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ORIGINAL ARTICLE

Vape, quit, tweet? Electronic cigarettes and smoking cessation on Twitter

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Abstract
Objectives Individuals seeking information about electronic cigarettes are increasingly turning to social media networks like Twitter. We surveyed dominant Twitter communications about e-cigarettes and smoking cessation, examining message sources, themes, and attitudes.
Methods Tweets from 2014 were searched for mentions of e-cigarettes and smoking cessation. A purposive sample was subjected to mixed-methods analysis.
Results Twitter communication about e-cigarettes increased fivefold since 2012. In a sample of 300 tweets from high-authority users, attitudes about e-cigarettes as smoking cessation aids were favorable across user types (industry, press, public figures, fake accounts, and personal users), except for public health professionals, who lacked consensus and contributed negligibly to the conversation. The most prevalent message themes were marketing, news, and first-person experiences with e-cigarettes as smoking cessation aids. We identified several industry strategies to reach Twitter users.
Conclusions Our findings show that Twitter users are overwhelmingly exposed to messages that favor e-cigarettes as smoking cessation aids, even when disregarding commercial activity. This underlines the need for effective public health engagement with social media to provide reliable information about e-cigarettes and smoking cessation online.

Keywords Electronic cigarettes · Smoking cessation · Social media · Twitter

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Introduction

The majority of e-cigarette users cite smoking cessation or reduction as their primary reason for use (Goniewicz et al. 2013; Rutten et al. 2015), yet evidence for their effectiveness in this regard is inconclusive, short-term health effects largely unknown, and information about their long-term health effects is lacking (McRobbie et al. 2014). Individuals seeking information about electronic cigarettes (e-cigarettes) are increasingly turning to the Internet (Ayers et al. 2011; Emery et al. 2014), where e-cigarette advertising has proliferated on social media networks like Twitter, Facebook, and Instagram (de Andrade et al. 2013). Identifying sources and characteristics of online communication about e-cigarettes and smoking cessation is therefore of great interest for public health researchers and policy makers. Social media is of particular interest given its ease of use and popularity.

Communication about e-cigarettes on Twitter is overwhelmingly dominated by e-cigarette companies (Huang et al. 2014; Myslín et al. 2013), and similar findings have been reported with respect to YouTube (Luo et al. 2014; Paek et al. 2014), Facebook, Tumblr, and Pinterest (de

Andrade et al. 2013). Huang et al. (2014) examined nearly 75,000 Twitter messages, known as tweets, about e-cigarettes posted in May and June 2012, and found that over 10 % mentioned smoking cessation. A separate analysis of 153 active Twitter accounts dedicated to smoking cessation revealed that 43 % of users mentioned e-cigarettes (Prochaska et al. 2012). The overall sentiment on Twitter toward e-cigarettes as smoking cessation aids tends to be positive (Myslín et al. 2013).

Little is known, however, about the precise make-up of Twitter communication about e-cigarettes and smoking cessation. For instance, who are the most popular Twitter users tweeting about this topic? Is the positive sentiment reported by Myslín et al. (2013) shared by all or limited to specific groups? How is the Twitter landscape affected by fake accounts and 'bots,' automated programs designed to tweet spam, mine data, and manipulate account statistics (Boshmaf et al. 2011; Gao et al. 2010)? Is there evidence of 'astroturfing,' that is, fabricated grassroots movements manipulating online conversation (Harris et al. 2014)? What other industry strategies are used on Twitter? We conducted a mixed-methods analysis to identify and describe categories of influential Twitter users, examine their tweets about e-cigarettes and smoking cessation, and compare their associated message themes and attitudes. We also provide an 'industry-free' perspective to examine communications among noncommercial Twitter users, and identified several e-cigarette industry strategies used to reach them.

Methods

Data collection

We chose to study Twitter because it is one of the most popular social media networks (Brenner and Smith 2013), allows for direct peer-to-peer exchanges between individuals, companies, and other users, and is easily accessed and indexed. In contrast to previous Twitter studies on e-cigarettes which were limited to analyzing random samples captured through periodic keyword searches over short timeframes, we accessed a full year's worth of Twitter data through Sysomos HeartBeat, a subscription-based service for social media data collection and analysis which allowed us to capture a purposive sample of tweets from users with the highest authority; those with the widest and farthest reach on Twitter. This authority-based approach is an established methodology (Wu et al. 2013) used to study the most popular 5 % of Twitter users, who are estimated to generate up to 75 % of activity (Cheng and Evans 2009a). We employed this strategy to sample tweets from the most authoritative Twitter users communicating about e-cigarettes and smoking cessation.

