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Does Seeking e-Cigarette Information Lead to Vaping? Evidence from a National Longitudinal Survey of Youth and Young Adults

Qinghua Yang [a], Jiaying Liu [b], Kirsten Lochbuehler[c,e], and Robert Hornik [c,d]

[a]Department of Communication Studies, Texas Christian University; [b]Department of Communication Studies, University of Georgia; [c]University of Pennsylvania Tobacco Center of Regulatory Science (TCORS); [d]Annenberg School for Communication, University of Pennsylvania; [e]Perelman School of Medicine, University of Pennsylvania

ABSTRACT

Youth and young adults (YYAs) are vulnerable populations for e-cigarette use or vaping. This study examined the effect of YYAs' health information seeking behavior (HISB) around e-cigarette use and vaping on their subsequent vaping behavior. We conducted a nationally representative longitudinal phone survey of 13–25 year olds from June 2014 to September 2016, with 2,413 respondents who completed a baseline and follow-up survey six months later. The results from lagged logistic regressions and mediation analyses showed a) that information seeking predicted higher likelihood of vaping six months later even after controlling for baseline smoking and vaping status, intention to vape, and demographics, and b) that information seeking partially mediated the relationship between intention to vape and subsequent vaping behavior. Theoretical and regulatory implications are discussed.

Electronic Nicotine Delivery Systems (ENDS), including electronic cigarettes (e-cigarettes), cigalikes, tank systems, personal vaporizers and other similar devices, are battery-powered devices designed to deliver nicotine and simulate smoking by vaporizing a flavored liquid producing an inhaled aerosol (NIDA, 2016). Vaping refers to the use of e-cigarettes, but also to the use of the mentioned devices.[1]

The global market for ENDS (and their non-nicotine counterparts) in 2015 was estimated at almost $10 billion (WHO, 2016). E-cigarette sales, in particular, have been steadily increasing since their introduction to the American market around 2007, totaling $2.5 billion in 2014, and some projected that they would surpass traditional cigarette sales by 2047 (Mickle, 2015; Robehmed, 2013). E-cigarette marketing had been referred to as the "wild west" due to the lack of regulation, which meant that the information available in media sources was uncontrolled. For example, although the science is in dispute, health benefits and cessation-related claims, such as reduced harm and using e-cigarettes or vaping to quit smoking, are predominant on ENDS retail websites (Grana & Ling, 2014). If individuals are seeking information about ENDS, they are likely to find pro-ENDS information readily available.

In 2016, the U.S. Food and Drug Administration (FDA) issued a rule that deemed e-cigarettes to be subject to FDA's oversight (FDA, 2016), which may provide opportunities to constrain what claims about e-cigarettes can be made. To better inform the FDA and the federal rule about the direction of e-cigarette information regulation in the public communication environment (PCE), this article presents the research on how e-cigarette-related information is retrieved and consumed by the public, and how such exposure affects vaping behavior, especially among vulnerable youth and young adult (YYA) populations.

Rapidly growing marketing of and media attention to e-cigarettes have pervaded the PCE throughout the past years (Noel, Rees, & Connolly, 2011). E-cigarettes have been marketed heavily via not only traditional media channels – on television, on the radio, in magazines—but also online, via social media, at retail stores, and at sport events and music festivals (e.g., Duke et al., 2014; Ganz et al., 2015; Grana & Ling, 2014; Huang, Kornfield, Szczypka, & Emery, 2014; Luo, Zheng, Zeng, & Leischow, 2014; Paek, Kim, Hove, & Huh, 2014). Besides the heavy marketing of e-cigarettes, media has also given attention to the product in the form of increased newspaper and online media coverage (Rooke & Amos, 2014). Moreover, the interest in the product has been increasing. A study monitoring Google search queries from January 2009 to January 2015 reported rapidly increasing levels of e-cigarette web searches in every U.S. state indicating that people actively seek information about e-cigarettes (Ayers, Althouse, Allem, Leas, Dredze, & Williams, 2016).

Such aggressive marketing and the considerable media coverage of e-cigarettes could be a great public health concern, if exposure to such information leads to experimentation and established use. Meanwhile, previous research argued that younger populations are especially vulnerable to the persuasive advertising messages because they may not be able to protect themselves from well-produced commercials and may not be able to recognize the selling intent (e.g., Biener & Albers, 2004). The use of e-cigarettes by YYAs has substantially increased in the last few years (Camenga et al.,

CONTACT Qinghua Yang q.yang@tcu.edu Department of Communication Studies, Texas Christian University, TCU Box 298045, Fort Worth, TX 76129, USA.

