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# Social Media Message Designs to Educate Adolescents About E-Cigarettes

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A B S T R A C T

**Purpose:** E-cigarette use is increasing among adolescents, despite potential harms. Social media messages are a promising way to educate youth about e-cigarettes, yet little is known about what message topics and formats will have beneficial impacts for message reception, reach, e-cigarette knowledge, and beliefs about harms.
**Methods:** A national convenience sample of adolescents (n = 928, aged 15–18 years) in high school was recruited for an online experiment. In October 2019, participants were randomized to view one of three social media formats (visual based, quiz, and text only) or a no-message control. Participants in format conditions viewed six unique topics in a random order. Outcomes were e-cigarette knowledge and beliefs. Message reactions and sharing preferences were also assessed among youth who saw social media messages.
**Results:** Social media messages led to greater knowledge (Cohen's $f = .19$; $p < .001$) and beliefs ($f = .16$; $p < .001$) about harms of e-cigarettes compared with the control, regardless of format. Almost four in five adolescents (79%) reported they would share the social media messages, most likely in person (49%) and with friends (52%). Message topics for missing out because of lung damage, having uncontrolled moods, and ingesting specific harmful chemicals elicited higher intended message reactions.
**Conclusions:** Social media messages can educate about e-cigarette harms. Social media campaigns are a promising e-cigarette education strategy to reach youth, directly and potentially through peer-to-peer sharing.



**IMPLICATIONS AND CONTRIBUTION**

Youth education about e-cigarette harms is needed to counter marketing. Adolescents are receptive to education via social media, especially for topics with social implications of harms. Messages with visuals, quizzes, or text alone increase knowledge, beliefs about harms, and are likely to be shared to increase message reach.

Adolescent use of e-cigarettes has risen sharply, even as rates of combustible cigarette consumption have declined [1]. In 2019, 31.2% of high school students reported current use (past 30 days) of tobacco products, with e-cigarette use (27.5%) most common [1]. Youth e-cigarette use, or vaping, is partially attributed to exposure to persuasive marketing appeals and misperceptions about e-cigarette harms [2]. Advertising on social media portrays e-cigarettes as appealing, healthy, and socially desirable, which likely reinforces misperceptions of little harm [3,4]. Adolescent exposure to e-cigarette marketing online (e.g., Instagram) is associated with e-cigarette experimentation and continued use [5,6]. Effective counter marketing approaches are needed to reach youth online.

One promising approach is to leverage digital media designs to deliver counter messages on social media. Adolescents use

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digital media regularly; most U.S. adolescents own or access a smartphone (95%) and are online constantly or multiple times daily (89%) [7]. Many adolescents (82%) use visual-based social media (i.e., Instagram, Snapchat, and YouTube) as their primary social media platform, where they engage in fundamental development tasks (e.g., exploration and learning), identity formation, and social connectivity (e.g., engaging with friends) [8]. Daily, millions of youth are seeking information (e.g., different viewpoints) and sharing about accomplishments, emotions, and other social issues on these platforms.

For social media messages to educate youth, they must include message topics that encourage adolescents to think about harms, have negative feelings toward the products, and facilitate understanding of facts to influence their beliefs [9–11]. Most e-cigarettes contain toxic chemicals and the highly addictive chemical nicotine, which can have harmful health effects for developing brains and lungs [12,13]. A National Academy review found conclusive evidence of additional e-cigarette harms [14], including death from drinking or injecting e-liquids and burns from e-cigarette explosions. Additional harms may also come from inhaling e-cigarette aerosol with human carcinogens, such as formaldehyde [15]. There is some promising evidence that messages highlighting the addictive potential and health harms of e-cigarettes that elicit intended message reactions can educate adolescents and encourage sharing for message reach [16]. However, little is known about what topics resonate most with teens on social media and how we can optimize delivery for these platforms.

