobacco product, 26.38% believed e-cigarettes don't contain tar, and 18.98% believed e-cigarettes don't produce smoke. Almost two-thirds (66.72%) of adolescents agreed or strongly agreed that e-cigarette vapor is dangerous to babies and kids. Approximately 43.99% and 43.13% of participants believed that e-cigarettes feel cleaner and safer than smoking cigarettes, and 40.36% felt e-cigarettes help people quit cigarettes. 49.70% of participants agreed that teens use e-cigarettes to get the same buzz they get from tobacco cigarettes. See Table 3 for the means and standard deviations for each item.

Compared to non-users, adolescents who had ever used cigarettes or e-cigarettes were more likely to agree that e-cigarettes just produce water, don't contain tar, aren't addictive, aren't a tobacco product,

**Table 4**  
Perceived e-cigarette and cigarette acceptability.

	Total sample Mean (SD)	Users <sup>a</sup> Mean (SD)	Non-users <sup>a</sup> mean (SD)	Total sample: attitudes towards e-cigarette vs. cigarette p value	Users and non-users <sup>a</sup> : attitudes towards e-cigarettes and cigarettes p value
E-cigarettes should be allowed in indoor spaces such as malls and theatres	1.63 (0.73)	1.88 (0.77)	1.51 (0.68)	<0.0001	<0.0001
Smoking cigarettes should be allowed in indoor spaces such as malls and theatres	1.27 (0.62)	1.37 (0.68)	1.23 (0.58)	–	0.0008
E-cigarettes should be allowed in outdoor spaces such as parks	1.94 (0.90)	2.27 (0.92)	1.78 (0.85)	<0.0001	<0.0001
Smoking cigarettes should be allowed in outdoor spaces such as parks	1.57 (0.78)	1.76 (0.81)	1.47 (0.74)	–	0.0004
Friends think it's okay to use e-cigarettes	1.91 (0.93)	2.40 (0.94)	1.66 (0.83)	<0.0001	<0.0001
Friends think it's okay to use cigarettes	1.63 (0.77)	1.90 (0.86)	1.50 (0.69)	–	<0.0001
It's okay to use e-cigarettes in the house	1.80 (0.83)	2.13 (0.87)	1.62 (0.74)	–	<0.0001
E-cigarettes are futuristic	1.99 (0.78)	2.12 (0.74)	1.93 (0.79)	–	0.0004

Response scale ranged from strongly agree (4) to strongly disagree (1).

<sup>a</sup> "Users" were those who had ever used an e-cigarette and/or a cigarette; "non-users" were those who had never used either an e-cigarette or a cigarette.

**Table 5**  
Attitudes towards e-cigarette accessibility, price, and regulation.

	Total sample Mean (SD)	Users <sup>a</sup> Mean (SD)	Non-users <sup>a</sup> Mean (SD)	Total sample: attitudes towards e-cigarette regulation p value	Attitudes towards e-cigarette and cigarette regulation
E-cigarettes cost too much	2.46 (0.84)	2.49 (0.80)	2.46 (0.86)	0.0107	NS (0.19)
Cigarettes cost too much money	2.62 (0.98)	2.69 (0.95)	2.60 (0.99)	–	NS (0.54)
If e-cigarettes were more expensive, teens would be less likely to use them	2.89 (0.89)	2.71 (0.91)	2.98 (0.86)	0.0498	0.0001
If cigarettes were more expensive, teens would be less likely to use them	2.94 (0.86)	2.84 (0.89)	2.99 (0.85)	–	NS (0.07)
Raising the age at which you can use e-cigarettes is a good idea	2.77 (0.94)	2.51 (0.92)	2.90 (0.92)	0.000	0.0001
Raising the age at which you can use cigarettes is a good idea	2.86 (0.96)	2.67 (0.94)	2.95 (0.96)	–	0.002
Raising taxes on e-cigarettes is a bad idea	1.93 (0.82)	2.13 (0.84)	1.83 (0.79)	<0.0001	<0.0001
Raising taxes on cigarettes is a bad idea	1.76 (0.80)	1.90 (0.86)	1.70 (0.77)	–	0.0003
E-cigarettes should be regulated by the federal government	2.72 (0.91)	2.47 (0.87)	2.85 (0.91)	<0.0001	<0.0001
Cigarettes should be regulated by the federal government	2.89 (0.95)	2.72 (0.93)	2.98 (0.95)	–	<0.0001
Cigarettes are easier to get than e-cigarettes	2.20 (0.90)	2.13 (0.87)	2.24 (0.91)	–	NS (0.21)
Cigarettes are cheaper than e-cigarettes	2.32 (0.89)	2.29(0.85)	2.34 (0.90)	–	NS (0.47)

Response scale ranged from strongly agree (4) to strongly disagree (1).