2014; Campaign for Tobacco-Free Kids, 2015), although it may have reached a plateau by mid-2014 and declined since then (Hornik & Gibson, 2016; Miech, Johnston, O'Malley, Bachman, & Schulenberg, 2016). The prevalence of youth who reported using e-cigarettes but had never smoked a combustible cigarette tripled between 2011 and 2013 (Bunnell et al., 2015). Youth who exclusively use e-cigarettes also reported significantly greater intention to use (Bunnell et al., 2015) and eventual initiation (Wills et al., 2016) of combustible cigarette use than never e-cigarette users.

Despite the prevalence of e-cigarette use among YYAs and its potential significance as a public health issue, no study so far has examined how YYAs' exposure to e-cigarette information influences their vaping behavior. To fill this gap, in the current study, we examine whether seeking e-cigarette information predicts later vaping behavior even when adjusted for baseline behavior and potential confounders. We also investigate whether seeking mediates the expected effects of intention on behavior.

Intention and behavior

One of the most frequently used models for the prediction of many health-risk behaviors is the Theory of Reasoned Action (TRA) later incorporating a fuller set of predictors in the Reasoned Action Approach (RAA; Fishbein & Ajzen, 2011). The TRA proposed that an individual's behavioral intention (i.e., his/her intention to perform a certain behavior), forms the proximal and most direct determinant of a person's actual behavior, when the behavior is under volitional control (Fishbein & Ajzen, 1975, 2011). Fishbein and Ajzen reported that "overall, intentions have considerable predictive validity" (2011, p. 68). In a meta-analytic review of 87 studies using the TRA, Sheppard and colleagues (1988) found a significant and substantial relationship between individuals' intention and behavior, with the mean correlation coefficient being .53 for 11,566 participants. We will show parallel and thus unsurprising evidence for the ability of intention to predict subsequent behavior here.

H1: YYAs' vaping intention positively predicts their e-cigarette use six months later.

However, the more intriguing analyses take one further step and ask about the evidence for information seeking as a mediator of the intention-behavior link.

Health information seeking behavior

Access to health information in the PCE may contribute to an individual's health knowledge (Brashers, Goldsmith, & Hsieh, 2002), and be a first step toward health behavior change (Freimuth, Stein, & Kean, 1989). Health information seeking behavior (HISB) is an "active effort to obtain specific information" in response to a health issue in a manner beyond routine or customary exposure to information sources (Niederdeppe et al., 2007, p. 154). HISB merits particular attention from researchers given (1) the growing reliance on individuals' active participation in health care, leading to a paradigm shift from a paternalistic to a shared decision-making model (Institute of Medicine, 2001), and (2) the increased availability of healthcare options and ubiquity of health information (Viswanath, 2005). Individuals may seek health information from various sources (e.g., Brashers et al., 2002), including family members, mediated sources (e.g., Internet, social media), and health care providers. Previous studies have documented HISB's positive association with health behavior and other outcomes, such as improved health knowledge about cancer and cancer-preventive lifestyle choices (Shim, Kelly, & Hornik, 2006), healthy eating behavior (e.g., Moldovan-Johnson, Martinez, Lewis, Freres, & Hornik, 2014), cancer screening (e.g., Lee, Zhao, & Pena-y-Lillo, 2016), and self-reported excellent/good health status (Feinberg et al., 2016).

However, Johnson and Case (2012) also cautioned about potential negative outcomes of HISB, arguing that "it is not that people do not gather information or learn things, but often they gather the wrong information for the wrong reasons from the wrong sources" (p. 133). Previous content analyses have documented that information that is positive or supportive of e-cigarette use (i.e., pro-e-cigarette information) dominates across different media channels, particularly on web and social media sources (e.g., Cole-Lewis et al., 2015; Grana & Ling, 2014; Klein et al., 2016; Luo et al., 2014; Paek et al., 2014; Richardson, Ganz, Stalgaitis, Abrams, & Vallone, 2013). Using a large national survey, Emery, Vera, Huang, and Szczypka (2014) observed that while e-cigarette information searching was rare (5%), it was associated with tobacco use. However, it remains unclear whether information seeking and e-cigarette use are associated. The current study addresses the issue of the relationship between e-cigarette information seeking and use directly, and explores predictive effects with data collected over time.