Message designs that use a theory-based "mix of attributes" approach [17], including the use of visuals and interactivity, such as interactive quizzes, have been shown to increase intended message reactions (e.g., thinking). Visuals can quickly convey meaning to influence thinking and feeling for enduring beliefs [18]. Although visual portrayals in e-cigarette marketing on social media entice youth by normalizing use and associate e-cigarettes with aspirational lifestyles [2], youth also rely on visuals in e-cigarette education to guide their attention and interpretation of information [19]. Online quizzes can increase interaction, knowledge, and risk beliefs of health information [20,21]. Despite the promise of these attributes, few studies have examined whether these design strategies will be well received, educate adolescents, or impact message reach for tobacco prevention among adolescents.

The overall objective of the study was to identify promising message content (six topics) and evaluate message format (visual based, quiz, text only, and no-message control) to educate adolescents about e-cigarettes in our always-on, participatory media environment. To do so, this study used an online experiment (format × topic) with adolescents in high school to assess the impact of social media e-cigarette messages on knowledge and beliefs, as well as message reactions and sharing among those who saw messages.

## Methods

### Participants

In October 2019, a convenience sample of 928 adolescents, including e-cigarette users and nonusers, was recruited for the online experiment. Inclusion criteria were being 15–18 years old and currently enrolled in high school. Lightspeed Health, a division of Kantar, recruited participants directly (if 18 years of age) or through parents in their panels by notifying individuals of the opportunity through their consumer research platform. All interested individuals completed a screener to determine eligibility; 89% of eligible participants enrolled. Participants who were aged 18 years gave consent before starting the study. For participants aged <18 years, parents gave their consent, and adolescents assented before beginning. Participants were compensated for their time (approximately $5) through the Lightspeed Health payment system. The University of North Carolina Institution Review Board approved all study procedures.

### Procedures

*Stimuli development.* Six unique messages for e-cigarette hazards, harms, and industry practices were created using a mock Instagram interface. Message topics were selected based on evidence of prevalent myths, misperceptions, and social/product trends, as well as identified desires for e-cigarette education among youth [2,9,22–24]. Evidence-based statements were created from scientific literature on vaping [14,25,26] and given to a young adult to rewrite with age-appropriate copy (wording shown in Table 1). Messages about hazards were about how an e-cigarette "contains chemicals," such as formaldehyde, and "can explode." Messages for harms were about "nicotine effects" beyond addiction, irritability, and other "mood effects," and missing out on activities because of "lung damage." The industry practices message focused on how sleek "vape designs" may deceive youth.

The six message topics were then developed for each of the three digital media design conditions (examples shown in Figure 1). All messages appeared as Instagram posts or stories with consistent social media cues (e.g., profile and hashtags) but were not posted online. For the visual-based condition, stock or creative commons images were selected by the young adult designer to illustrate the message topic. For the quiz messages, all topics were formatted to be true–false questions. Each social media message in the quiz condition had two pages. On the first page of the post, users were presented with a potentially true or false statement. On the following screen, users received immediate quiz feedback (correct answer) and evidence to support the correct answer. One of the quiz pages contained the same image used in the visual-based condition. For the text only condition, each message was displayed as a sentence in black Arial font on a white background where an Instagram image would normally appear.

*Experiment.* Participants were randomized to an online experiment with two factors (message format × topic). The first factor for message format was between subjects; participants were randomly assigned to one of four conditions: visual-based messages, quizzes, text-only messages, or a no-message control. The second factor for message topic was within subjects; participants who were assigned to one of three message conditions (visual based, quiz, or text only) saw content for six unique e-cigarette message topics, presented in a random order.

### Measures

*Message reactions.* Following exposure to each message, participants in message conditions rated their perceived message effectiveness (PME), cognitive elaboration, and affect (Table 2).

