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Worldviews and trust of sources for health information on electronic nicotine delivery systems: Effects on risk perceptions and use[☆]



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ARTICLE INFO

Keywords:

USA
Trust
Worldviews
Risk perceptions
E-cigarettes
Electronic nicotine delivery systems

ABSTRACT

Public health agencies, the news media, and the tobacco/vapor industry have issued contradictory statements about the health effects of electronic nicotine delivery systems (ENDS). We investigated the levels of trust that consumers place in different information sources and how trust is associated with cultural worldviews, risk perceptions, ENDS use, and sociodemographic characteristics using a nationally representative sample of 6051 U.S. adults in 2015. Seventeen percent of adults were uncertain about their trust for one or more potential sources. Among the rest, the Centers for Disease Control and Prevention (CDC), health experts, and the Food & Drug Administration (FDA) elicited the highest levels of trust. In contrast, tobacco and vapor manufacturers, vape shop employees, and, to a lesser extent, the news media were distrusted. Adults who had higher incomes and more education or espoused egalitarian and communitarian worldviews expressed more trust in health sources and the FDA, whereas those identifying as non-Hispanic Black or multiracial reported less trust. Current smokers, those who identified as non-Hispanic Black or other race, had lower incomes, and espoused hierarchy and individualism worldviews expressed less distrust toward the tobacco and vapor industry. Greater trust (or less distrust) toward the tobacco and vapor industry and an individualism worldview were associated with perceptions of lower risk of premature death from daily ENDS use, greater uncertainty about those risks, and greater odds of using ENDS. Public health and the FDA should consider consumer trust and worldviews in the design and regulation of public education campaigns regarding the potential health risks and benefits of ENDS.

Introduction

While public health experts engage in an ongoing debate about the population- and individual-level risks and benefits of electronic nicotine delivery systems (ENDS) and the most appropriate regulatory response (Avdalovic & Murin, 2015; Bernstein, 2015; Britton, 2015; Middlelekauff, 2015; The Lancet, 2015; Unger, 2015), the tobacco and vapor industry and affiliated groups promote ENDS with messages about their health benefits (Grana & Ling, 2014). This has led to a consumer environment characterized by conflicting communications about the safety of ENDS that often confuse absolute harm with relative harm compared to

cigarettes. The dynamics of this environment may amplify or attenuate perceptions of the risks of ENDS with implications for product use and regulatory actions (Kasperson et al., 1988; Kasperson, Kasperson, Pidgeon, & Slovic, 2003). A recently published study found that nearly 40% of the U.S. population perceive ENDS as being equally or more risky than cigarettes, and this proportion tripled from 2012 to 2015. Another one-third is uncertain about their relative harms (Majeed, Sterling, Weaver, Pechacek, & Eriksen, 2017). There is currently little research on how consumer perceptions and use of ENDS are influenced by the conflicting messages and whom consumers trust for information on the health effects of ENDS.

[☆] Research reported in this publication was supported by grant number P50DA036128 from the National Institutes of Health, National Institute of Drug Abuse (NIH/NIDA) and Food and Drug Administration, Center for Tobacco Products (FDA CTP) and by grant number R00CA187640 from the National Institutes of Health, National Cancer Institute (NIH/NCI) and Food and Drug Administration, Center for Tobacco Products (FDA CTP). 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. The authors report no conflicts of interest.

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Trust and risk perceptions

Trust has been widely considered an important factor in risk communication, particularly with new or complex technologies for which consumers lack the experience, knowledge, or motivation to directly assess the risks (Slovic, 1993; Kasperson, Kasperson, Pidgeon, & Slovic, 2003; Chryssochoidis, Strada, & Krystallis, 2009; Frewer, 2004; Hmielowski, Feldman, Myers, Leiserowitz, & Maibach, 2013; Poortinga & Pidgeon, 2003; Renn & Levine, 1991; Schmidt, Ranney, Pepper, & Goldstein, 2016; Siegrist, 1999; Siegrist, Cvetkovich, & Roth, 2000; Siegrist, Gutscher, & Earle, 2005). When an issue or technology is complex or new, individuals become more reliant upon the risk assessments of experts and their institutions (e.g., industry, regulatory agencies, independent experts and scientists), where trust serves as a peripheral/heuristic cue that operates to reduce the complexity of the individual's risk-benefit assessment (Cvetkovich, Siegrist, Murray, & Tragesser, 2002; Renn & Levine, 1991). Several empirical studies have found trust in risk communication sources to be predictive of individual risk perceptions and attitudes toward a broad range of new and complex technologies and issues relevant to public health and safety (Slovic, Flynn, & Layman, 1991; Cvetkovich et al., 2002; Lobb, Mazzocchi, & Traill, 2007; Siegrist, 1999; Siegrist et al., 2000; Siegrist et al., 2005).

ENDS are a new and evolving technology of sufficient complexity that most consumers lack the expertise to independently evaluate the conflicting evidence to make informed decisions about them (Unger, 2015). Public trust, or lack thereof, in prominent sources for information about ENDS may play an important role in how consumers react to the conflicting risk communications about ENDS. Only a limited number of studies have examined consumer trust in sources providing information about the health effects of ENDS. One recent study found that over one-half of US adult smokers rated doctors as the most trustworthy source of information about ENDS (Wackowski, Bover Manderski, & Delnevo, 2015). Less trusted were package information, the internet, other users, and pharmacists (each endorsed as the most trustworthy source by 15% or fewer smokers). Noting the FDA's role in communicating the potential risks of tobacco and its consumer education campaigns, Boynton et al. (2016) argued for the importance of research on the FDA and US government's credibility. In a national survey of US adults, they found that about two-thirds thought that the FDA could effectively regulate tobacco products. Credibility ratings of the FDA for the regulation of tobacco products were similar between smokers and nonsmokers. Identifying and understanding the factors that influence perception of the FDA as a trusted and credible source of information about the health risks of tobacco products has been identified as a research priority by the FDA's Center for Tobacco Products (Ashley & Backinger, 2012).