High availability of pro-e-cigarette information in the PCE facilitates access to such information, and may directly give rise to YYAs' uptake of e-cigarettes. It may also stimulate their curiosity about vaping, and in turn drive additional seeking of information. Also, YYAs who are already using or intending to use e-cigarettes may seek information to justify their vaping behavior. In both cases, they are likely to find a prevailing pro-e-cigarette information environment, which may lead them to reinforce their intentions, initiate or maintain vaping behavior. Out of this narrative about reciprocal relationships among intentions, information seeking, and behavior, and the crucial assumption that the e-cigarette information landscape is fundamentally pro-e-cigarettes, we focus on two expected relationships. We hypothesize that YYAs' e-cigarette information seeking predicts their subsequent e-cigarette use and that it mediates the relation between their vaping intention and behavior at a later time.

H2: YYAs' e-cigarette HISB positively predicts their e-cigarette use six months later.

H3: The relation between YYAs' intention to use e-cigarettes and their e-cigarettes use six months later is mediated by YYAs' e-cigarette information seeking.

Method

Participants

Data were collected using a nationally representative phone survey of 13–25 year olds between June 2014 and December 2016. A panel of participants was recruited by Social Science Research Solutions from a partially list-assisted, random digit dial population of all landline telephone and cellphone numbers in the U.S. to provide a probability-based sample. The American Association of Public Opinion Research response rate three for the cross-sectional interviews was estimated at 21%. About 35% of the participants who completed the interviews at Time 1 (T1) were successfully re-interviewed at Time 2 (T2) six months later.[2] Only participants who completed the interviews at both T1 and T2 were included in the lagged analyses (n = 2,799). 13–17 year olds took up 49.04% and 56.27% of the cross-sectional and longitudinal data respectively. Sample demographics, comparing the original sample with those retained for analysis, are shown in Table 1. There are some differences, mostly related to the lower retention of the older sample members. The retained sample was then less far along in school, and less likely to be engaged in tobacco and e-cigarette use. The samples were weighted to the known current census population distributions on major demographic variables for the analyses.[3]

Measures

E-cigarette information seeking

Participants were asked an extended set of questions about the information engagement around tobacco cigarettes. After that sequence, the phone interview turned to e-cigarettes. Participants' e-cigarette information seeking behavior was measured by asking "Now I'd like to ask you specifically about vaping or using e-cigarettes. Thinking about the past 30 days, did you *actively* look for information about vaping or using e-cigarettes, yes or no?" The responses were recorded on a dichotomous scale with 0 = *No* and 1 = *Yes*. The information seeking measure, together with other parallel information exposure measures has been examined extensively in prior studies and demonstrated good construct validity (e.g., Kelly, Niederdeppe, & Hornik, 2009; Shim et al., 2006). In the current longitudinal dataset, the measure also provides consistent assessment over time; 94% reported the same seeking behavior at T1 and T2, with T1 seekers much more likely than non-seekers to again report being previous 30-day seekers at T2 (*OR* = 10.15, 95% CI = 5.90, 17.48).

Current e-cigarette use

Current e-cigarette use was measured by asking "During the past 30 days, did you vape or use e-cigarettes?" with 0 = *No* and 1 = *Yes*. This question is a standard measure for asking current

Table 1. *Demographics for the full sample* (*N* = 10,123) *and re-contact sample* (*N* = 2,799).

	Full sample (T1, unweighted)	Re-contact (T1, unweighted)	Full sample (T1, weighted)	Re-contact (T1, weighted)	Re-contact (T2, weighted)	Test Statistics
Age (years; *M* ± *SD*)	18.44 ± 3.70	17.26 ± 3.47	19.08 ± 3.91	18.66 ± 3.51		t = 5.34***
Female (%)	47.34	45.41	49.13	49.44		$\chi^2(1)$ = .08
Race/ethnicity (%)						$\chi^2(3)$ = 5.49
Non-Hispanic White	50.85	57.31	51.82	53.58		
Non-Hispanic African American	14.52	12.29	14.16	14.08		
Hispanic	22.66	19.03	21.26	21.12		
Other	11.98	11.36	12.77	11.22		
Education (%)						$\chi^2(1)$ = 1.04
Less than high school	42.22	56.89	35.63	35.83		
High school	22.92	15.49	29.38	28.94		
Some college	22.39	17.50	26.26	26.95		
College degree or more	11.46	10.11	8.73	8.28		
Parental education (%)						$\chi^2(1)$ = 12.85*
Less than high school	5.72	4.10	6.85	5.94		
High school	21.71	18.68	25.92	25.96		
Some college	15.97	15.09	18.86	19.39		
College degree	31.45	31.06	26.98	24.70		
Completed graduate school	25.15	31.06	21.39	24.01		
Intention to vape (%)						$\chi^2(3)$ = 2.91
Definitely will not	73.61	76.56	71.89	70.48	68.93	
Probably will not	15.43	14.85	15.80	16.63	18.87	
Probably will	7.26	5.80	7.96	8.68	7.26	
Definitely will	3.70	2.79	4.35	4.22	4.94	
Current cigarette smokers (%)	12.37	7.88	15.69	15.24	15.96	$\chi^2(1)$ = .33
Current e-cigarette users (%)	10.29	8.51	11.30	12.29	12.39	$\chi^2(1)$ = 2.15
Ever puffed a cigarette (%)	28.77	22.31	33.91	35.35	37.91	$\chi^2(1)$ = 1.98
Ever puffed an e-cigarette (%)	25.56	21.61	28.36	31.67	36.16	$\chi^2(1)$ = 11.64**
Seeking for e-cigarette information (%)	4.65	4.75	5.20	5.92	5.23	$\chi^2(1)$ = 2.35
Sensation seeking (*Min* = 1, *Max* = 4; *M* ± *SD*)	2.49 ± .52	2.46 ± .52	2.50 ± .52	2.51 ± .52	2.51 ± .52	t = - 1.47
Number of close friends who vape (*Min* = 0, *Max* = 4; *M* ± *SD*)	.68 ± 1.12	.60 ± 1.06	.71 ± 1.14	.71 ± 1.12	.67 ± 1.07	t = -.04
Vaping allowed at home (%)	21.15	18.68	23.54	24.82	23.56	$\chi^2(1)$ = 2.02