**Table 1**
Social media message topics

| Topic | Visual-based and text-only text | Quiz question text | Quiz feedback text |
|---|---|---|---|
| Lung damage | Hope you like watching from the sidelines. Vaping can cause serious breathing problems that can lead to long-term lung damage. | Vaping will have no effect on my ability to play sports. | False: Hope you like watching from the sidelines. Vaping can cause serious breathing problems that can lead to long-term lung damage. |
| Contains chemicals | You thought that vape was water. False; ecig vapor contains chemicals, including formaldehyde, and what they do to your body is not well understood. | Unlike smoking cigarettes, vaping involves inhaling only water vapor. | False: You thought. Vape contains chemicals, including formaldehyde, and what they do to your body is not well understood. |
| Mood effects | Vaping may make you feel good in the moment, but can affect brain development that can cause long-term mood alterations such as increased aggression, irritability, or anxiety. | Vaping may make you feel good in the moment but does not affect your long-term mood. | False: Vaping can affect brain development, causing long-term mood alterations such as increased aggression, irritability, or anxiety. |
| Nicotine effects | Nicotine is more than addictive; it can make you moody or unfocused, can keep you from having children, and can be lethal if ingested at high doses. Good luck getting a date like that. | The only downside to nicotine is that it's addictive. | False: Nicotine can make you moody or unfocused, can keep you from having children, and can be lethal if ingested at high doses. Good luck getting that date. |
| Can explode | Like hover boards, vapes have been known to spontaneously explode, causing serious burns to users. | Vapes and hover boards have nothing in common. | False: Both have been known to spontaneously explode, causing serious burns to users. |
| Vape designs | Some vapes are designed to look like everyday items (USB drives, pens, and markers) to dupe you by reducing negative associations with normal cigarettes. | Some vapes are designed to look like everyday items to dupe you into thinking the product is not very harmful. | True: Many vapes resemble USB drives, pens, and markers to reduce negative associations with normal cigarettes. |

PME was assessed with the three-item University of North Carolina PME Scale, validated to identify promising anti-smoking messages among adolescents [27]: "This message makes vaping seem unpleasant to me"; "This message makes me concerned about the health problems caused by vaping"; and "This message discourages me from wanting to vape." The five-point response scale ranged from "strongly disagree" (coded as 1) to "strongly agree" (5). The three items were averaged at each time point ($\alpha = .90–92$). Cognitive elaboration, or thinking in reaction to each message, was assessed with, "How much did this message make you think about the harmful effects of vaping?" [28]. Response options ranged from "not at all" (coded as 1) to "a great deal" (5). Affect was assessed with the item, "how did this message make you feel about vaping," with responses ranging from "very bad" (coded as 1) to "very good" (7) [28].

*Knowledge.* After viewing all messages, the survey assessed e-cigarette knowledge with eight previously used or newly developed items (Table 3) [9,10,16]. Knowledge response options were "true," "false," or "I do not know." Correct responses were coded as 1. Incorrect or "I do not know" were coded as 0. Responses were summed for scores potentially ranging from 0 (none correct) to 8 (all correct).

*Beliefs.* The survey also assessed beliefs about the effects of e-cigarettes with seven previously used or newly developed items (Table 3) [29]. Response options for these items ranged from "strongly disagree" (1) to "strongly agree" (5). Scores were averaged for beliefs overall ($\alpha = .94$).

*Sharing.* Participants who viewed social media messages selected all the ways they might share these messages and all the people who they would share with (Table 4) after viewing all messages [16,30].

*E-cigarette use status.* Participants were asked, "have you ever used an e-cigarette or vaped, even one or two puffs [22]?" Those who answered "yes" (vs. "no" defined as nonusers) were asked, "How often do you currently use an e-cigarette or vaping device [31]?" Responses of "not at all" (coded as 1) and "less than monthly" (2) were defined as ever users. Responses of "less than weekly, but at least once a month" (3), "less than daily, but at least once a week" (4), and "daily or almost daily" (5) were defined as current users. Participants were defined as susceptible to future use if they had never used e-cigarettes and responded "definitely yes," "probably yes," or "probably no" to at least one of three questions about e-cigarettes: "Have you ever been curious about using e-cigs or vaping devices"; "Do you think you might try an e-cigarette or vaping device soon"; or "If one of your best friend were to offer you an e-cigarette or other vaping device, would you use it [32]?"

*Smoking status.* Participants were asked if they have "ever tried smoking cigarettes, even one or two puffs?" Those who responded "yes" (vs. "no" defined as nonsmokers) also reported if they currently smoke "not at all" (ever smokers) or if they now smoke "some days" or "every day" (current smokers) [16].