We searched the HeartBeat database for English-language tweets (we did not differentiate between tweets, retweets, and replies) related to e-cigarettes posted between January 1 and December 31, 2014, inclusive. Search terms were selected from peer-reviewed literature and through pilot searches on Twitter, using variations of the terms 'e-cigarette,' 'vaping' (slang for the act of using an e-cigarette), and Twitter hashtags like #ecigs and #vapelife (see Online Resource for all search terms). Brand names were not used due to the practical limitations of collating an exhaustive list and the risk of over/under representating certain brands. Tweets about marijuana vaping were filtered out. Our search identified 2,543,726 tweets about e-cigarettes posted in 2014. These were then filtered to include only variations of the terms 'quit' and 'stop smoking,' yielding the primary dataset of 120,803 tweets (by 80,809 users) about e-cigarettes and smoking cessation, estimated by HeartBeat to have been seen 316 million times by other Twitter users (see Fig. 1 for a description of the data collection process).

To generate a separate 'industry-free' dataset, an additional query was used that filtered out tweets suggesting commercial activity (based on keywords such as #giveaway, #promo, and #win). Tweets in each of the two datasets were then rank-ordered by Sysomos's proprietary measure of authority, which assigns a score between 0 (lowest authority) and 10 (highest) based on an analysis of the user's number of followers, other users followed, number of tweets, and number of retweets (Sysomos does not divulge the exact algorithm). Finally, from the first and second dataset we selected the 300 highest authority tweets, providing a 'complete' sample and an 'industry-free' sample. Any commercial tweets missed by the filter were manually removed from the industry-free sample until 300 tweets were included.

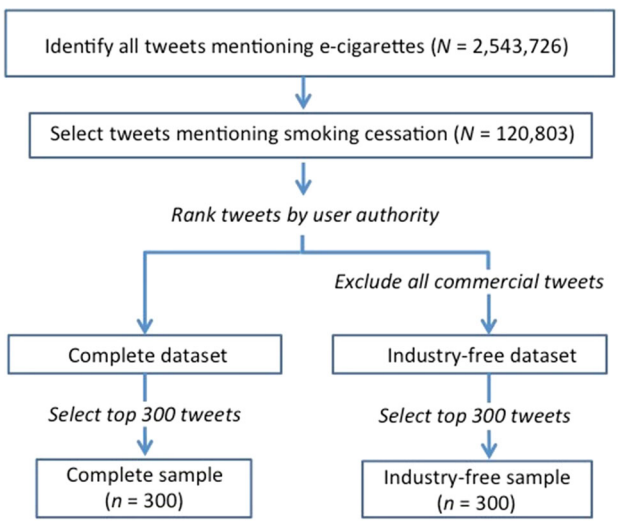

Fig. 1 Flow chart illustrating the data collection process

Coding and analysis

Coding categories were based on previous literature with guidance from a social media analysis specialist. As HeartBeat's native sentiment analysis was judged as unreliable, sentiment was manually recoded (HeartBeat's sentiment and manual coding of affect showed 51 % agreement, $r = .227$, $p < .001$). Following Hovy (2015), our analysis distinguished between a message's feeling/emotion or affective content (positive, negative, or neutral) and its attitude (pro, con, neutral/do not know) toward the use of e-cigarettes for smoking cessation. Message attitude included explicit statements (opinions, claims, citations of studies), implicit outcome expectancies, and advice. Following Myslín et al. (2013), thematic analysis employed an open coding approach by which a message was coded with one or more tags describing its context/genre or message theme.