Note. The percentage was calculated without including the missing values. The demographic variables for the T2 weighted re-contact sample (fifth column) was not reported because they are the same as those in the T1 weighted re-contact sample (fourth column). The last column shows the statistics comparing the mean (t statistic) or proportion (χ^2 statistic) of each demographic variable of the weighted T1 full sample (third column) and the weighted T1 re-contact sample (fourth column). *p < .05, **p < .01, ***p < .001.

behavior status. Past 30-day vapers at T1 were much more likely to report ever use of e-cigarettes at T2 (93% versus 20% of T1 non-users; *OR* = 51.32, 95% CI = 28.74, 91.63) and again claim past 30 day use at T2 (*OR* = 11.70, 95% CI = 7.94, 17.25).

Intention to use e-cigarettes

Participants' intention to vape in the next six months was assessed by asking "How likely is it that you will vape or use an e-cigarette, even one or two puffs, at any time in the next 6 months?" Items were measured on a 4-point scale (1 = *definitely will not*, 2 = *probably will not*, 3 = *probably will*, 4 = *definitely will*). Higher values indicate participants' higher intention to vape in the next six months. The intention to vape in the next six months measured at T1 shows clear correspondence with the vaping behavior assessed six months later. Intention to vape at T1 ranges from *definitely will not* to *definitely will*, and the percentages of participants reporting use of e-cigarettes at T2 demonstrate an evidently increasing trend, that is, 2%, 13%, 55%, and 68% at each of the intention levels. The intention measure has strong support for its validity; it predicts the behavior it is meant to predict. Below we consider whether that association is likely to be causal, adjusting for prior behavior and potential confounders. To make the effect sizes comparable across predictors in the logistic regression models, the highly skewed 4-point scale was recoded into a binary measure with 0 = *definitely will not* and 1 = *probably will not/ probably will/ definitely will* in the analysis.

Other confounders

All models were adjusted for potential confounders, including baseline vaping and smoking statuses, sensation seeking, number of close friends who vape, household vaping rule, age, gender, race, and parents' education level (see Table 1 for details). Parental education was used as a proxy for social economic status.

Valence

To better understand the valence of e-cigarette information participants sought, survey respondents who said they sought e-cigarette information were asked to characterize its valence ("Was the information you looked for mostly positive about vaping or using e-cigarettes, mostly negative, or a mix of positive and negative?").

Data analyses

We tested the hypotheses in three steps. First, we examined the zero-order correlations of the key variables (i.e., e-cigarette vaping intention, e-cigarette information seeking, e-cigarette and cigarette use) both cross-sectionally and longitudinally. In order to establish temporal order of the key variables, we conducted lagged logistic regression analyses as the second step to provide further evidence for the causal order of effects using two waves of panel data. Each of the lagged models were adjusted for the T1 measure of the corresponding variables and potential confounders. The data are weighted to represent the population, and analyses use standard errors corrected for the use of weighted data. In addition, recognizing the possibility of the reverse direction of all the relations, we conducted sensitivity analyses using reverse lagged regression models. Finally, we also analyzed whether the relationship between e-cigarette HISB and subsequent vaping behavior is conditional on age group, baseline vaping and smoking status.