### Data analyses

For message reactions, a factorial (three formats × six topic) repeated measures analysis of variance (ANOVA) was conducted for each outcome (PME, cognitive elaboration, and affect). For significant *F*-tests, planned pairwise comparisons were then conducted to compare the highest and lowest rated messages to all other messages. Separate one-way ANOVAs and Bonferroni post-hoc comparisons were conducted to examine the impact of format (four conditions) on knowledge and beliefs. Exploratory ANOVAs were conducted to examine possible moderation of e-cigarette use status across all outcomes.

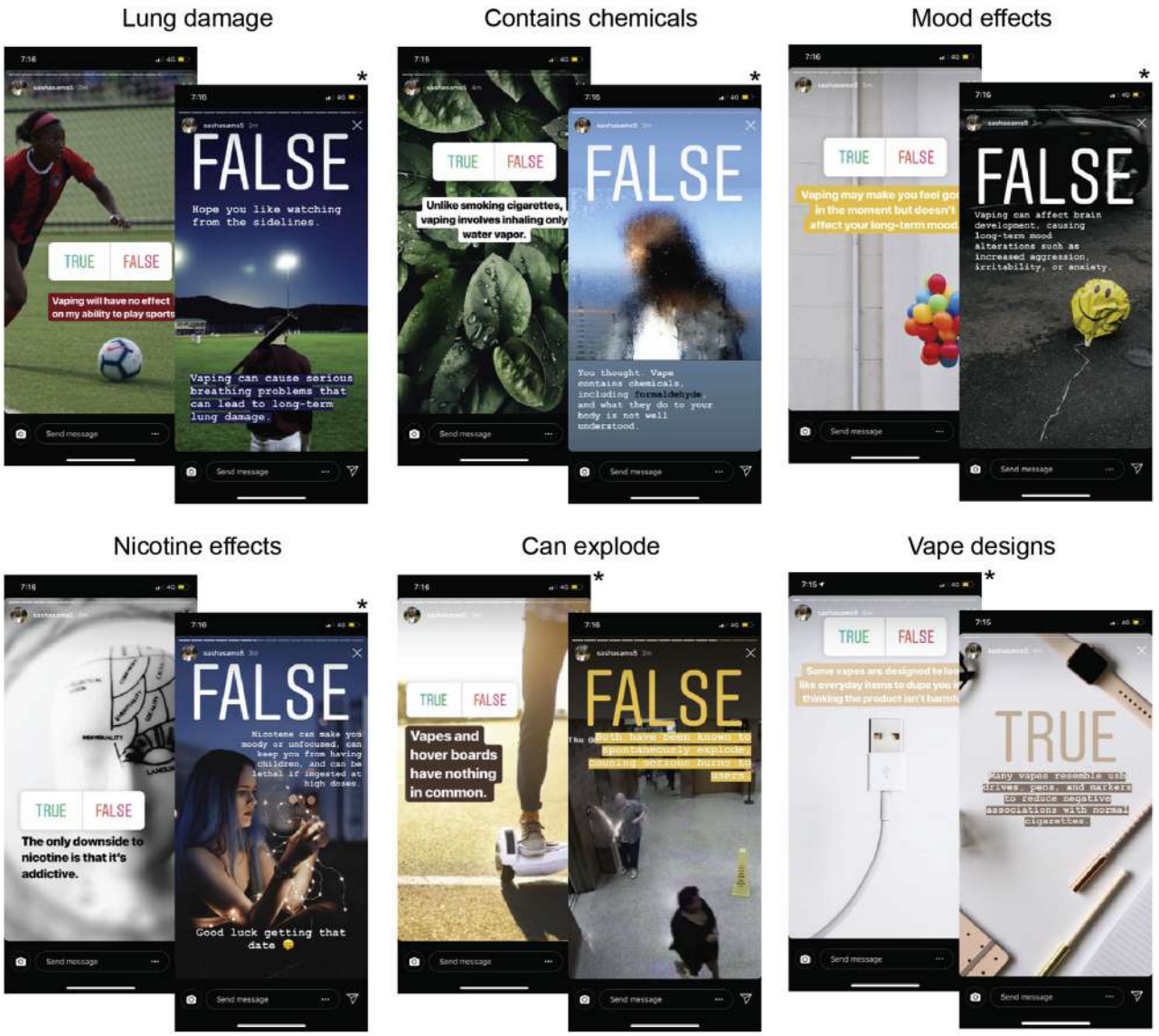


**Figure 1.** Example social media messages. Quizzes shown. *Image used in visual-based message condition.

Descriptive statistics were used to assess message sharing. Point-biserial correlations were conducted to explore relationships between sharing (would share vs. would not share) and PME of each message.

## Results

Adolescent participants (n = 928) were aged between 15 and 18 years (mean = 16.08, standard deviation [SD] = .87; Appendix A). About half of the participants (52%) were female. Most participants were white (81%) and non-Hispanic (90%). Approximately three of 10 participants (29%) reported the use of e-cigarettes, with 10% current users and 19% ever users. An additional 23% of e-cigarette nonusers were susceptible to use. More than one fourth of participants (26%) had smoked cigarettes, with 9% current smokers and 17% ever smokers.

### *Impact of topic and format on social media message reactions*

There was a main effect of message topic for PME, cognitive elaboration, and affect (all $p < .001$; Table 2). The pattern of results was similar for PME and elaboration. The "lung damage" message led to the highest PME (mean = 4.4, SD = .9) and elaboration (mean = 4.0, SD = 1.1), followed by the "contains chemicals" message, which did not differ significantly. The "lung