Worldviews, trust, and risk perceptions

Studies examining determinants of perceived trust in institutions engaged in risk management and communication found that cultural worldviews were stronger predictors of trust than political orientation (Leiserowitz, Maibach, Roser-Renouf, Smith, & Dawson, 2013) and that there were marked differences in trust levels by socio-demographic factors, such as gender, education, race/ethnicity, and church attendance (Gauchat, 2012). According to cultural theory, worldviews are "orienting dispositions" or interpretive lenses in the form of a patterned collection of social, cultural, and political attitudes that shape and define how individuals construe their world, including perceptions of risk, and how they seek, interpret, and assimilate new information (Peters, & Slovic, 1996; Buss & Craik, 1983; Dake, 1991, 1992; Kahan, Jenkins-Smith, & Braman, 2011; Leiserowitz, 2006). Kahan et al. (2011, p. 151) defined two worldview dimensions: (1) *hierarchy-egalitarianism*, which reflects people's "attitudes toward social orderings that connect authority to stratified social roles based on highly conspicuous and

largely fixed characteristics such as gender, race, and class" and (2) *individualism-communitarianism*, which reflects "attitudes toward social orderings that expect individuals to secure their own well-being without assistance or interference from society versus those that assign society the obligation to secure collective welfare and the power to override competing individual interests."

The cultural cognition perspective postulates that people tend to attribute greater trust and expertise to those whose statements on a technological or societal issue are more closely aligned with their cultural worldviews (Kahan, 2012; Kahan et al., 2011; Siegrist et al., 2000). In support of this postulate, an experimental study found that individuals with hierarchical-individualist worldviews rated fictional scientists as being more trustworthy when the statements of the scientists reflected a low-risk conclusion, whereas the opposite pattern was observed for those with an egalitarian-communitarian worldview (Kahan et al., 2011). From this, we might expect that people who have a hierarchical-individualist worldview would place greater trust in information sources who present ENDS as being of low-risk to their health, and people with egalitarian-communitarian worldviews might have greater trust in sources who espouse a high-risk view of ENDS. Other research suggests that worldviews may also directly affect risk-benefit perceptions, perhaps by modifying the effect of risk information on perceptions (Peters, & Slovic, 1996, Kahan, Braman, Slovic, Gastil, & Cohen, 2009; Palmer, 1996; Siegrist, 1999).

Present study

Little research on the importance of worldviews and trust for risk communication has been invoked for understanding ENDS use. Knowing whom consumers trust for information about ENDS and the extent to which trust and worldviews might influence risk perceptions is likely to inform our understanding of how different risk communication strategies affect decisions to use ENDS. This would have important implications for both the regulation of industry messages about these risks and benefits and for developing informed risk communication strategies. To address this research gap, we report on a study with the following objectives: (a) estimate the levels of trust for different major sources that provide information about the health effects of ENDS; (b) examine differences in whom consumers trust by smoking status, sociodemographic characteristics, cultural worldviews, and other factors; and (c) test the hypotheses that worldviews and trust of sources of information will be uniquely associated with perceptions of risk and the decision to use ENDS.

Methods

Data source

Data for this study were obtained from the 2015 Tobacco Products and Risk Perceptions Survey conducted from August to September by the [Georgia State University Tobacco Center of Regulatory Science]. This survey was administered to a cross-sectional, probability sample drawn from GfK's KnowledgePanel, a probability-based web panel designed to be representative of non-institutionalized US adults. We invited 8135 panelists to participate in the survey and obtained a sample of 6091 qualified completers. Forty cases were excluded for refusal to answer more than one-half of the survey questions, yielding a final sample of 6051 cases with a final stage completion rate of 74.0% and a study qualification rate of 98.5%. The average panel recruitment rate for this study was 13.8%, and the average profile rate was 64.6%, for a cumulative response rate of 6.8% (Callegaro & DiSogra, 2008). A study-specific post-stratification weight was computed using an iterative proportional fitting (raking) procedure to adjust for sources of sampling and non-sampling error, such as panel recruitment non-response and panel attrition. Demographic and geographic distributions from the March 2015 Current Population Survey (CPS) were employed as

benchmarks for adjustment, and included sex, age, race/ethnicity, education, household income, census region, metropolitan area, and internet access. This study was approved by the [details omitted for double-blind review]. The analytic sample for this study is composed of the 5389 (89.1%) participants who reported awareness of ENDS because the variables of interest were measured only for this group.

Measures

Trust in information sources for the health effects of ENDS

Participants who had indicated they were aware of ENDS were asked, “How much do you trust what each of the following say about the health effects of electronic vapor products?” for seven potential sources (randomized): (a) health experts and scientists, (b) the Food and Drug Administration (FDA), (c) the Centers for Disease Control and Prevention (CDC), (d) companies that manufacture and sell cigarettes and cigars, (e) companies that only manufacture and sell electronic vapor products, (f) vape shop employees, and (g) the news media (newspapers, magazines, TV, Internet) (Leiserowitz et al., 2013; U.S. Department of Health and Human Services, 2015). Responses were obtained on a 5-point scale (-2 = *strongly distrust*, -1 = *somewhat distrust*, 0 = *neutral*, 1 = *somewhat trust*, 2 = *strongly trust*), or *Don't know*. Correlations of trust levels between sources were high among health sources ($r_s > .67$) and among the tobacco/vapor industry sources ($r_s > .65$) and were low between health sources and tobacco/vapor industry sources ($r_s < .11$) (See Supplemental Table S2). Correlations of trust levels for the news media with ratings for other sources were moderately high ($r_s = .34$ – $.43$). Therefore, composite trust scores were computed as the average of trust levels for public health sources and for tobacco/vapor industry sources, respectively, for some analyses.

Risk perceptions of ENDS

Participants were asked about their perceived chances of early death if they were to use electronic vapor products every day based on an adaptation of a previously validated measure (Chaffee et al., 2015). Specifically, participants were asked, “Imagine that you just began using electronic vapor products every day. What do you think your chances are of having each of the following happen to you if you continue to use electronic vapor products every day? [Early/Premature death].” Participants could respond on a 6-point scale ranging from 0 (*No chance*) to 6 (*Very good chance*) or choose *I don't know*.