<sup>a</sup> “Users” were those who had ever used an e-cigarette and/or a cigarette; “non-users” were those who had never used either an e-cigarette or a cigarette.

don't produce smoke, feel cleaner and are safer than smoking, and help people quit cigarettes (p-values ranged from  $p < 0.0001$  to  $< 0.0022$ ). Non-users were more likely to agree that e-cigarette vapor is dangerous to babies and children ( $p = 0.019$ ). There were no differences between users and non-users when asked if teens use e-cigarettes to get the same buzz they get from tobacco cigarettes ( $p = 0.11$ ). See Table 3 for specific numbers and statistics.

#### 4.3. E-cigarette and cigarette acceptability

Participants were generally more accepting of e-cigarette use in both indoor and outdoor spaces, compared to cigarettes, with 28.27% agreeing or strongly agreeing that e-cigarettes should be allowed in outdoor spaces such as parks, compared to 13.51% who agreed/strongly agreed that cigarette smoking should be allowed in those spaces ( $p < 0.0001$ ). 11.34% of participants agreed e-cigarettes should be allowed in indoor spaces, while only 5.21% agreed cigarettes should be allowed indoors ( $p < 0.0001$ ). Of the respondents, 20.92% agreed it was okay to use e-cigarettes in the house. Participants generally reported that their friends were more accepting of e-cigarette than cigarette use ( $p < 0.0001$ ), and 26.22% agreed that e-cigarettes are futuristic. See Table 4 for details on the means and standard deviations for each variable.

Participants who used e-cigarettes and/or cigarettes generally had more favorable views towards e-cigarette and cigarette use in indoor and outdoor spaces compared to those without such use experiences ( $p < 0.001$ ). Users were also more likely to believe their friends are accepting of e-cigarette and cigarette use ( $p < 0.01$ ; see Table 4 for means, SDs and significance tests).

#### 4.4. E-cigarette and cigarette accessibility, price, taxation, and regulation

Among participants, 64.33% and 65.53% agreed/strongly agreed that the age for buying e-cigarettes and cigarettes should be raised; 64.37% and 71.28% favored e-cigarette and cigarette regulation respectively; 23.13% and 15.22% felt that raising e-cigarette and cigarette taxes was a bad idea; 38.87% agreed/strongly agreed that cigarettes were easier

to get than e-cigarettes; 47.47% thought that cigarettes are cheaper; 49.63% and 54.84% of participants felt that e-cigarettes and cigarettes cost too much; and 69.79% and 73.21% felt that if e-cigarettes and cigarettes were more expensive, teenagers would be less likely to use them. See Table 5 for means, SDs, and statistics.

Compared to e-cigarette and cigarette users, non-users were more likely to believe that teens would be less likely to use e-cigarettes if they were more expensive ( $p < 0.0001$ ), that raising the age for buying e-cigarettes as well as cigarettes is good ( $p < 0.0001$  and  $< 0.002$ , respectively), and were more in favor of governmental regulation of e-cigarettes and cigarettes ( $p$ 's  $< 0.0001$ ). Users were more likely to feel that raising taxes on e-cigarettes and cigarettes is a bad idea ( $p$ 's  $< 0.0001$  and  $< 0.003$ , respectively). There were no significant differences between users and non-users about whether cigarettes were easier to get or cheaper than e-cigarettes, whether cigarettes or e-cigarettes cost too much, and whether teens would be less likely to use cigarettes if they were more expensive. See Table 5 for specific numbers and statistics.

## 5. Discussion

This is one of the first studies to more comprehensively examine adolescents' knowledge of and attitudes towards e-cigarette ingredients, addictive properties, safety, perceived prevalence, acceptability, and regulation (including taxation, age requirements, and price regulation). In our study of 9th and 12th graders, participants had more favorable attitudes towards and perceived less risk from e-cigarettes than cigarettes, and they expressed less support for policies that applied to e-cigarette than cigarette regulation. Participants believed that about 30% of their closest friends used e-cigarettes, which is approximately 10% higher than the self-reported rates in the sample. Their perceived prevalence is similar to the national rate of e-cigarette ever-use of 27.4% in the National Youth Tobacco Survey (Gilreath et al., 2016) and 30% in a California survey (California Department of Public Health, 2015), but much higher than the Monitoring the Future rate of 17.4% (NIDA, 2016). As we hypothesized, adolescents who have ever used

tobacco perceive greater prevalence of e-cigarette use among their parents, siblings, and peers. While there have been few studies published on the impact of adolescents' perceived prevalence of e-cigarette use, there are numerous studies that have focused on the relationship between adolescents' perceived prevalence, initiation, and acceptability of use of conventional cigarettes (D'Amico and McCarthy, 2006; Maxwell, 2002; Page et al., 2002; Pedersen et al., 2013; Tucker et al., 2011), showing that those who perceive cigarette use as more prevalent and acceptable are more likely to initiate tobacco use (Olds et al., 2005; Page et al., 2002). These findings are consistent with behavioral decision-making models, which argue that perceptions of risk and social norms influence behavioral engagement (Fishbein and Ajzen, 1975). These findings demonstrate the importance of developing educational and health messages that correct misperceptions about use rates of e-cigarettes, since it is plausible that beliefs about how many peers use e-cigarettes can translate into increased adolescent e-cigarette use.

