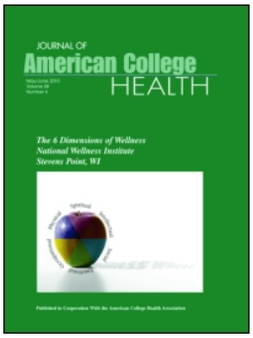

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MAJOR ARTICLE

Aerosol, vapor, or chemicals? College student perceptions of harm from electronic cigarettes and support for a tobacco-free campus policy

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ABSTRACT

Objective: This study is the first to examine the influence of e-cigarette emission phrasing on perceived harm of secondhand exposure, and whether harm perception was associated with support for a tobacco-free campus policy. **Participants:** In the fall 2018 and spring 2019 semesters, 52 sections of a college English course (N = 791 students) were cluster randomized to one of three conditions ("vapor," "aerosol," or "chemicals") assessing harm of secondhand exposure to e-cigarette emissions. **Methods:** Regression models adjusted for demographic characteristics, tobacco use, and other potential confounders. **Results:** Compared to the "vapor" condition, "chemicals" and "aerosol" conditions were associated with increased odds of perceiving secondhand exposure to e-cigarettes to be harmful/very harmful (AOR = 2.0, $p < 0.01$). Greater perceived harm of secondhand e-cigarette exposure was associated with increased odds of supporting a tobacco-free campus policy (AOR = 2.22, $p < 0.001$). **Conclusions:** Health campaigns should use accurate terminology to describe e-cigarette emissions, rather than jargon that conveys lower risk.

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Introduction

Health communication is more than simply providing health-related information. The manner in which such information is framed and presented often has important consequences for audience understanding, risk perception, individual behavior, and public policy making.[1–4] Some health topics represent particularly contentious issue domains because vested interests are motivated to promote particular frames to attempt to influence public discourse. Tobacco is one such domain where there is currently a continuously shifting landscape of emerging products, coupled with powerful industry marketing that present frames to compete with public health interest groups and vie for public attention and acceptance. There are many framing devices in tobacco marketing and risk communication, ranging from glamorous or grotesque imagery, to narratives about manipulation, to simple words used to describe tobacco products and consumer behavior.[5–8]

Shaping the ways people think about and describe secondhand smoke has been an industry tactic dating back to at least the early 1970s.[9] For example, tobacco industry representatives have referred to secondhand smoke as "environmental tobacco smoke" to make it sound more natural, with weaker direct linkages to their products, and thereby less harmful.[10] Similarly, industry representatives have used the term "passive smoking," which carries the connotation of indifference, and may be used to downplay the annoyance often felt by nonsmokers who are unable to avoid exposure.[9]

There has long been interest in the harms and consequences of secondhand exposure to cigarette smoke. Secondhand exposure to cigarette smoke, ie, smoke inhaled involuntarily from cigarettes being smoked by others, can cause asthma attacks, coronary heart disease, strokes, lung cancer, and lower respiratory illness, among other harms.[11] Furthermore, each year secondhand smoke causes an estimated 42,000 deaths in the United States (U.S.)[12] and 603,000 deaths worldwide.[13] Smoke-free laws and policies are important because they not only protect nonsmokers from secondhand smoke exposure, but also may reduce smoking among the general population.[14]

Smoke-free college campus policies—which prohibit smoking on campus—are critical in eliminating exposure to secondhand smoke, as well as preventing smoking initiation and promoting cessation.[15] As a result, there is a major nationwide movement to implement smoke-free campus policies. Since 2012, the number of 100% smoke-free campuses in the U.S. has more than tripled from 774 to 2,487.[16] However, approximately 1-in-6 of these smoke-free campus policies do not address e-cigarettes.[16]