Cultural worldviews

We used a validated short-form scale (Kahan et al., 2011) consisting of two 6-item subscales assessing two bipolar dimensions: hierarchy-egalitarianism and individualism-communitarianism. The hierarchy-egalitarianism subscale included items such as “we have gone too far in pushing equal rights in this country” and “our society would be better off if the distribution of wealth was more equal.” The individualism-communitarianism subscale included items such as “it's not the government's business to try to protect people from themselves” and “sometimes government needs to make laws that keep people from hurting themselves.” Participants rated each statement on a 6-point Likert response scale (*Strongly Disagree* to *Strongly Agree*). The scales were scored so higher scores indicated greater agreement with ideas of hierarchy and individualism, respectively.

Cigarette smoking status

Participants who reported not having smoked at least 100 cigarettes in their lives were classified as *never smokers*. Those who reported smoking at least 100 cigarettes in their lives were classified as *current smokers* if currently smoking cigarettes “every day” or “some days” and as *former smokers* if not smoking cigarettes at all.

Lifetime and current use of ENDS

To assess ENDS use, respondents were first provided a description

and an image of ENDS depicting various device types. Lifetime (ever) use of ENDS was then assessed by asking, “Have you ever used electronic vapor products, even one or two times?” Adults reporting “no” were classified as *never users*. Adults reporting lifetime use were then asked “Do you now use electronic vapor products every day, some days, rarely, or not at all?” to identify *current users* (every day, some days, or rarely) and *former users* (not at all).

Exposure to ENDS advertising

Participants were asked to indicate which places, if any, they have seen or heard advertisements for electronic vapor products in the past 30 days from a fixed list of eight different places (e.g., magazines, billboards) or “some other place”. Those who indicated *yes* to any of the eight places or “some other place” were coded as 1 (exposed), whereas respondents who indicated *no* to all places were coded as 0 (not exposed).

Respondent characteristics

Data on demographic and other respondent characteristics were obtained from profile surveys administered by GfK to KnowledgePanel panelists. These characteristics included sex, age, race/ethnicity, educational attainment, annual household income, census region, metropolitan statistical area, political orientation, and sexual orientation.

Statistical analysis

Statistical analyses were conducted using R (v. 3.3.1) and SAS (v. 9.4) survey packages that account for the complex survey design. Design-based (weighted) point estimates and 95% confidence intervals for mean trust ratings and correlations between trust ratings for different sources were obtained. Weighted general linear mixed models tested whether ratings differed between sources, and weighted bivariate and multivariable general linear models were estimated to examine how sociodemographic factors, worldviews, and smoking were associated with trust levels. Weighted general linear and generalized linear models assessed whether trust levels were predictive of risk perceptions and ENDS use.

Results

Among adults who were aware of ENDS, 14.8% (95% CI [13.6, 15.9]) were current smokers, 8.5% (95% CI [7.5, 9.5]) were current ENDS users, and 4.8% (95% CI [4.1, 5.5]) were current smokers and current ENDS users. Over one half (56.6%; 95% CI [54.9, 58.2]) of these adults were never smokers, 80.6% (95% CI [79.2, 81.9]) had never used ENDS, and 51.8% (95% CI [50.1, 53.6]) had neither used ENDS nor smoked cigarettes.

Perceived trust of sources of health information about ENDS

Among US adults aware of ENDS, 17.1% (95% CI [15.7%, 18.4%]; $n = 887$) reported that they were uncertain (*Don't know*) about their trust levels for one or more of the listed sources of health information about ENDS. The remainder ($n = 4415$) reported, on average, that they trust the information from public health experts and agencies (viz., FDA and CDC) concerning the health effects of ENDS (see Table 1 and Supplemental Fig. S1). The highest levels of trust were expressed for the CDC ($M = 0.69$) and health experts ($M = 0.62$), followed by the FDA ($M = 0.31$). In contrast, respondents expressed somewhat to strong distrust of the tobacco and vapor industry as a source of information about the health effects of ENDS. Tobacco manufacturers ($M = -1.25$) were distrusted more than vapor manufacturers ($M = -1.16$), who were, in turn, distrusted more than vape shop employees ($M = -1.06$). The news media ($M = -0.54$) was also generally distrusted.

There were several differences among subgroups. Current ENDS users reported lower trust of the CDC than never ENDS users. Compared to never smokers, current smokers reported lower trust of all public

Table 1
Mean Trust Levels by Source of Information about the Health Effects of ENDS, U.S. Adults, 2015.