To test the longitudinal mediation effects using two-wave panel data, we used e-cigarette vaping intention at T1 as the independent variable, e-cigarette information seeking at both T1 and T2 as the mediators respectively, and e-cigarette use at T2 as the dependent variable. We implemented bootstrapping with 500 replications to obtain bias-corrected 95% confidence intervals for making statistical inference about the total and specific indirect effects (Preacher & Hayes, 2008). All analyses were conducted using STATA 14.0.

Results

Descriptive data

Table 1 shows descriptive statistics of demographic and key variables for participants included in the current study. After weighting the full and retained samples at T1, all focal variables are comparable ($p > .05$). However, the retained sample is on average younger than the full sample. This difference could be attributed to the difficulty of retaining the older respondents, because the younger ones went through a more demanding recruitment process including parental permission, and once they were involved they were more likely to continue. Table 2 shows the zero-order correlations among the key variables; all variables were significantly correlated with each other at both waves and across waves ($p < .001$). Specifically, e-cigarette information seeking was significantly correlated with vaping at both T1 ($r = .29$, $p < .001$) and T2 ($r = .28$, $p < .001$).

Cross-sectional analyses

Cross-sectionally, the binary e-cigarette vaping intention variable was significantly associated with e-cigarette use after controlling for participants' demographics, smoking status, and potential confounders (*OR* = 11.36, $p < .001$). In addition, e-cigarette information seeking significantly predicted e-cigarette use after controlling for smoking status, demographics, and confounders (*OR* = 6.50, $p < .001$); the effect of seeking (*OR* = 4.36, $p < .001$) remained significant even after controlling for vaping intention.

Lagged analyses

In the lagged analyses, we found that the intention to use e-cigarettes at T1 significantly predicted e-cigarette use at T2

Table 2. *Descriptive statistics and zero-order correlation matrix of focal variables (based on the weighted sample, n = 2,799).*

Variable	1	2	3	4	5	6	7	8
1. Intention to vape (T1)	–	.35	.67	.43	.61	.22	.47	.38
2. E-cigarette information seeking (T1)		–	.35	.12	.28	.26	.29	.09
3. E-cigarette use (T1)			–	.34	.46	.14	.41	.29
4. Cigarette use (T1)				–	.40	.14	.33	.72
5. Intention to vape (T2)					–	.37	.71	.41
6. E-cigarette information seeking (T2)						–	.34	.10
7. E-cigarette use (T2)							–	.32
8. Cigarette use (T2)								–

Note. The descriptive statistics of these focal variables can be found in Table 1. All pairwise correlation coefficients presented in this table are significant at the .001 level.

Table 3. Lagged logistic regression analyses predicting vaping behavior at T2 (N = 2,799).

H1: Intention (T1) → Vaping Behavior (T2)			H2: HISB (T1) → Vaping Behavior (T2)		
Predictor (T1)	*B(SE)*	OR (95% CI)	Predictor (T1)	*B(SE)*	OR (95% CI)
Intention to vape	1.19 (.26)***	3.29 (1.98, 5.45)	E-cig information seeking	1.05 (.29)***	2.84 (1.62, 4.99)
Age	.05 (.03)	1.05 (.99, 1.12)	Age	.05 (.03)	1.05 (.99, 1.12)
Male	.04 (.22)	1.04 (.68, 1.59)	Male	.07 (.22)	1.07 (.70, 1.64)
Race (reference = White)			Race (reference = White)		
Hispanic	−.58 (.28)*	.56 (.32, .97)	Hispanic	−.54 (.29)	.58 (.33, 1.01)
Black	−.34 (.39)	.71 (.33, 1.54)	Black	−.33 (.39)	.72 (.33, 1.55)
Other	.37 (.33)	1.45 (.76, 2.76)	Other	.39 (.32)	1.48 (.78, 2.80)
Parental education	−.02(.09)	.98 (.82, 1.18)	Parental education	−.00 (.09)	1.00 (.83, 1.20)
E-cig use	.81 (.28)**	2.24 (1.30, 3.86)	E-cig use	.62 (.29)*	1.86 (1.06, 3.27)
Cigarette use	1.09 (.25)***	2.98 (1.82, 4.86)	Cigarette use	1.14 (.25)***	3.14 (1.92, 5.15)
Sensation seeking	.07 (.22)	1.07 (.70, 1.65)	Sensation seeking	.04 (.22)	1.04 (.68, 1.61)
Number of close friends who vape	.41 (.09)***	1.51 (1.27, 1.80)	Number of close friends who vape	.38 (.09)***	1.46 (1.23, 1.74)
Household vaping rule (reference = no)	.25 (.23)	1.28 (.82, 2.01)	Household vaping rule (reference = no)	.21 (.23)	1.23 (.78, 1.94)
			Intention to vape	1.15 (.27)***	3.16 (1.87, 5.34)

Note. *$p < .05$, **$p < .01$, ***$p < .001$.