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The exclusion of e-cigarettes from clean air policies is problematic because there is a high prevalence of use among young people[17] and growing evidence that these products are harmful.[18,19] In 2019, 27.5% of high school students and 10.5% of middle school students reported current e-cigarette use.[17] E-cigarettes are now the most prevalent form of tobacco use among youth and young adults. One of the reasons e-cigarette use is so pervasive is the commonly held opinion that e-cigarettes pose less harm than cigarettes[20–27]—even though research has shown that the former products are not harmless. Indeed, there is growing evidence that e-cigarette emissions are harmful to human health.[28–46] Research demonstrates that e-cigarette generated aerosol includes harmful chemicals including formaldehyde, acetaldehyde, acrolein, furans, chloropropanols, and TSNAs.[36,47–49] Furthermore, research has documented that e-cigarette use in natural settings (ie, locations where e-cigarette use is common such as in homes, vaping conventions, or vape shops) results in secondhand exposures[35,50] and thirdhand exposures[51–53] (ie, chemical residue that collects on surfaces). Thus, there is a need for public policy designed to protect non-users of e-cigarettes from the products' emissions.

Despite their U.S. retail availability for approximately 15 years,[54] there is inconsistent language surrounding e-cigarette products and use,[55] as well as the emissions of e-cigarettes.[56] Some people seem to associate the commonly used word "vape" with harmless water vapor.[57,58] However, "aerosol," ie, solid and liquid particles suspended in gas, and "chemicals" (the composition of aerosol) are more accurate terms that may differentially communicate risk associated with exposure. The public health community more often refers to e-cigarette emissions as an "aerosol"[59–61] that is made up of "chemicals".[19,57,62] Previous research suggests that the use of "chemicals" might be associated with greater perceived harm.[57] One of the reasons people in the U.S. might associate "chemicals" with greater harm perceptions may be the historic influence of the landmark works of Rachel Carson, who in the 1960s exposed the corrupt practices of the chemical industry in spreading misinformation about the harmful effects of chemical exposures on environmental and human health.[63]

There is reason to believe that the different descriptors will matter in audience emission perceptions and related cognitions. As framing devices, specific words can activate different networks of related concepts and perspectives, which will then lead to different "problem definition[s]," "causal interpretation[s]," and "treatment recommendation[s]".[1] Moreover, initial evidence suggests that terminology related to e-cigarettes might be associated with how people view them. One study found that news articles published in the U.S. that include "vape" in the headlines tend to portray e-cigarette use more positively compared to the use of "e-cigarette" or "e-cig".[64] However, research has yet to examine whether different word uses for e-cigarette emissions influence perceptions of harmfulness.

We expect the contrast to be particularly sharp between "vape" and "aerosol/chemicals" because of the strong link between "vape" and innocuous water vapor on one hand, and the connection between "aerosol/chemicals" and environmental/physical risk on the other. Thus, the current study had two primary aims: (1) we investigated whether the terminology used to describe the secondhand output of e-cigarettes (aerosol, vapor, or chemicals) influenced undergraduates' perceptions of its harmfulness; and (2) we examined whether perceived harmfulness of secondhand exposure to e-cigarettes was associated with support for a tobacco-free campus, adjusting for support for a smoke-free campus and other important factors.

Methods

Procedure and participation rate

Data were collected during the Fall 2018 and Spring 2019 semesters from a large public research university in Virginia that did not have a smoke-free policy. An email communication requesting in-classroom data collection from students was sent to instructors of English courses (junior-level) required by most undergraduate degree programs. Instructors of 167 class sections were invited to participate in the study, resulting in data collection in 52 sections (31% of all class sections). The numerous English course sections provided a relatively large sample of comparable classrooms that were ideal for cluster randomization.[65] Because the sections of the English course were offered within students' major courses of study, ie, business, humanities, social sciences, natural sciences, and multidisciplinary studies, courses were block randomized to conditions based on these five subject areas. As a result, each condition was comprised of a comparable number of course sections of each type. Among the 52 courses, 17 were assigned to the "aerosol" condition, 18 to the "chemicals" condition, and 17 to the "vapor" condition. Among the 889 students present in these classrooms on the day of survey administration, 843 students (94%) participated in the study. Among those who participated, 791 (94%) provided complete data and therefore comprised the final study sample.