While some adolescents in our study had correct general knowledge of e-cigarette ingredients and risks, many did not. Our findings are particularly concerning considering that positive perceptions of e-cigarettes may be increasingly common among teens (Berg et al., 2015; Kong et al., 2015). In a study conducted in 2013 among adolescents in North Carolina, 50–60% perceived e-cigarettes to be safer and less harmful than conventional cigarettes. In that sample, only 7.5% felt e-cigarettes were healthier than cigarettes, 3.5% felt they were trendier, and only 2% felt e-cigarettes were easy to get (Anand et al., 2015). While these samples are not directly comparable, the increase in positive perceptions towards e-cigarettes in our sample may be reflective of a changing shift in social norms around e-cigarette use that has occurred over the past 2 years, corresponding with the increase in actual use rates. It is thus important to educate adolescents about e-cigarettes, including harm from nicotine and flavorants (Barrington-Trimis et al., 2014; Behar et al., 2014; Dwyer et al., 2009), and the lack of clear evidence on its role as a cessation tool. Further, it is concerning that adolescents appear to be initiating tobacco use with e-cigarettes, which then can lead to cigarette use (Leventhal et al., 2015; Primack et al., 2015; Wills et al., in press).

Overall, adolescents in our study are more accepting of e-cigarette use in both indoor and outdoor settings, compared to cigarette use. One out of 10 adolescents believe that e-cigarettes should be allowed indoors, 3 out of 10 felt that e-cigarettes should be allowed in outdoor spaces, and 1 out of 5 adolescents felt it was okay to use e-cigarettes in their house. These numbers may reflect a shift in perceptions regarding e-cigarette use in public places, compared to perceptions of indoor and outdoor cigarette use. Interestingly, despite greater acceptance of e-cigarettes among the adolescents in our study, they were largely supportive of both e-cigarette and cigarette regulation, with 3 out of 5 adolescents feeling that the federal government should regulate e-cigarettes. This statement was particularly endorsed among adolescents who have not used cigarettes or e-cigarettes. A majority favored raising the age for buying e-cigarettes and cigarettes. This finding is important, especially given the recent IOM report showing the health effects of raising the minimum purchase age of tobacco to 21, as well as several states and localities raising their minimum purchase age to 21 (Bonnie et al., 2015). Adolescents also felt that e-cigarettes were easier to obtain than cigarettes, and a majority felt that if e-cigarettes cost more, teenagers would be less likely to use them.

This study was limited to a school-based convenience sample recruited from California schools, and given the relatively low response rate, as is true with other convenience samples, it is unclear how representativeness and generalizable the sample is compared to California adolescents. Nevertheless, our sample was similar to California adolescents with respect to tobacco use. Further, it is important to understand the perspectives of adolescents who grew up in a state with strong tobacco-free policies and anti-smoking social norms. The increased acceptability and positive attitudes towards e-cigarettes by adolescents

in California may be magnified in states with less stringent anti-tobacco laws.

In sum, these findings suggest that we need to provide adolescents with messages concerning e-cigarettes, including their ingredients, nicotine content, addictive properties, and risks. In addition, health care providers need to understand basic facts concerning e-cigarettes as well as adolescents' attitudes towards these products since e-cigarettes are becoming a more predominant tobacco product among adolescents. Healthcare providers need to regularly screen for e-cigarette use, and educate patients and parents about misconceptions associated with e-cigarettes (AAP, 2015).

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### Potential conflicts of interest

The authors have no conflicts of interest relevant to this article to disclose.

### Transparency document

The [Transparency document](#) associated with this article can be found, in the online version.

### Contributors' statements

Ms. Gorukanti helped conceptualize and design the study, drafted the initial manuscript, and approved the final manuscript as submitted.

Dr. Delucchi carried out all analyses, reviewed and revised the manuscript, and approved the final manuscript as submitted.

Dr. Ling helped conceptualize the study, reviewed and revised the manuscript and approved the final manuscript as submitted.

Mr. Fisher-Travis conducted a literature review, reviewed and revised the manuscript and approved the final manuscript as submitted.

Dr. Halpern-Felsher conceptualized and designed the study and survey, supervised the analysis, drafted the initial manuscript, and approved the final manuscript as submitted.

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