($OR = 3.29$, $p < .001$), after controlling for baseline smoking and vaping status, and confounders, which supported H1. The longitudinal analysis showed that e-cigarette HISB at T1 positively predicted e-cigarette use at T2 ($OR = 2.84$, $p < .001$), even after controlling for vaping status, vaping intention, and confounders at baseline. Thus, H2 was supported. See Table 3 for detailed results. It is worth noting that the opposite effect, whether vaping at T1 predicted HISB at T2, was not supported ($OR = 0.65$, $p = .30$). Also, none of the interactions between e-cigarette HISB and age group (13–17 or 18–25 year olds), baseline vaping or smoking status was significant in predicting subsequent vaping behavior.

Testing the mediation hypothesis was limited in the current study by having only two waves of data; we were not able to test whether intention at T1 predicts HISB at T2 that in turn predicts use at T3. To resolve this, we show that the prediction from intention at T1 to use at T2 is mediated both by HISB at T1 and at T2. The longitudinal mediation analyses showed that e-cigarette information seeking at both T1 (indirect effect = .03, 95% CI = .01–.05; total effect = .29, 95% CI = .18–.36) and T2 (indirect effect = .07, 95% CI = .04–.10; total effect = .36, 95% CI = .28–.43)[4] significantly mediated the relation between vaping intention at T1 and vaping at T2, which supported H3.

Discussion

In this study, we showed that in a nationally representative sample of 13–25 year olds, both vaping intentions and e-cigarette information seeking predicted vaping or using e-cigarettes six months later; in part, the influence of intentions on use was mediated by information seeking. All effects were maintained after adjustments for all variables at the baseline, and important potential confounders, as well as weighting the sample to the population. Thus, YYAs who intended to vape at T1, regardless of their age group, baseline smoking and vaping status, were more likely to vape at T2, with the effect partially mediated by e-cigarette HISB. We presented evidence that those who sought e-cigarette use or vaping information reported that the information they saw was often positive or mixed in valence.

We speculate that these findings would be consistent with at least two different processes. Individuals might be open to the use of e-cigarettes and engage in HISB that reinforces their intention and leads to actual use. Or the presence of pro-e-cigarette information in the PCE creates curiosity about vaping, which leads to e-cigarette use through information seeking. These similar processes rely on the crucial assumption that the PCE is largely favorable towards e-cigarettes. Other studies were consistent with this claim (e.g., Cole-Lewis et al., 2015; Luo et al., 2014; Paek et al., 2014), and our survey provides additional evidence. E-cigarette information sought in the current study was mostly pro-e-cigarette (38% at T1; 32% at T2) or mixed (50% at T1; 57% at T2) but rarely negative (12% at T1; 11% at T2). This contrasts with tobacco cigarette information sought, with rare positive reports (9% at T1 and 5% at T2) but commonly negative reports (57% at T1; 48% at T2). A lagged logistic regression model shows that YYAs' cigarette information seeking was not a significant predictor of their smoking behavior six months later.[5] The contrast in the evidence about cigarette versus e-cigarette seeking on respective behaviors is clear. We speculate about a number of influences: e-cigarettes are novel so information about them provides new knowledge; smokers may already be immune to the persuasive information about the harms of cigarette smoking and the health benefits of quitting. In addition, while e-cigarette information is both positive and negative, cigarette information is almost always negative; it may be harder to reduce the initiation or increase cessation (the expected effect of an anti-tobacco communication environment) than to increase initiation of vaping. In particular, the addictive nature of nicotine also hinders smokers' quitting behavior in response to information seeking even though they intend to stop.

The prevalence of pro-e-cigarette information has been attributed to the heavy marketing and advertising of e-cigarettes through traditional and online channels (Duke et al., 2014; Ganz et al., 2015; Grana & Ling, 2014). For instance, health benefits were the most frequent claims of e-cigarette websites, such as e-cigarettes' absence of carcinogens, being effective cessation tools, reduced harm relative to tobacco cigarettes, and being harmless to others (Grana & Ling, 2014). Other non-health-related benefits include e-cigarettes'

ability to be concealed, demonstration of sociability and individuality, and environmental friendliness (Grana & Ling, 2014; Richardson et al., 2013). Our results offer several important theoretical and regulatory implications.