Trained graduate students visited participating classroom sections to conduct the paper survey. Prior to the start of the survey, an informed consent form was read aloud to the class and a print copy provided to all participants. To prevent bias in participation, students were only told that this study was about "health, health knowledge, and policy preferences." Participants were instructed not to use their computers or cellular devices, nor speak to one another during survey administration. Most participants completed the survey within 10 to 20 minutes. Double data entry was used and any discrepancies in data entry were resolved by referring back to the original survey. Institutional review board approval was obtained prior to data collection.

Survey measures

All bolded and underlined text reflects how these prompts and questionnaire items were presented to students on the paper survey.

Demographic characteristics

Measured demographic characteristics included age, sex, and race/ethnicity. Race/ethnicity was recoded into the following four mutually exclusive categories: Hispanic/Latino of any race, Non-Hispanic/Latino White only, Non-Hispanic/Latino Black only, and Non-/Latino other race(s).

Tobacco use

Lifetime cigarette and e-cigarette use were assessed via the questionnaire items: "Have you ever smoked a cigarette, even one or two puffs?" and "Have you ever tried using an e-cigarette/vaping device, even one or two puffs?" Prior to an item assessing e-cigarette use, the following questionnaire prompt appeared: "The following questions are about e-cigarettes/vaping devices, which include cig-alikes, vapes, mods, pod mods (such as JUUL), vape pens, e-hookahs, etc. The picture below shows some examples." The picture used was originally created by the U.S. Food and Drug Administration to depict common e-cigarette types.[66] We modified the photo to include pod mods because the brand JUUL became more popular.[67,68] Previous research supports the use of pictures and a preamble describing what products are considered e-cigarettes,[69,70] because the products and terminology used are evolving rapidly.

Tobacco policy support

Support for stricter campus tobacco policies were assessed by the questionnaire items: "Would you prefer [Name] University be a smoke-free campus?" and "Would you prefer [Name] University be a tobacco-free campus, including e-cigarettes?" Given the current study's second aim, to examine whether perceived harmfulness of secondhand exposure to e-cigarettes was associated with support for a tobacco-free campus, adjusting for support for a smoke-free campus, it was important to assess support for each of these two types of policies.

Perceived harmfulness of secondhand exposure

Questionnaire items assessing secondhand exposure to e-cigarettes varied based on survey condition. Course sections were randomized to receive one of three survey conditions, which only differed on the words used to describe the secondhand output of e-cigarettes: aerosol, chemicals, or vapor. Prior to responding to items assessing secondhand exposure to e-cigarettes, participants in the "chemicals" condition received the following prompt: **"The following questions are based on what you know or believe about the health effects of secondhand e-cigarette chemicals, that is, the chemicals inhaled involuntarily from e-cigarettes being used by others."** Following this prompt, participants responded to: "How harmful do you think **secondhand exposure to e-cigarette chemicals** is to a person's health?" For other survey conditions, parallel prompts and items used the words "**aerosol**" or "**vapor**" instead of "**chemicals**." Prior to any questions related to e-cigarettes, all participants responded to the questionnaire item: "How harmful do you think **secondhand exposure to cigarette smoke** is to a person's health?" Response options to both of these perceived harmfulness questions were: "very harmful," "harmful," "somewhat harmful," "slightly harmful," and "not at all harmful." These response options were assigned values of 1 through 5, with 1 indicating not at all harmful and 5 indicating very harmful.

Statistical analyses

Statistical analyses were conducted using Stata version 14.2. One regression model examined the association between survey conditions (vapor, aerosol, or chemicals) and perceived harmfulness of secondhand exposure to e-cigarettes, adjusting for perceived harmfulness of secondhand cigarette smoke, tobacco use, and demographic characteristics. Due to the extreme values of the scale being more sparsely represented (14% of respondents "Not at all harmful" and 15% "Very harmful", respectively), similar levels of perceived harm were grouped together. As a result, the final response variable had three categories: (1) not at all harmful/slightly harmful versus (2) somewhat harmful versus (3) harmful/very harmful. An approximate likelihood-ratio test of proportionality of odds provided evidence that the proportional odds assumption was violated. Therefore, nominal (multinomial) logistic regression was used instead of an ordinal logistic regression. A second regression model (binary logistic) was used to examine the association between perceived harmfulness of secondhand exposure to e-cigarettes and support for a tobacco-free campus policy, adjusting for support for a smoke-free campus policy, previous use of cigarettes and e-cigarettes, and demographic characteristics.