damage" message led to greater PME than the "mood effects" message ($p = .20$), but not greater elaboration. The "lung damage" message also led to greater PME and elaboration than the "nicotine effects" and "can explode" messages (all $p < .01$). The "vape designs" message led to less PME (mean = 3.7, SD = 1.1) and cognitive elaboration (mean = 3.2, SD = 1.4) than all other message topics (all $p < .001$).

The effects of message topic on affect were again similar but varied slightly. The "contains chemicals" message led to the

**Table 2**
Impact of social media designs on message reactions (n = 686)

| | 1. Lung damage, M (SD) | 2. Contain chemicals, M (SD) | 3. Mood effects, M (SD) | 4. Nicotine effects, M (SD) | 5. Can explode, M (SD) | 6. Vape designs, M (SD) | *F* (Cohen's *f*) |
|---|---|---|---|---|---|---|---|
| Perceived message effectiveness (all) | 4.4 (.9) | 4.4 (.9) | 4.3 (.9) | 4.3 (1.0) | 4.2 (1.0) | 3.7 (1.1) | 116*** (.41) |
| Visual based | 4.4 (.9) | 4.4 (.9) | 4.4 (.8) | 4.3 (.9) | 4.1 (1.0) | 3.8 (1.1) | |
| Quiz | 4.4 (1.0) | 4.3 (1.0) | 4.3 (1.0) | 4.3 (1.0) | 4.2 (1.0) | 3.8 (1.1) | |
| Text only | 4.5 (.8) | 4.4 (.8) | 4.3 (.9) | 4.3 (1.0) | 4.3 (.9) | 3.6 (1.2) | |
| Cognitive elaboration (all) | 4.0 (1.1) | 3.9 (1.2) | 3.9 (1.2) | 3.9 (1.2) | 3.7 (1.3) | 3.2 (1.4) | 94*** (.37) |
| Visual based | 3.9 (1.2) | 3.9 (1.2) | 3.8 (1.2) | 3.8 (1.3) | 3.6 (1.3) | 3.3 (1.5) | |
| Quiz | 4.0 (1.2) | 3.9 (1.2) | 3.9 (1.3) | 3.8 (1.2) | 3.7 (1.4) | 3.3 (1.4) | |
| Text only | 4.1 (1.1) | 4.0 (1.2) | 4.0 (1.1) | 3.9 (1.1) | 3.9 (1.2) | 3.1 (1.4) | |
| Affect (all) | 2.0 (1.6) | 2.0 (1.5) | 2.0 (1.6) | 2.1 (1.6) | 2.1 (1.6) | 2.6 (1.2) | 47*** (.26) |
| Visual based | 2.1 (1.7) | 2.0 (1.6) | 2.2 (1.7) | 2.2 (1.7) | 2.2 (1.7) | 2.5 (1.8) | |
| Quiz | 2.0 (1.6) | 2.0 (1.6) | 2.0 (1.5) | 2.0 (1.6) | 2.1 (1.6) | 2.6 (1.8) | |
| Text only | 2.0 (1.5) | 2.0 (1.5) | 2.0 (1.5) | 2.1 (1.6) | 2.0 (1.5) | 2.8 (1.6) | |