Each tweet was classified according to user type (Paek et al. 2014), which typically involved a detailed inspection of the associated Twitter account. Categories were determined with guidance from a social media analysis specialist and iteratively revised during coding, resulting in the following definitions. Industry/related accounts were explicitly linked to e-cigarette or marketing companies. Following Benevenuto et al. (2010) recommendation to consider both tweet content and user behavior to identify spam, fake users were those who either (a) appeared to be run by bots (defined by extremely high volume of tweets, all original tweets with URLs, and primarily promotional content or links to random websites) or (b) demonstrated (mostly) human attributes or behaviors, but whose identity could not be verified through Google searches or other social media platforms. Public figures were (a) those with more than 10,000 followers and (b) judged to be popular figures in mainstream entertainment and media, politics or business, or social media. Press/media users were those linked to verifiable press or other prominent media sources of information, such as blogs. Public health and healthcare users were linked to public health organizations and healthcare providers, respectively. Personal users were accounts from private individuals not explicitly associated with organizations, movements, or other agendas; those who showed evidence of commercial activity related to e-cigarettes were classified as personal users with industry ties.

Content analysis employed the constant comparative method and was performed by a single researcher; intercoder reliability on a subsample (10 % of tweets) by a second researcher indicated good agreement, with percentage agreement ranging from 68.2 % (affective content) to 93.5 % (attitude), yielding an overall Cohen's kappa of .74. Descriptive statistics and Chi-square tests for association were used to explore and compare characteristics within samples. HeartBeat's native analytics provided summary statistics about the full dataset. Much gender data and nearly all age data were missing, and location data were found to be unreliable (e.g., "CA" could signify either California or Canada), so these were not used.

Results

Sample characteristics and associations between tweet sources and characteristics

Tweets in the complete sample ($n = 300$) were generated by 148 unique Twitter users, while the industry-free sample ($n = 300$) contained 215 unique users. See Table 1 for detailed sample characteristics. The two samples were not statistically compared as the data did not meet the standard assumption of independence of observations (both were drawn from the same dataset and thus contained overlapping data). Chi-square analysis was employed to test for associations between Twitter user type, message affective content, and attitude about e-cigarettes as smoking cessation aids (see Table 2 for tweet frequencies). To maximize sample size and ensure cell count minimums were met, the complete and industry-free samples were combined. In addition, the categories industry/related, fake users, and personal with industry ties were collapsed into a single group labeled industry ties as each was deemed commercial in nature, while public health and healthcare were collapsed into a single group labeled health. As the two samples were drawn from the same dataset, 119 overlapping tweets were identified as duplicates and removed, leaving 481 tweets for analysis. Chi-square analysis revealed a significant, medium-sized association between user type and message attitude, $\chi^2(8) = 82.01$, $p < .0001$, Cramer's $V = .292$. In addition, there was a significant, medium-sized association between user type and affective content, $\chi^2(8) = 97.85$, $p < .0001$, Cramer's $V = .319$, which was also associated with attitude, $\chi^2(4) = 116.70$, $p < .0001$, Cramer's $V = .348$.

Content analysis

Each tweet in the combined sample ($n = 481$) was coded for message themes (see Table 3 for theme distributions). A brief summary is provided below (see Online Resource for detailed results and discussion).

One hundred and thirty four tweets from industry/related users were identified, representing nearly half (45 %) of the complete sample. The majority of these came from a small number of highly active users, with one major e-cigarette

Table 1 Sample characteristics for complete and industry-free samples (frequency-ranked)

	Complete sample tweets ($n = 300$)		Industry-free sample tweets ($n = 300$)	
	Frequency	%	Frequency	%
User type				
Industry/related	134	45	–	–
Press/media	51	17	92	31
Public figure	45	15	90	30
Fake account	29	10	–	–
Personal	22	7	106	35
Personal with industry ties	13	4	–	–
Public health	4	1	10	3
Healthcare	2	1	2	1
Message affective content				
Neutral	142	47	174	58
Positive	137	46	81	27
Negative	21	7	45	15
Message attitude				
Pro	238	79	187	62
Con	37	12	51	17
Neutral/do not know	25	8	62	21
Message type				
Tweet	239	80	178	59
Retweet	40	13	69	23
Reply	21	7	53	18
Source authority				
Very high	104	35	219	73
Highest	196	65	81	27
(Average number of followers)	244,286		195,922	
Gender				
Not reported	204	68	146	49
Male	65	22	101	34
Female	31	10	53	18