Results

Table 1 provides descriptive information about the overall study sample as well as the group-randomized conditions. Chi-squared tests and ANOVA F-tests were used to examine statistically significant differences between randomized survey conditions. In these unadjusted analyses, there were no statistically significant differences between groups with regard to demographic characteristics, tobacco use, and perceived harmfulness of exposure to secondhand smoke, which suggests that the randomization process produced comparable groups.

Table 2 presents results from a multinomial logistic regression model. This analysis examined the association between wording condition for secondhand exposure to e-cigarettes and perceived harmfulness of secondhand exposure to e-cigarettes, adjusting for demographic characteristics, previous use of various tobacco products, and perceived harmfulness of secondhand smoke.

Compared to the "vapor" condition, "chemicals" and "aerosol" conditions were associated with increased odds of perceiving secondhand exposure to e-cigarettes to be "harmful"/"very harmful" compared to "not at all harmful"/

Table 1. Group characteristics.

	Aerosol ($n = 265$)	Chemicals ($n = 275$)	Vapor ($n = 251$)	Overall ($n = 791$)
Demographic characteristics	–	–	–	–
Mean age (SE)	22.2 (0.27)	22.8 (0.25)	22.7 (0.32)	22.6 (0.16)
Percent male	56.2%	52.0%	45.0%	51.2%
Percent White only (non-Hispanic)	34.3%	35.3%	36.3%	35.3%
Percent Hispanic any race	17.0%	16.7%	19.5%	17.7%
Percent Black only (non-Hispanic)	10.9%	10.6%	13.6%	11.6%
Percent other race(s) (non-Hispanic)	37.7%	37.5%	30.7%	35.4%
Tobacco use	–	–	–	–
Cigarette smokers	40.0%	38.2%	39.0%	39.1%
E-cigarette users	49.1%	40.0%	46.2%	45.0%
Perceived harmfulness of exposure	–	–	–	–
SH Harm Cigarette (Mean, SE)	4.2 (0.05)	4.2 (0.05)	4.1 (0.05)	4.2 (0.03)

Category names for the different types of variables were in bold.

Table 2. Multinomial logistic regression model of factors associated with perceived harmfulness of secondhand exposure to e-cigarettes ($n = 791$).

	AOR	SE	p	95% CI
Somewhat harmful versus slightly harmful/not at all harmful				
Secondhand smoke harmfulness	**1.5**	**0.2**	**0.001**	**1.2, 1.9**
Chemicals condition (vs vapor)	1.3	0.3	0.252	0.8, 2.1
Aerosol condition (vs vapor)	**1.9**	**0.4**	**0.011**	**1.2, 3.0**
Lifetime smoking status	1.3	0.3	0.258	0.8, 2.2
Lifetime E-cigarette use status	**0.3**	**0.1**	**<0.001**	**0.2, 0.4**
Age	1.0	0.03	0.903	1.0, 1.1
Male (vs female)	**0.6**	**0.1**	**0.009**	**0.4, 0.9**
Hispanic/Latino, any race	**2.3**	**0.7**	**0.003**	**1.3, 4.0**
non-hispanic/latino, black only	**2.0**	**0.7**	**0.033**	**1.1, 3.9**
Non-Hispanic/Latino, other race(s)	1.4	0.3	0.152	0.9, 2.3
Non-Hispanic/Latino, White only	ref	ref	ref	ref
Harmful/very harmful versus slightly harmful/not at all harmful				
Secondhand smoke harmfulness	**3.2**	**0.4**	**<0.001**	**2.5, 4.2**
Chemicals condition (vs vapor)	**2.0**	**0.5**	**0.003**	**1.3, 3.3**
Aerosol condition (vs vapor)	**2.0**	**0.5**	**0.006**	**1.2, 3.2**
Lifetime smoking status	1.1	0.3	0.766	0.7, 1.8
Lifetime E-cigarette use status	**0.2**	**0.1**	**<0.001**	**0.1, 0.3**
Age	1.0	0.03	0.271	1.0, 1.1
Male (vs Female)	**0.5**	**0.1**	**0.001**	**0.3, 0.7**
Hispanic/Latino, any race	**2.3**	**0.7**	**0.005**	**1.3, 4.0**
Non-Hispanic/Latino, Black only	**2.6**	**0.9**	**0.005**	**1.3, 5.1**
Non-Hispanic/Latino, other race(s)	**2.3**	**0.5**	**0.001**	**1.4, 3.6**
Non-Hispanic/Latino, White only	ref	ref	ref	ref