Group (n)	Public Health Mean [95% CI]			Tobacco/Vapor Mean [95% CI]			News Media Mean [95% CI]
	Health Experts	FDA	CDC	Tobacco Manufacturers	Vapor Manufacturers	Vape Shop Employees	
Overall (4415)	0.62 ^(a) [0.58, 0.66]	0.31 ^(b) [0.27, 0.35]	0.69 ^(c) [0.65, 0.74]	-1.25 ^(d) [-1.29, -1.21]	-1.16 ^(e) [-1.20, -1.13]	-1.06 ^(f) [-1.09, -1.02]	-0.54 ^(g) [-0.58, -0.50]
ENDS use							
Current user (474)	0.59 ^(a) [0.47, 0.72]	0.23 ^(c) [0.097, 0.37]	0.49 ^(a) [0.35, 0.63]	-0.73 ^(d) [-0.88, -0.58]	-0.43 ^(b) [-0.56, -0.29]	-0.29 ^(e) [-0.41, -0.17]	-0.42 ^(b) [-0.55, -0.29]
Former user (546)	0.62 ^(a) [0.50, 0.73]	0.21 ^(b) [0.070, 0.36]	0.65 ^(a) [0.51, 0.78]	-1.08 ^(c) [-1.19, -0.98]	-0.9 ^(d) [-1.01, -0.79]	-0.78 ^(e) [-0.89, -0.66]	-0.55 ^(f) [-0.67, -0.44]
Never user (3394)	0.63 ^(a) [0.58, 0.67]	0.33 ^(b) [0.28, 0.38]	0.72 ^(c) [0.68, 0.77]	-1.33 ^(d) [-1.37, -1.29]	-1.28 ^(e) [-1.32, -1.24]	-1.18 ^(f) [-1.22, -1.14]	-0.55 ^(g) [-0.59, -0.51]
<i>p</i>	.85	.05	< .001	< .001	< .001	< .001	.06
Cigarette smoking							
Current smoker (961)	0.48 ^(a) [0.38, 0.57]	0.21 ^(c) [0.10, 0.31]	0.50 ^(a) [0.40, 0.61]	-0.71 ^(d) [-0.81, -0.61]	-0.6 ^(b) [-0.69, -0.50]	-0.59 ^(b) [-0.68, -0.50]	-0.38 ^(e) [-0.48, -0.28]
Former smoker (1221)	0.55 ^(a) [0.47, 0.62]	0.20 ^(b) [0.12, 0.28]	0.63 ^(c) [0.55, 0.70]	-1.31 ^(d) [-1.38, -1.25]	-1.22 ^(e) [-1.28, -1.15]	-1.09 ^(f) [-1.16, -1.02]	-0.61 ^(g) [-0.68, -0.54]
Never smoker (2233)	0.70 ^(a) [0.64, 0.75]	0.39 ^(b) [0.33, 0.45]	0.78 ^(c) [0.72, 0.83]	-1.36 ^(d) [-1.40, -1.31]	-1.28 ^(e) [-1.33, -1.23]	-1.16 ^(f) [-1.21, -1.11]	-0.55 ^(g) [-0.60, -0.50]
<i>p</i>	< .001	< .001	< .001	< .001	< .001	< .001	< .001

Note. Don't know responses were excluded. Non-matching superscripts indicate a statistically significant difference ($p < .05$) between means across sources. Column *p*-values refer to comparisons across smoking or ENDS use groups. ENDS = Electronic Nicotine Delivery System. CI = Confidence Interval; FDA = Food & Drug Administration; CDC = Centers for Disease Control and Prevention.

health sources and former smokers reported lower trust of health experts and the FDA. For the tobacco/vapor industry, never ENDS users reported the lowest levels of trust, and current ENDS users reported the highest levels of trust. Former and never smokers reported more distrust of tobacco/vapor industry sources than did current smokers. Of the news media, never ENDS users reported more distrust than current ENDS users, and never and former smokers reported more distrust than current smokers. Trust ratings also differed by sex, race/ethnicity, age, education, income, sexual orientation, metropolitan statistical area status, US region, and exposure to ENDS advertising (Supplemental Table S1).

Predictors of trust ratings in multivariate regression models

Individualistic and hierarchical worldviews were associated with less trust of health experts, CDC, FDA, and the news media (Table 2). Hierarchical worldviews were also associated with greater trust of tobacco and vapor manufacturers. Smoking status was not significantly related to trust of health experts, FDA, or CDC, but it was associated with trust of the tobacco/vapor industry and news media. Smokers were more trusting of all industry sources and the news media and former smokers were more trusting of the vapor industry than were never smokers.

Several sociodemographic variables were also associated with levels of trust of sources of information on the health effects of ENDS, after adjusting for all other variables in the model. Older adults reported less trust of health experts, tobacco and vapor manufacturers, and vape shop employees. Non-Hispanic Black and multiracial adults reported less trust of public health sources than non-Hispanic White adults; whereas among non-Hispanic other race adults reported greater trust of the FDA and CDC than non-Hispanic White adults. Non-Hispanic Black, Hispanic, and non-Hispanic other race adults expressed greater levels of trust of the tobacco/vapor industry than did non-Hispanic White adults. Compared to those with less than a high school education, those with more education reported greater trust of public health sources. Having an annual household income of more than \$100,000 was associated with greater trust of public health sources and less trust of the tobacco/vapor industry relative to those making less than \$15,000.

Associations between trust, risk perceptions, and use of ENDS

Nearly one-fourth of respondents (24.8%; 95% CI [23.2, 26.4]) were uncertain whether daily ENDS use would increase their chances of premature death. Those who did not report being uncertain rated their chances as moderately high ($M = 4.15$; 95% CI [4.07, 4.23]). Using the composite trust scores to predict risk perceptions of ENDS, and adjusting for worldviews, political orientation, prior exposure to ENDS advertising, ENDS use, cigarette smoking, and sociodemographic variables, only trust in the tobacco/vapor industry was a statistically significant predictor of risk perceptions of ENDS (Table 3). Greater trust of industry sources was associated with perceptions of lower risk of premature death due to daily ENDS use but higher odds of being uncertain about risk perceptions. Trust levels of public health and the news media did not significantly predict risk perceptions. Adults with a greater individualistic worldview perceived lower risk of premature death from daily ENDS use and were more likely to be uncertain about the risk than those with a communitarianism worldview. Those with a hierarchical worldview were less likely to be uncertain regarding their perceived risk of ENDS.

Multivariable multinomial logistic regression models examined whether trust ratings were associated with ENDS use (Table 3). An increase in trust ratings for the tobacco/vapor industry was associated with greater odds of being a current or former ENDS user compared to being a never ENDS user, after adjustment for other trust ratings, worldviews, political orientation, exposure to ENDS advertising, smoking status, and sociodemographic differences. Greater trust of the news media was associated with lower odds of being a current ENDS user.

Discussion

Effective risk-benefit communication might need a different approach from that required for simple risk communication (Frewer, Howard, & Shepherd, 1996). Unfortunately, there has been little research to guide public health and the FDA on effectively communicating both the potential risks and benefits of ENDS so consumers can make informed decisions. Where the research literature does agree is the importance of trust and credibility for effective risk communication (Schmidt et al., 2016). This study, in support, found that those who

Table 2
Predictors of Trust Ratings for Sources of Information about the Health Effects of ENDS, U.S. Adults, 2015 (N = 4415).