Table 2 Tweet message attitude and affective content, by user type

	User type ($n = 481$ tweets)									
	Industry ties ($n = 176$)		Personal ($n = 106$)		Press/media ($n = 92$)		Public figure ($n = 94$)		Health ($n = 13$)	
	N	%	*n*	%	*n*	%	*n*	%	*n*	%
Attitude										
Pro	166	94	73	69	49	53	66	70	4	31
Neutral/maybe	7	4	22	21	19	21	17	18	4	31
Con	3	2	11	10	24	26	11	12	5	38
Affective content										
Positive	110	63	42	40	8	9	32	34	1	8
Neutral	62	35	47	44	75	81	44	47	10	77
Negative	4	2	17	16	9	10	18	19	2	16

Table 3 Themes identified in message content ($n = 481$ tweets)

Frequency	Theme
165	Marketing
131	News articles
84	First-person experience
	Pro (72)
	Neutral/do not know (10)
	Con (2)
62	Neutral information
37	Humor
25	Just starting e-cigs
23	Advocating e-cigs
22	More economical than smoking
21	Second-person experience
	Pro (11)
	Neutral/do not know (7)
	Con (3)
18	Healthy and safe way to quit
16	Personal opinion
16	Attempt to engage other Twitter users
15	Offering advice
11	Nicotine craving
9	Tastes good
7	Using or comparing to other substances/NRTs
6	Policy-related
5	Getting others started

Each tweet tagged with one or more themes

vendor generating up to 63 % of tweets to over 100,000 followers. No connections to the tobacco industry were found in this group. The most common theme was the claim that e-cigarettes are more economical and efficient nicotine delivery systems than tobacco smoking. Notably absent were claims about health benefits and the effectiveness of e-cigarettes as a cessation aid—although several tweets did link to press releases about studies suggesting a positive association between e-cigarettes and cessation. In contrast, almost all tweets by another active user in this group, a marketing agency promoting local commercial ventures in Indonesia, claimed health benefits of vaping versus smoking.

Twenty nine tweets from fake users (10 %) were identified in the complete sample. Most tweets (76 %) in this category promoted e-cigarettes as effective smoking cessation aids, either by emulating first-person anecodotes or linking to news articles or other online media.

Thirteen tweets from personal users with industry ties (4 %) were identified. All endorsed e-cigarettes as effective smoking cessation aids. In addition to marketing activity, common themes included first-person experiences, activism, and advice about quitting smoking. One especially prolific user posted over 24,000 tweets and retweets in 2014 and had nearly 60,000 followers who actively engaged with her content, as suggested by the apparent frequency of retweeted and 'favorited' messages. This user regularly tweeted about her experience quitting smoking using e-cigarettes and advised others to do so, sometimes directing them to a specific e-cigarette vendor with whom she disclosed a financial relationship.

Forty five tweets from public figure users (15 %) were identified. These had an average following of 111,230 users. The top authority in this category was a popular film actress and outspoken e-cigarette supporter who tweeted daily to nearly one million followers. Attitudes toward the effectiveness of e-cigarettes as smoking cessations aids among public figures were largely pro (70 %), while 19 % expressed uncertain or neutral views, and 11 % opposed e-cigarette use. Many tweets recounted first-person experiences (27 %) or second-person experiences (14 %), followed by retweets or links to news articles (17 %). Nine tweets (10 %) contained links to e-cigarette vendors; however, as these were mostly retweets rather than originals and appeared to be rare occurrences in the users' tweet history, these were not classified as marketing activity.

Fifty one tweets from press/media users (17 %) were identified with an average of 370,000 followers, with major news outlets (The Economist, Newsweek) boasting upwards of seven million followers. Just over half (53 %) of tweets in this category supported the effectiveness of e-cigarettes for smoking cessation. Out of all user types, press/media users posted the most tweets opposing or criticizing e-cigarettes (21 %). The most common types were headlines with links to articles (72 %), the majority of which reported on scientific studies about e-cigarettes, with a smaller proportion retweeting first-hand experiences by other Twitter users.

Six tweets from healthcare/public health users (2 %) were identified. Follower counts ranged from just under 30,000 for a local municipal public health department to 1,200,000 for a major health information website, with a mean of 258,226 followers. News articles and policy statements formed the major themes. There appeared to be no agreement regarding the effectiveness of e-cigarettes for smoking cessation, with message attitudes divided evenly between pro, con, and neutral/maybe. The majority (77 %) of tweets by public health and healthcare users linked to news articles which tended to report negative or neutral findings about e-cigarettes, while most of the positive reports were retweets of first-person experiences.