Theoretical and regulatory implications

Several scholars (e.g., Anker, Reinhart, & Feeley, 2011; Case, Andrews, Johnson, & Allard, 2005) have pointed out that compared to the corpus of studies identifying factors that influence HISB, there is far less research focusing on examining the outcomes of the seeking behavior. Thus, the current study adds to the HISB literature by investigating an outcome of HISB and does so by focusing on a potentially risky behavior among a vulnerable population.

Previous research on HISB documented effects assumed to be mostly beneficial to people's health outcomes (e.g., Feinberg et al., 2016; Lee et al., 2016; Moldovan-Johnson et al., 2014; Shim et al., 2006). The current study, however, seems to suggest the opposite which echoes Johnson and Case's (2012) warning about the potential negative outcomes of HISB. Still, from a theoretical perspective, our results may be interpreted as consistent with prior studies. Previous studies focused on recommended behaviors, and assumed that the information seekers who encounter positive information about engaging in those behaviors are more likely to adopt those "good" behaviors. Our study however, suggests that the PCE around vaping is substantially positive, or at least mixed. Thus, information seekers who encounter such information would be expected to be more likely to adopt the behavior, consistent with prior findings, despite the fact that the outcome of vaping may be potentially risky, even negative.

Indeed, the scientific uncertainty around the risks of e-cigarettes, and the potential benefits for current smokers (Royal College of Physicians, 2016) leave unclear whether these pro-e-cigarette effects of HISB represent a case of an unequivocally negative public health outcome. Still, the predominantly pro-e-cigarette information could mislead YYAs to underestimate the potential harms (Fillon, 2015; Primack, Soneji, Stoolmiller, Fine, & Sargent, 2015; Wills et al., 2016) while overestimating the benefits of initiating e-cigarette use, by highlighting the harm reduction aspect of vaping compared to combustible cigarette use. Description of these relative benefits were prevalent in both traditional and new media (Duke et al., 2014; Grana & Ling, 2014; Huang et al., 2014; Luo et al., 2014). Therefore, this study not only highlights the mixed effects of HISB, but puts emphasis on understanding the characteristics of the information sought in examining the outcomes of HISB.

The evidence that both intentions and HISB predict use is consistent with prior research; they are of importance given their application to an emerging behavior and for a vulnerable YYA population. The second result of these analyses, that the effect of e-cigarette intention on use is partially mediated by HISB, is perhaps more interesting. It suggests that the intentions do not automatically turn into behavior, but do so when intentions lead to more information seeking which reinforces the intentions. The implications of this finding are intriguing. They suggest that if the valence of e-cigarette information available in the PCE was shifted to be less positive towards e-cigarettes, some of those YYAs open to e-cigarette use might not so readily find support, and be less likely to initiate or maintain their behavior.

The results of the current study provided empirical evidence about HISB effects and may speak to possible directions of regulation. The evidence presented here is consistent with this narrative: youth are intrigued by and open to initiating e-cigarette use; they look for information about vaping and find substantial information supporting their use in the PCE around them; the information seeking reinforces their openness and leads them to initiate use. In this narrative, the possible role for the FDA focuses on its ability to influence what youth can find in the PCE, without impermissibly restricting speech. As the FDA has now deemed ENDS under their regulation, regulatory decisions may permit reshaping the PCE, as have been done for combustible cigarettes. For instance, the publishing of claims on marketing websites or commercially supported social media about the benefits of vaping that are not yet validated by scientific evidence, could be screened and regulated; age restrictions could be required for entering those websites to at least prevent YYAs from overexposure to pro-e-cigarette information when they search for e-cigarette information. In addition, the FDA might consider addressing vaping in a similar way to how cigarette initiation was addressed with the current Real Cost campaign (Farrelly, 2017). It would use advertising to reshape the PCE, informing YYAs of the potential harmful consequences and the scientific uncertainty about effects of vaping or e-cigarette use. Finally, like warning labels on current cigarette packaging, a policy requiring attaching warning labels to e-cigarette products or marketing materials might raise e-cigarette users' awareness of the potential risk of vaping e-cigarettes and balance the predominant supportive information about e-cigarettes currently available.

Insofar as deliberate marketing efforts by e-cigarette manufacturers and sellers have produced a favorable climate for those products and the FDA is now able to constrain what those marketing messages can say, the public communication climate may change. This may be true because the specific messages diffused by manufacturers and vendors may be different, and also because the changed marketing messages may affect what is being said by others in traditional and new media. If the PCE were to become less positive, information seekers would likely to find less support for use, and perhaps be less likely to start or keep using e-cigarettes.