Predictor	Public Health Estimate [95% CI]			Tobacco/Vapor Estimate [95% CI]			News Media [95% CI]		
	Health experts	FDA	CDC	Tobacco manufacturers	Vapor manufacturers	Vape Shop employees	Tobacco manufacturers	Vapor manufacturers	Vape Shop employees
Age (years)	-0.005** [-0.007, -0.002]	-0.001 [-0.003, 0.002]	-0.001 [-0.004, 0.001]	-0.003 [-0.005, -0.001]	-0.006** [-0.009, -0.004]	-0.008** [-0.01, -0.005]	-0.003 [-0.005, -0.001]	-0.006** [-0.009, -0.004]	-0.008** [-0.01, -0.005]
Female	-0.034 [-0.12, 0.048]	-0.052 [-0.14, 0.036]	-0.081 [-0.16, 0.001]	0.027 [-0.048, 0.10]	0.05 [-0.027, 0.13]	0.029 [-0.05, 0.11]	0.027 [-0.048, 0.10]	0.05 [-0.027, 0.13]	0.029 [-0.05, 0.11]
Race/Ethnicity (ref = White, non-Hispanic)									
Black, Non-Hispanic	-0.44*** [-0.59, -0.29]	-0.309* [-0.47, -0.14]	-0.38** [-0.53, -0.23]	0.35*** [0.19, 0.51]	0.45** [0.29, 0.60]	0.39** [0.25, 0.54]	0.35*** [0.19, 0.51]	0.45** [0.29, 0.60]	0.39** [0.25, 0.54]
Hispanic	-0.10 [-0.23, 0.031]	-0.095 [-0.24, 0.05]	-0.18 [-0.32, -0.037]	0.053 [-0.054, 0.16]	0.12 [0.002, 0.23]	0.12 [0.004, 0.24]	0.053 [-0.054, 0.16]	0.12 [0.002, 0.23]	0.12 [0.004, 0.24]
2+ Races, Non-Hispanic	-0.32** [-0.57, -0.081]	-0.305* [-0.55, -0.065]	-0.30* [-0.53, -0.074]	0.021 [-0.18, 0.23]	0.042 [-0.21, 0.29]	0.067 [-0.16, 0.29]	0.021 [-0.18, 0.23]	0.042 [-0.21, 0.29]	0.067 [-0.16, 0.29]
Other, Non-Hispanic	0.003 [-0.19, 0.20]	0.33*** [0.11, 0.55]	0.21* [0.017, 0.402]	0.33** [0.12, 0.55]	0.20 [0.008, 0.40]	0.41*** [0.20, 0.62]	0.33** [0.12, 0.55]	0.20 [0.008, 0.40]	0.41*** [0.20, 0.62]
Education (ref = < High school)									
High school	0.084 [-0.11, 0.28]	0.19 [-0.002, 0.38]	0.21* [0.02, 0.40]	0.031 [-0.13, 0.20]	0.061 [-0.10, 0.23]	0.075 [-0.087, 0.24]	0.031 [-0.13, 0.20]	0.061 [-0.10, 0.23]	0.075 [-0.087, 0.24]
Some college	0.17 [0.032, 0.38]	0.13 [-0.067, 0.33]	0.21* [0.019, 0.41]	-0.002 [-0.17, 0.16]	0.091 [-0.075, 0.26]	0.15 [-0.012, 0.32]	-0.002 [-0.17, 0.16]	0.091 [-0.075, 0.26]	0.15 [-0.012, 0.32]
Bachelor's degree or higher	0.28** [0.074, 0.49]	0.31** [0.11, 0.51]	0.33** [0.13, 0.52]	-0.12 [-0.28, 0.049]	-0.072 [-0.24, 0.094]	-0.015 [-0.18, 0.15]	-0.12 [-0.28, 0.049]	-0.072 [-0.24, 0.094]	-0.015 [-0.18, 0.15]
Annual Household Income (Ref = < \$15,000)									
\$15,000 to \$24,999	0.033 [-0.17, 0.24]	0.039 [-0.18, 0.26]	0.027 [-0.17, 0.23]	0.038 [-0.17, 0.25]	-0.15 [-0.36, 0.047]	-0.045 [-0.25, 0.16]	0.038 [-0.17, 0.25]	-0.15 [-0.36, 0.047]	-0.045 [-0.25, 0.16]
\$25,000 to \$39,999	-0.005 [-0.20, 0.19]	0.059 [-0.15, 0.26]	0.031 [-0.16, 0.23]	-0.16 [-0.33, 0.013]	-0.19 [-0.36, -0.014]	-0.19 [-0.36, -0.022]	-0.16 [-0.33, 0.013]	-0.19 [-0.36, -0.014]	-0.19 [-0.36, -0.022]
\$40,000 to \$59,999	0.083 [-0.095, 0.26]	-0.006 [-0.20, 0.18]	0.20 [0.024, 0.38]	-0.20 [-0.37, -0.034]	-0.31* [-0.48, -0.14]	-0.26** [-0.42, -0.095]	-0.20 [-0.37, -0.034]	-0.31* [-0.48, -0.14]	-0.26** [-0.42, -0.095]