Model $X^2 = 255.20$, df = 20, $p < 0.0001$.
Variables that were statistically significantly associated with perceived harmfulness of secondhand exposure to e-cigarettes ($p < 0.05$) were in bold.

"slightly harmful" (AOR = 2.0 for both; 95% CI = 1.3, 3.3 for chemicals; 95% CI = 1.2, 3.2 for aerosol). Those in the aerosol group also had approximately two times the odds of perceiving secondhand exposure to e-cigarettes to be "somewhat harmful" compared to "not at all harmful"/"slightly harmful" (AOR = 1.9, 95% CI = 1.2, 3.0).

E-cigarette users perceived secondhand exposure to be less harmful than non-users. For example, compared to e-cigarette users, non-users were nearly five times as likely to perceive secondhand exposure to e-cigarettes to be "harmful"/"very harmful" as opposed to "slightly harmful"/"not at all harmful" (AOR = 4.7 [1/0.214 = 4.7], 95% CI = 2.9, 7.6 [1/0.346, 1/0.132]). Respondents who were male (AOR = 0.5, 95% CI = 0.3, 0.7) and/or White (AOR = 0.4, 95% CI = 0.3, 0.6) perceived secondhand exposure to e-cigarettes to be less harmful. Furthermore, respondents who perceived secondhand smoke exposure to be less harmful similarly perceived secondhand exposure to e-cigarettes to be less harmful (AOR = 0.3 [1/3.236], 95% CI = 0.2, 0.4 [1/4.232, 1/2.474]).

Table 3 shows results from a multivariable binary logistic regression model of factors associated with support for a tobacco-free campus policy. Support for a smoke-free campus policy was strongly associated with support for a tobacco-free policy, including e-cigarettes (AOR = 351.7, 95% CI = 142.7, 867.1). Adjusting for support for a smoke-free campus policy and other factors, perceived harmfulness of secondhand exposure to e-cigarettes was associated with higher odds of supporting a tobacco-free campus policy (AOR = 2.2, 95% CI = 1.7, 2.8). Specifically, a one point increase in the perceived harmfulness scale, eg, responding "somewhat harmful" versus "slightly harmful," was associated with more than twice the odds of supporting a tobacco-free campus (AOR = 2.2, 95% CI = 1.7, 2.8). In addition, lifetime non-users of e-cigarette had roughly 2.6 times the odds of supporting a tobacco-free campus policy (AOR = 0.4, 95% CI = 0.5, 2.7; 1/0.37 = 2.6).

Discussion

This study was the first known investigation to examine whether the word used for e-cigarette emissions was associated with perceived harmfulness of secondhand exposure. The results indicate that labeling emissions as "vapor" was associated with lower levels of perceived harm relative to the more accurate terms "aerosol" or "chemicals." Thus, the findings of this exploratory study suggest that product verbiage may be critical in the formation of perceptions of e-cigarette harms among young adults.

This study was also the first to identify that perceptions of harmfulness from secondhand exposure to e-cigarettes was associated with increased likelihood of supporting the implementation of a 100% tobacco-free campus policy. Tobacco-free campus policies are crucial in reducing secondhand exposure to tobacco product emissions, reducing tobacco use rates, and changing social norms among college students.[71] A substantial proportion of campuses with 100% smoke-free policies have already extended their policies to include e-cigarette use.[16] In this sample, 60% of students supported a tobacco-free campus, including e-cigarettes. Thus, data from the current study suggest that, at least at some universities that have yet to implement these comprehensive policies, the majority of students support a 100% tobacco-free campus policy inclusive of e-cigarettes. Furthermore, there are numerous state and municipal laws

Table 3. Multivariable logistic regression model of factors associated with support for a tobacco-free campus policy ($n = 791$).