Visual-based messages = 217; quiz messages = 239; text-only messages = 230.
M = mean; SD = standard deviation.
*** $p < .001$.

greatest negative affect (mean = 2.0, SD = 1.5), followed by the "lung damage" and "mood effects" messages, which did not differ significantly. The "contains chemicals" message led to greater negative affect than the "nicotine effects" message ($p = .023$) and the "can explode" message ($p = .002$). Again, the "vape designs" message was rated lowest with less negative affect (mean = 2.6, SD = 1.2) than all other message topics (all $p < .001$). There was no main effect for message format on PME. E-cigarette use status did not moderate the effects of message topic or format on message reactions.

### *Impact of social media messages on knowledge and beliefs*

Adolescents who viewed social media messages had greater knowledge about e-cigarettes than those who did not see any messages (Cohen's $f = .19$; $p < .001$; Table 3), regardless of the message format. Adolescents who saw messages, on average, answered one additional true–false item correctly, bringing the average score of these groups to approximately 6/8 (vs. 5/8 correct in the control condition). The messages had a higher impact on knowledge of some topics (12%–19% for irritability due to nicotine withdrawal and harm to teen brain development) compared with others (2%–9% unknown long-term health effects and usually contain nicotine). Notably, knowledge that e-cigarettes contain nicotine, contain harmful chemicals, and have unknown long-term health effects was high among adolescents across all conditions (>70%).

Viewing e-cigarette messages also had an impact on beliefs ($f = .16$, $p > .001$). Adolescents in all social media message conditions reported significantly greater beliefs in

**Table 3**
Impact of social media designs on e-cigarette knowledge and beliefs (n = 928)

| | Visual-based messages | Quiz messages | Text-only messages | No-message control | *F* |
|---|---|---|---|---|---|
| | M (SD) or % correct | M (SD) or % correct | M (SD) or % correct | M (SD) or % correct | |
| Knowledge overall | 6.2 (1.9) | 6.1 (2.1) | 6.0 (2.0) | 5.2 (2.1) | 10.8*** |
| E-cigarettes usually contain nicotine | 82% | 77% | 81% | 73% | |
| People who vape can exhibit signs of irritability due to nicotine withdrawal | 79% | 81% | 79% | 62% | |
| First-hand vapor is just water vapor (false) | 60% | 60% | 44% | 41% | |
| E-cigarettes may harm teen brain development | 86% | 85% | 81% | 69% | |
| E-cigarettes use liquids that contain harmful chemicals | 87% | 85% | 86% | 78% | |
| E-cigarettes have unknown long-term health effects | 80% | 76% | 78% | 74% | |
| Nicotine can be lethal in very high doses | 81% | 82% | 84% | 72% | |
| E-cigarettes do not contain any of the toxic chemicals that can be found in combustible (regular) cigarettes (false) | 64% | 68% | 63% | 55% | |
| Beliefs overall | 4.4 (.8) | 4.5 (.8) | 4.4 (.7) | 4.2 (.9) | 7.7*** |
| If I vape regularly, I will… | | | | | |
| Damage my body | 4.6 (.8) | 4.5 (.9) | 4.5 (.8) | 4.3 (1.1) | |
| Damage my lungs | 4.6 (.8) | 4.5 (.9) | 4.6 (.7) | 4.4 (1.0) | |
| Become addicted to vaping | 4.4 (.9) | 4.4 (1.0) | 4.3 (1.0) | 4.1 (1.2) | |
| Inhale harmful chemicals | 4.6 (.8) | 4.6 (.8) | 4.6 (.6) | 4.5 (.9) | |
| Hurt my health | 4.5 (.9) | 4.6 (.9) | 4.6 (.7) | 4.4 (1.0) | |
| Disrupt my mental focus | 4.2 (1.0) | 4.4 (1.0) | 4.3 (.9) | 4.1 (1.1) | |
| Become more irritable | 4.1 (1.1) | 4.3 (1.0) | 4.1 (1.1) | 3.6 (1.2) | |