\$60,000 to \$84,999	0.13 [-0.043, 0.31]	0.12 [-0.07, 0.30]	0.18 [0.004, 0.36]	-0.24 [-0.40, -0.079]	-0.33*** [-0.49, -0.17]	-0.36*** [-0.52, -0.20]	-0.24 [-0.40, -0.079]	-0.33*** [-0.49, -0.17]	-0.36*** [-0.52, -0.20]
\$85,000 to \$99,999	0.10 [-0.11, 0.31]	0.079 [-0.14, 0.30]	0.13 [-0.091, 0.35]	-0.15 [-0.35, 0.049]	-0.28 [-0.48, -0.085]	-0.35** [-0.54, -0.15]	-0.15 [-0.35, 0.049]	-0.28 [-0.48, -0.085]	-0.35** [-0.54, -0.15]
≥ \$100,000	0.19 [0.009, 0.37]	0.21* [0.021, 0.40]	0.27** [0.087, 0.45]	-0.21 [-0.37, -0.042]	-0.30** [-0.46, -0.14]	-0.34*** [-0.49, -0.18]	-0.21 [-0.37, -0.042]	-0.30** [-0.46, -0.14]	-0.34*** [-0.49, -0.18]
Metro (ref = Non-metropolitan)	-0.059 [-0.17, 0.055]	-0.022 [-0.15, 0.11]	-0.088 [-0.20, 0.026]	0.042 [-0.06, 0.14]	-0.068 [-0.17, 0.033]	-0.048 [-0.15, 0.053]	0.042 [-0.06, 0.14]	-0.068 [-0.17, 0.033]	-0.048 [-0.15, 0.053]
US region (ref = West)									
Midwest	0.041 [-0.074, 0.16]	0.24** [0.11, 0.36]	0.073 [-0.047, 0.19]	0.093 [-0.011, 0.20]	0.066 [-0.039, 0.17]	0.009 [-0.10, 0.12]	0.041 [-0.074, 0.16]	0.066 [-0.039, 0.17]	0.009 [-0.10, 0.12]
Northeast	-0.025 [-0.15, 0.10]	0.15 [0.009, 0.29]	0.014 [-0.12, 0.15]	0.057 [-0.053, 0.17]	0.065 [-0.049, 0.18]	0.059 [-0.057, 0.18]	-0.025 [-0.15, 0.10]	0.065 [-0.049, 0.18]	0.059 [-0.057, 0.18]
South	-0.016 [-0.13, 0.094]	0.15* [0.036, 0.27]	0.047 [-0.067, 0.16]	0.15** [0.046, 0.25]	0.093 [-0.008, 0.20]	0.005 [-0.096, 0.11]	-0.016 [-0.13, 0.094]	0.093 [-0.008, 0.20]	0.005 [-0.096, 0.11]
Previous exposure to ENDS advertising	0.067 [-0.022, 0.16]	0.059 [-0.036, 0.16]	0.11 [0.018, 0.20]	-0.013 [-0.09, 0.065]	0.026 [-0.051, 0.10]	-0.024 [-0.10, 0.057]	0.067 [-0.022, 0.16]	0.026 [-0.051, 0.10]	-0.024 [-0.10, 0.057]
Sexual orientation (ref = heterosexual)	-0.058 [-0.23, 0.12]	-0.036 [-0.24, 0.17]	-0.046 [-0.23, 0.14]	-0.016 [-0.14, 0.11]	-0.011 [-0.14, 0.12]	0.002 [-0.14, 0.15]	-0.058 [-0.23, 0.12]	-0.011 [-0.14, 0.12]	0.002 [-0.14, 0.15]
Political orientation	0.013 [-0.018, 0.044]	0.025 [-0.009, 0.059]	0.022 [-0.009, 0.052]	0.012 [-0.015, 0.04]	0.006 [-0.021, 0.033]	0.018 [-0.01, 0.046]	0.013 [-0.018, 0.044]	0.006 [-0.021, 0.033]	0.018 [-0.01, 0.046]
Individualism-Communitarianism ^a	-0.11*** [-0.15, -0.066]	-0.16*** [-0.21, -0.12]	-0.13*** [-0.18, -0.089]	-0.003 [-0.039, 0.033]	0.001 [-0.036, 0.038]	0.03 [-0.008, 0.068]	-0.11*** [-0.15, -0.066]	0.001 [-0.036, 0.038]	0.03 [-0.008, 0.068]
Hierarchy-Egalitarianism ^b	-0.20*** [-0.25, -0.16]	-0.17*** [-0.21, -0.12]	-0.23*** [-0.28, -0.19]	0.078*** [0.041, 0.11]	0.077*** [0.041, 0.113]	0.014 [-0.025, 0.052]	-0.20*** [-0.25, -0.16]	0.077*** [0.041, 0.113]	0.014 [-0.025, 0.052]
Cigarette smoking (ref = Never smoker)									
Current smoker	-0.079 [-0.19, 0.037]	-0.013 [-0.14, 0.11]	-0.12 [-0.24, 0.001]	0.56*** [0.45, 0.67]	0.55*** [0.44, 0.66]	0.45*** [0.34, 0.56]	-0.079 [-0.19, 0.037]	0.55*** [0.44, 0.66]	0.45*** [0.34, 0.56]
Former smoker	-0.04 [-0.14, 0.056]	-0.09 [-0.19, 0.009]	-0.08 [-0.18, 0.02]	0.07 [-0.015, 0.16]	0.10 [0.017, 0.19]	0.15** [0.057, 0.23]	-0.04 [-0.14, 0.056]	0.10 [0.017, 0.19]	0.15** [0.057, 0.23]