Strengths, limitations and future research

To the best of our knowledge, the current study is the first one to examine the effect of YYAs' e-cigarette HISB on subsequent vaping behavior using a longitudinal design. The large, weighted, nationally representative sample enhances the generalizability of the results, and the use of both landline and cell phones improves the quality of sampling. Another strength of the study lies in its use of longitudinal lagged regression analyses, which are superior to cross-sectional analyses. They enhance confidence in claims of temporal order and reduce the risk that confounders challenge evidence consistent with the proposed model.

Despite the strengths of the current study, several limitations should be noted. First, e-cigarette information seeking, vaping

intention, and smoking and vaping behavior were measured by single, self-reported items. While single-item measures are frequently used when assessing HISB (Anker et al., 2011), they are more error-prone than multi-item measures. We provided some support for the validity of these measures above. Second, although the longitudinal panel data enable us to test the hypothesized models more rigorously compared to the use of cross-sectional data, the analyses do not allow ruling out the effects of unmeasured confounders that might affect seeking first but behavior later. One example might be that prior interest in e-cigarettes or vaping first leads to seeking information and only later to vaping behavior (although the fact that the seeking-behavior relationship was maintained even when intention was controlled may reduce that specific concern). Third, the two-wave panel data restrains us from testing the mediation in complete three-wave lagged analyses. Instead, we conducted two mediation analyses with e-cigarette HISB at T1 and T2 as mediators between intention at T1 and vaping at T2, with e-cigarette HISB being treated either cross-sectionally with intention at T1 or with vaping behavior at T2. Fourth, although we have worked hard to increase the retention rate, we did have a substantial drop-out rate, particularly among older respondents. Finally, the current study only examined general e-cigarette HISB without differentiating the sources of information sought. Given that YYAs are heavy Internet and social media users (Perrin, 2015; Pew Research Center, 2014), future studies could examine whether seeking e-cigarette information from various channels (e.g., traditional media, Internet, social media) influences vaping-related cognitions and behaviors differently.

Conclusions

The current study empirically tests the effect of e-cigarette HISB on subsequent e-cigarette use with a longitudinal nationally representative survey. The findings suggest that e-cigarette HISB at T1 predicts YYAs' e-cigarette use six months later, and mediates the relation between vaping intention at T1 and e-cigarette use at T2. Moreover, this study provides important and timely results which bear on the implementation of the deeming rule (Food and Drug Administration (FDA), 2016), and highlights the potential effects of regulating e-cigarette marketing information and correcting misinformation about vaping behavior available to young information seekers. Insofar as the FDA wishes to reduce initiation of use, it may need to consider how to increase the stock of skeptical information likely to be found by information seekers, and consider regulating the content of marketing information consistent with its authority under the deeming rule.

Disclosure of potential conflicts of interest

The content is solely the responsibility of the authors and does not necessarily represent the official views of the NIH or the Food and Drug Administration (FDA).

Notes

1. To capture this, the research reported here operationalizes ENDS seeking and use questions by referring to "vaping or e-cigarette use" which allows respondents to consider any ENDS product.
2. We chose the six-month lag as a tradeoff between risking a too large dropout of our sample, which might happen with a longer interval between waves, and giving respondents as much time as possible to initiate a new behavior. Some scholars argue also that it takes at least 6 months for information exposure to affect cognition, attitude and behavior (Schar, Gutierrez, Murphy-Hoefer, & Nelson, 2006).
3. The weight was designed using adjustment for oversampling of listed landline households, adjustment for unequal selection among age-groups, adjustment for probability of selection within age-group, post-stratification weighting with the 2016 U.S. Census Current Population Survey as the anchor for demographic parameters, and trimming. More details are available upon request.
4. The indirect effects can be computed based on the formula $ab_{cs} = ab\frac{\sigma_X}{\sigma_Y}$ (Preacher & Hayes, 2008; Preacher & Kelley, 2011). The details of the analytic results are available upon request.
5. Cigarette information seeking was measured by asking "Thinking about the past 30 days, did you actively look for information about cigarettes or other tobacco products, yes or no?" with responses recorded on a dichotomous scale with 0 = *No* and 1 = *Yes*. Current cigarette use was measured by asking "During the past 30 days, did you smoke cigarettes?" with 0 = *No* and 1 = *Yes*.

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ORCID

Qinghua Yang http://orcid.org/0000-0003-1358-8096
Jiaying Liu http://orcid.org/0000-0001-8461-0954
Robert Hornik http://orcid.org/0000-0002-2148-8805

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