Knowledge items were true unless noted as (false).
M = mean; SD = standard deviation.
*** $p < .001$.

harm from e-cigarettes (e.g., damage my body) compared with those in the no-message control, with no differences among the formats. E-cigarette use status did not moderate the message effects on knowledge or beliefs about e-cigarette harms.

*Impact of social media messages on sharing*

Almost four of five adolescents (79%) who saw social media messages indicated they would share them with others (Table 4). Notably, most adolescents wanted to share these messages in person (49%), followed by sharing on one's Instagram story or by texting. Less than one in five adolescents thought they would post the message to their Instagram (nonstory) or other social media account. Few adolescents endorsed emailing or direct messaging on another social media site as a way to share the message. Although participants could select multiple ways of sharing these messages, more than two thirds (67%) of adolescents interesting in sharing would use only one or two communication channels. Sharing through any channel (vs. not sharing) was positively associated with PME of each message ($r_{pb} = .14–20$; $p < .001$; Appendix B).

More than half of adolescents (52%) were most interested in sharing these e-cigarette messages with their friends. Two of five adolescents also indicated they would share e-cigarette messages with their sibling. Parents, girl/boyfriends, and other family members were the next most common recipients, with very few endorsing sharing with someone outside these roles.

## Discussion

Social media messages are a promising way to educate youth about the harms of e-cigarettes. In this first study of social media e-cigarette messages, exposure led to greater knowledge about the harms of e-cigarettes, including lesser-known harmful effects of nicotine (irritability from withdrawal and harms brain development). This, coupled with greater knowledge of chemicals in e-cigarette aerosol (vapor), indicates social media messages could help counter marketing and dispel misperceptions. Adolescents who saw the social media messages also had stronger beliefs about general (e.g., damage my body) and specific (e.g., become more irritable) health effects if they used e-cigarettes regularly. These educational gains, however, must be considered in the broader social media landscape where youth are regularly engaging with (e.g., following and attending to) and bonding over positive e-cigarette portrayals [2,23]. All messages were formatted as Instagram posts or stories, but not shown in social media feeds; future studies should juxtapose e-cigarette education with positive portrayals of e-cigarettes that dominate social media (e.g., Instagram) to understand the feasibility and impact of these messages to inform and discourage use among youth [24].

**Table 4**
Sharing e-cigarette social media message designs (n = 688)

| | n (%) |
|---|---|
| Would share by… | |
| Showing someone in person | 335 (49) |
| Posting to my Instagram story | 219 (32) |
| Texting | 207 (30) |
| Posting to my Instagram profile | 120 (17) |
| Posting on another social media site | 110 (16) |
| Email | 92 (13) |
| Sending in a direct message on another social media site | 21 (3) |
| Would not share | 141 (21) |
| Would share with… | |
| Friend | 481 (52) |
| Brother or sister | 274 (40) |
| Parents | 244 (36) |
| Boyfriend or girlfriend | 220 (32) |
| Other family member | 186 (27) |
| Other | 8 (1) |
| Would not share with anyone | 117 (17) |