	AOR	SE	p	95 % CI
Smoke-free policy preference	**351.7**	**161.9**	**<0.001**	**142.7, 867.1**
Perceived harmfulness of secondhand E-cigarette emissions	**2.2**	**0.3**	**<0.001**	**1.7, 2.8**
Lifetime smoking status	0.6	0.2	0.207	0.3, 1.3
Lifetime E-cigarette use status	**0.4**	**0.1**	**0.005**	**0.2, 0.7**
Age	1.0	0.04	0.630	0.9, 1.1
Male (vs Female)	1.3	1.0	0.333	0.7, 2.4
Hispanic/Latino, any race	1.2	0.4	0.702	0.5, 2.7
Non-Hispanic/Latino, Black only	0.9	−0.2	0.849	0.4, 2.3
Non-Hispanic/Latino, other race(s)	0.6	−1.2	0.234	0.3, 1.3

Model $X^2 = 716.67$, df = 9, $p < 0.0001$.
The comparison group for race/ethnicity variables is Non-Hispanic/Latino, White only.

prohibiting smoking in specific venues that fail to restrict e-cigarette use.[72] Findings from this study may be useful when advocating to refine these clean air laws so that they are inclusive of e-cigarettes and therefore comprehensive.

E-cigarettes have been marketed[73] (and are often perceived by the public)[20–27] as products that pose little to no risk of harm. However, emerging evidence suggests that there are prevalent and severe risks from inhalation of e-cigarette aerosol/chemicals.[18,19,28–49] and that bystanders are subject to secondhand and thirdhand exposures.[50–53] Although communication campaigns promoting tobacco-free policies must consider a variety of factors, findings from this study suggest that e-cigarette emissions should be clearly described as "aerosol" or "chemicals" and not as "vapor." The selection of these words is important because they can directly influence perceptions of harm and possibly indirectly affect support for tobacco control policies.

This study adds evidence to support the importance of message framing in health communication and tobacco control. Past studies in tobacco risk communication have approached message framing from a variety of different angles, most prominently that of valence framing, ie, packaging the same health information as either gains or losses.[5,74,75] Findings from this study show that simple wording choices can also have an important impact on risk perceptions and potentially policy support. More research attention to such linguistic framing devices is warranted.

Strengths and limitations

This study was the first to examine the influence of wording for e-cigarette emissions on perceived harm of secondhand exposure, and whether this harm perception was associated with support for a tobacco-free campus policy. This study's design, that is, the randomization of classroom sections and adjustment for important confounding variables strengthened its internal validity. Questions may be raised about the external validity of the study findings, with regard to the representativeness of the students to the entire student body, given the use of a convenience sample. Moreover, it is unclear the extent to which these findings are generalizable to other populations. To minimize the possibility that students would self-select into the study based on their tobacco use status, students were told that this was a survey related to health, health knowledge, and policy preferences. Regardless, future research is needed to examine these associations in other populations.

Conclusion

This study highlights the importance of using accurate terminology to describe e-cigarette emissions. Findings may help inform messaging designed to both deter e-cigarette use and increase support for policies that reduce secondhand exposure. Health experts and communication campaign developers should recognize the power of framing and avoid using inaccurate terms that perpetuate misconceptions of minimal harm from e-cigarette use and exposure. Tobacco control efforts should also be directed to passing new legislation to regulate the marketing practices of the e-cigarette industry so that, among other issues, they do not frame communication to downplay nor deceive the public with regard to the harmfulness of their products.

Conflict of interest disclosure

The authors have no conflicts of interest to report. The authors confirm that the research presented in this article met the ethical guidelines, including adherence to the legal requirements, of U.S. and received approval from the Institutional Review Board of George Mason University.

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