Note. Weighted, unstandardized linear regression coefficients are reported. The majority of significant effects remained significant in ordinal logistic regression analyses (not shown). "Don't know" responses were excluded. ENDS = Electronic Nicotine Delivery System; CI = Confidence Interval; FDA = Food & Drug Administration; CDC = Centers for Disease Control and Prevention.

^a Individualism-Communitarianism: Higher values indicate agreeing with ideas of individualism.
^b Hierarchy-Egalitarianism: Higher values indicate agreeing with ideas about hierarchy.

* $p \leq 0.05$.
 ** $p \leq 0.01$.
 *** $p \leq 0.001$.

Table 3
The Effects of Trust Levels on ENDS Use and the Perceived Risk of Premature Death from Daily ENDS Use among U.S. Adults, 2015 (N = 4415).

Predictor	Perceived risk of premature death		ENDS use (ref = Never)	
	Perceived risk coefficient ^d [95% CI]	Uncertain about perceived risk aOR ^b [95% CI]	Current ENDS use aOR [95% CI]	Former ENDS use aOR [95% CI]
Trust of public health	-0.03 [-0.12, 0.05]	1.08 [0.97, 1.19]	0.94 [0.77, 1.15]	1.02 [0.88, 1.19]
Trust of tobacco/vapor industry	-0.48*** [-0.6, -0.36]	1.22** [1.07, 1.38]	2.55*** [2.07, 3.13]	1.39** [1.15, 1.68]
Trust of news media	0.01 [-0.09, 0.11]	0.99 [0.89, 1.1]	0.74** [0.6, 0.92]	0.86 [0.72, 1.02]
Individualism-Communitarianism ^c	-0.22*** [-0.29, -0.14]	1.26*** [1.15, 1.38]	1.13 [0.95, 1.35]	1.29** [1.13, 1.48]
Hierarchy-Egalitarianism ^d	-0.002 [-0.08, 0.08]	0.88** [0.79, 0.96]	0.95 [0.79, 1.14]	0.92 [0.79, 1.07]
Political orientation	-0.002 [-0.06, 0.05]	1.02 [0.95, 1.1]	0.89 [0.78, 1.01]	0.92 [0.82, 1.04]
Exposure to ENDS advertising (ref = no exposure)	0.11 [-0.05, 0.28]	0.75** [0.62, 0.91]	1.51 [0.97, 2.35]	1.34 [0.97, 1.84]
ENDS use (ref = never user)				
Current user	-1.05*** [-1.38, -0.72]	0.48** [0.32, 0.74]	–	–
Former user	-0.64*** [-0.91, -0.38]	0.94 [0.68, 1.31]	–	–
Cigarette smoking (ref = never smoker)				
Current smoker	-0.28* [-0.55, -0.001]	1.16 [0.85, 1.57]	20.81*** [13.01, 33.28]	16.04*** [10.57, 24.33]
Former smoker	-0.11 [-0.29, 0.08]	0.95 [0.76, 1.18]	3.88*** [2.36, 6.37]	6.38*** [4.41, 9.23]

Note. Weighted, multinomial logistic and linear regression models control for age, sex, sexual orientation, ethnicity, education, household income, metropolitan vs. non-metropolitan area, and U.S. census region. ENDS = Electronic Nicotine Delivery System; CI = Confidence Interval; aOR = Adjusted Odds Ratio; ref = Reference group or category.

^a Unstandardized linear regression coefficients, weighted, are reported.

^b Adjusted ratio of the odds of responding “I don’t know” to the odds of selecting another option are reported.

^c Individualism-Communitarianism: Higher values indicate agreeing with ideas of individualism and lower values indicate agreeing with ideas of communitarianism.

^d Hierarchy-Egalitarianism: Higher values indicate agreeing with ideas about hierarchy, and lower values indicate agreeing with ideas about egalitarianism.

* $p \leq 0.05$.

** $p \leq 0.01$.

*** $p \leq 0.001$.

have greater trust of the tobacco and vapor industry perceived lower risk from using ENDS, were more likely to be uncertain about the health risks of ENDS, and were more likely to use ENDS. On the other hand, this study did not find a significant association between trust of public health sources and risk perceptions.

Given the heated debate about ENDS, it is important for public health and government institutions to maintain a high level of public trust. Despite a widely cited decades-long erosion in public trust of science and government (Gauchat, 2012) and the current heated controversy around ENDS, the current study found that most adults trust health experts and the CDC to communicate health information about ENDS. This is consistent with other research that has found high public trust in physicians (Blendon, Benson, & Hero, 2014), including as sources of risk information about ENDS (Wackowski et al., 2015). As physicians remain conflicted or uncertain on the health costs and benefits of ENDS (Avalovic & Murin, 2015; Middlekauff, 2015), further research to track their opinions and communication about ENDS with their patients and the public will be important (Kandra, Ranney, Lee, & Goldstein, 2014; Pepper, Gilkey, & Brewer, 2015; Steinberg, Giovenco, & Delnevo, 2015).

With the authority to regulate health claims about ENDS, the FDA should be cognizant of the trust it generates. Our findings indicate that the FDA is generally trusted by consumers, but less so than health experts and the CDC. The comparatively low level of trust of the FDA on information pertaining to the health effects of ENDS could be explained by the lack of consumer knowledge that the FDA regulates ENDS. At the time of our survey, the Deeming Rule that establishes FDA’s authority in regulating ENDS was still pending (Food and Drug Administration, 2016), and less than 50% of consumers were aware that the FDA regulates tobacco products (Wackowski & Delnevo, 2015). In contrast, our findings indicate that the vapor industry is distrusted, even among ENDS users, and nearly as much as the tobacco (non-vapor) industry. While this may be surprising, it is consistent with increasing trends in the perception that ENDS are equally or more harmful than combustible cigarettes (Majeed, Sterling, Weaver, Pechacek, & Eriksen, 2017). Distrust of the vapor industry may stem from an initial predisposition towards distrust from associations with the tobacco industry or a profit motive that might be viewed as in conflict with unbiased messages

about the health effects of ENDS.

Some studies have suggested that trust is asymmetrical; that is, it is often much more challenging to build trust than it is to lose it (Slovic, 1993; Siegrist & Cvetkovich, 2001). Prior research has shown that new information and events, regardless of whether considered good or bad, tends to further lower trust levels within individuals who are initially oriented to distrust an industry (Cvetkovich et al., 2002). The extensive media coverage of ENDS, including low probability but high “dread” events where users have been injured when their ENDS have caught fire or exploded (Rudy & Durmowicz, 2016), might be amplifying the distrust of the industry and negative risk perceptions towards ENDS (Kasperson et al., 1988; Kasperson, Kasperson, Pidgeon, & Slovic, 2003). Although this study did not find that trust in the news media uniquely predicted risk perceptions of ENDS, individuals who trusted the media more were less likely to use ENDS. This latter finding is consistent with Lobb et al. (2007), who found that trust in food safety information from the media was associated with a lower likelihood to purchase, and with risk perception scholars who have highlighted the strong influence of the media in shaping risk perceptions (Leiserowitz et al., 2013). Our finding that smokers had greater trust in news media than non-smokers is in line with other studies that found that a greater proportion of current smokers trusted health information from the Internet “a lot” (20.9%) than never smokers (16.9%) (Rutten, Blake, Hesse, & Ackerson, 2011). In addition, news media in the US between 2006 and 2014 have increasingly described harm reduction approaches to smoking (including ENDS) as potentially beneficial (Eversman, 2015); and many smokers (61%) learn about ENDS from the media and 39% attribute to the news the belief that ENDS are less harmful than regular cigarettes (Wackowski et al., 2015). It is plausible that smokers are selectively attuned to this media coverage of the harm reduction potential of ENDS. Therefore, it is not surprising that smokers trust news media for information on ENDS health effects more than non-smokers.