Almost four of five adolescents indicated they would share these educational messages, with many wanting to share with other youth (e.g., friends and siblings). Designing messages so youth desire to share may be instrumental to organically increase peer-to-peer message reach. These findings indicate the potential for social media messages with intended effects to facilitate social interactions. In the context of e-cigarette and tobacco warnings, sharing not only increased the reach of the actual messages but also sparked social interactions about the health harms of tobacco or benefits of quitting that are likely influential mechanisms of attitude and behavior change [16,30,33]. Notably, more adolescents wanted to share e-cigarette messages in person than through any particular digital channel, ahead of the next most frequently selected options to post to ephemeral digital channels (i.e., Instagram stories) and share directly via texting. Future research is needed to assess in-person sharing, which cannot be capture in digital metrics, to truly understand reach and impact of these conversations as antitobacco social interventions where peer and social networks yield substantial influence [30,34].

Messages that communicate nonaddiction health effects, especially for harms with social implications, had the greatest intended effects (e.g., increased unpleasantness of vaping) among adolescents in this study. Intended message reactions were strongest for topics about missing out because of lung damage, having uncontrolled moods, and ingesting specific (nonnicotine) harmful chemicals, identifying them as promising messages for youth. The nicotine message, although written to highlight effects other than addiction, elicited more muted message reactions. As “nicotine hit” is increasingly a motivator of youth Juul use [35], conveying the negative effects of nicotine exposure may not resonate with teens. Messages about burns from e-cigarettes exploding and the product designs of e-cigarettes were consistently rated the lowest for intended message reactions; this may be a result of low perceived likelihood of explosions because of underreporting [36] and the difficulty in countering established attitudes from the successful marketing of a sleek product [25]. Lower intended message reactions for design and safety issues mirror other findings that youth consistently prefer facts about specific negative effects on ones' social circumstances (e.g., acceptance and popularity), health, or appearance to change their beliefs [22,37].

Different formats can be used to educate youth about e-cigarettes. The message formats in this study—visual based, quizzes, and text only—had a similar impact on message reactions, knowledge, and beliefs. This evidence indicates health communicators have a number of options for delivering messages with the intended impact. Visuals facilitate positive reception and comprehension of critical health information by illustrating key concepts to convey meaning quickly and encourage message processing [18,38] that is necessary in our digital environment where good first impressions are key to

leveraging adolescents' fragmented attention [39]. Interactivity, such as quizzes, can increase health knowledge and influence attitudes. Quizzes encourage interaction and thinking critical for changing attitudes [21]. Quizzes with immediate feedback increase learning, appreciation of content, and perceptions of risk [20,40]. The text-only messages were also promising in this study; presenting novel information as text alone may be enough to challenge misperceptions. Black and white messages increase risk beliefs about other tobacco products [29], although it is unknown how these stark messages will perform alongside other attract-grabbing content.

The strengths of this study include a large sample of adolescents. However, message reactions and impact are limited to this convenience sample of U.S. participants. Research targeting more current e-cigarette users, nonwhite populations, and older adolescents or young adults may yield different results. The messages' impact on knowledge and beliefs were analyzed in comparison to a no-message control; future studies should compare the impact of e-cigarette social media messages to other tobacco education content on these outcomes and intentions to use or actual behavioral measures to indicate message effectiveness. In addition, single items were used to assess cognitive elaboration and affect and may not be as robust as multi-item measurement. A limited number of images were used in these messages; others could have greater or different effects. Crowdsourcing image selection or conducting qualitative studies would help identify effective imagery for specific and broad audiences.

## Conclusion

By leveraging digital media designs, this study fills a gap for effective strategies to counter e-cigarette marketing and adolescent misperceptions for vaping prevention on social media. Increasing e-cigarette use among adolescents, dynamically changing products, and a heavy marketing presence on social media may undo the gains made by tobacco control efforts. Social media campaigns have promise to counter marketing and educate youth. A variety of message topics and formats had beneficial impacts on knowledge and beliefs about e-cigarette harms, suggesting social media messages could improve youth education. Future studies are needed to assess the reach and impact of a broader set of messages delivered to youth through social media platforms.

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## Supplementary Data

Supplementary data related to this article can be found at https://doi.org/10.1016/j.jadohealth.2020.05.030.

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