Although this study shows that public trust of health experts, CDC, and FDA is positive, the levels of trust were modest. Our study identifies population groups (such as Black and multiracial people, people with lower levels of education) that might be targets for communication efforts aimed at improving trust in public health, CDC, and FDA – a tobacco regulatory science research priority (Schmidt et al., 2016). The

risk management literature offers guidance for improving trust and credibility (Bier, 2001; Frewer, 2004; Renn & Levine, 1991). For example, risk messages which are clear, transparent, and balanced regarding any expert disagreement and levels of scientific uncertainty may increase perceptions of trust (Frewer, 2004). This guidance may be particularly relevant to ENDS, where expert disagreement and uncertainty is prevalent, but more research is needed on how to effectively communicate risk uncertainty (Johnson, & Slovic, 1995; Johnson, & Slovic, 1998).

However, in order to modify public trust, the role of cultural worldviews in shaping whom people trust and their perceptions of risk needs to be considered (Hornsey & Fielding, 2017). Specifically, this study found that those with individualistic and hierarchical worldviews were less trusting of health experts, the CDC, and the FDA, and were more trusting of tobacco and vapor manufacturers. Those with individualistic worldviews perceived ENDS to be lower risk, were more uncertain about their risks, and were more likely to have used them. These findings are consistent with past research (Frewer, 2004; Leiserowitz, 2006; Leiserowitz et al., 2013) that has found that hierarchists and individualists tend to see environmental and health risks as lower, compared to egalitarians and communitarians, and this can be explained by the psychological construct of motivated reasoning where individuals attend to and process risk information in a manner that is consistent with their values and beliefs (White, Pahl, Buehner, & Haye, 2003). Individualists tend to not want regulatory interference and trust that individuals can handle risks themselves. Low risk means they neither have to worry about regulatory interference nor harm (Hornsey & Fielding, 2017). Hierarchists may be comforted by thoughts of low risk because they are power, wealth, and status oriented, and perceptions of low risk does not threaten those objectives (Hornsey & Fielding, 2017). Importantly, individuals' worldviews might interact with cognitive heuristics and biases to increase trust in sources whose messages are consistent with their views and beliefs and decrease trust in sources whose messages are incongruent (Kahan, 2012; Kahan et al., 2011). The same risk communication message can have different, opposing, or unintended effects on individuals' risk-benefit perceptions depending on their worldviews (Kahan, Braman, Slovic, Gastil, & Cohen, 2009), and different communication strategies and risk-benefit messages may be needed to communicate effectively (Hornsey & Fielding, 2017).

These results have implications for public health campaigns. Messages about health effects of ENDS should be attributed to trusted sources, and, based on our findings, consumers trust agencies that would typically deliver such messages (e.g., FDA or CDC). Research on consumers' trust for information about ENDS is also important for FDA regulations of marketing and communications about ENDS and other novel tobacco products (Ashley & Backinger, 2012). One area where it is particularly applicable is the approval of modified risk statements. FDA can authorize tobacco companies to make claims that a specific tobacco product is less risky or contains less harmful substances than another commercially available tobacco product (U.S. Food and Drug Administration, 2012). For example, Philip Morris International proposed the following modified risk claim for its iQOS HEETS product (which heats but not burns tobacco) "Switching completely from cigarettes to the iQOS system can reduce risks of tobacco-related diseases" (U.S. Food and Drug Administration, 2017). The FDA is yet to authorize a modified risk claim. It is unclear whether these modified risk claims will be attributed to either the FDA or the tobacco company as a source, but it would be important to study how people perceive the credibility of the source and, if no source is clearly indicated, which source they attribute it to. Statements like the aforementioned might also combine the sources, and it is important to study how this might affect trust. For example, would mistrust of tobacco companies spill into mistrust of regulatory agencies or would tobacco companies be trusted more because they carry FDA-authorized endorsements of their products?

Limitations

This was a cross-sectional, correlational study, which limits causal inference. There are limitations with our measure of trust. Specifically, this study did not assess trust for all potentially important sources of information about ENDS, such as family members, friends, or other industries, such as the pharmaceutical industry; additionally, "health experts and scientists" or the "news media" as sources are undifferentiated. More specific measures (e.g., "one's health care provider") might yield insights useful for informing risk communication efforts. Further, we neither assessed consumers' trust of institutions in general nor their overall tendency to trust. Our measure does not distinguish between trust and related constructs, such as perceived competence, confidence, or credibility, which may be important. Finally, this study did not measure perceived benefits of ENDS nor how the consumers weigh the perceived benefits relative to risks.

Conclusions

This study is among the first to examine whom consumers trust for information about ENDS from a variety of prominent sources. It demonstrates not only the relevance of trust, particularly of the tobacco and vapor industry, for risk perceptions and use of ENDS, but also the importance of considering worldviews. Future research, particularly experimental studies, is needed to better understand which risk communication strategies are most effective for which subpopulations. These findings will have important implications for how public health and the FDA communicate the potential risks and benefits of ENDS to achieve optimal population health impact (Ashley & Backinger, 2012).

Ethical statement

Research reported in this publication was supported by grant number P50DA036128 from the National Institutes of Health, National Institute of Drug Abuse (NIH/NIDA) and Food and Drug Administration, Center for Tobacco Products (FDA CTP) and by grant number R00CA187640 from the National Institutes of Health, National Cancer Institute (NIH/NCI) and Food and Drug Administration, Center for Tobacco Products (FDA CTP). 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. The authors report no conflicts of interest.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at <http://dx.doi.org/10.1016/j.ssmph.2017.09.003>.

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