Twenty two tweets from personal users (7 %) were identified in the complete sample, whereas 106 (35 %) were found in the industry-free sample. To maximize resolution of the analysis, themes were examined for all tweets by all 70 personal users, ranging from just under

20,000 followers to over 250,000. One user generated up to 25 % of tweets, expressing themes such as improved health/safety, decreased nicotine cravings, and overall enhanced quality of life as a result of his switch from tobacco to e-cigarettes. None of his tweets contained commercial activity. The majority (69 %) of tweets in this group endorsed the effectiveness of e-cigarettes, whereas only 11 % opposed them and 20 % were ambiguous. Affective content was primarily neutral (44 %) or positive (39 %), while negative affect (17 %) was expressed the least often. The most prominent themes in this group were first-person experiences (39), personal opinion (27), humor (20), and news (16). Among first- and second-person experiences, tweets were largely favorable (84 %), and only 8 % were unfavorable.

Industry Twitter strategies

Industry users increase the reach of their tweets using popular hashtags like #vape, #ecig, and #vapor (the most frequently used hashtags in our initial dataset), which allow marketing messages to 'piggyback' on trending topics and appear in the Twitter feeds of users interested in such trends (Gao et al. 2010). The most common hashtag used by industry tweeters was #quitsmoking, suggesting that marketers deliberately target tobacco users interested in quitting. Another strategy entails relationships with high-authority personal users who are rewarded for tweeting links to vendor websites. A third strategy identified was use of fake user accounts, including bots and false or hijacked identities, to disseminate spam and favorable views. A small number of tweets were duplicated (not retweeted) by multiple accounts within a short timespan, suggesting a single source using several fake user 'fronts' on Twitter. Many of these emulated 'organic' tweets (by regular users), but contained links—some of which hidden to the reader—to commercial websites. However, most fake user accounts were not dedicated to e-cigarette promotion or even advertising in general, but rather generated a continuous feed of random internet links. Only a few fake users appeared designed specifically for promoting e-cigarettes.

Discussion

Our analysis of Twitter communication about e-cigarettes revealed that millions of tweets mentioning e-cigarettes were shared in 2014, nearly five times more than found by Huang et al. (2014) in 2012. This trend, and the predominantly positive sentiment across user types, may reflect the general increase in public awareness of e-cigarettes and especially the burgeoning of 'vape culture' and communities both on- and offline. However, the main cause for the increased Twitter activity on this subject is almost certainly the growth of the e-cigarette industry. Our results support previous findings that the social media landscape around e-cigarettes and smoking cessation is overwhelmingly dominated by commercial activity from e-cigarette industry members (though no tobacco industry activity was found). Industry tweets unanimously favored e-cigarettes and recommended them in place of tobacco smoking.

However, most e-cigarette marketing did not contain explicit claims about the health benefits or cessation aid effectiveness of e-cigarettes—though this was often implied. This finding may be attributed to legislation prohibiting such claims (indeed, the only user promoting health benefits was based in Indonesia, a nation with comparatively lax legislation around advertising; Barber et al. 2008). Probable strategies to circumvent such legislation included tweeting links to scientific studies with favorable results and retweeting personal Twitter users' anecdotes about successful quitting experiences.

After the e-cigarette industry, the most authoritative Twitter users communicating on this subject were members of the press and media, closely followed by public figures, especially celebrities. As a first, our results indicate that public figures and news organizations both tend to tweet favorably about e-cigarettes and smoking cessation (although press tweets showed the highest proportion of critical attitudes compared to other user groups). This finding may be surprising given the apparent increase in negative press about e-cigarettes over the past few years. It is possible that news outlets deliberately target the relatively youthful Twitter population (Cheng et al. 2009b), which may be particularly receptive to positive messages about e-cigarettes and smoking cessation. As the largest news organizations possess millions of followers on Twitter, and considering the fact that roughly half of Twitter users visit the website to gather news (Holcomb et al. 2013), it can be assumed that the influence of the press on popular opinion via Twitter is substantial, including on issues about e-cigarettes. Similarly, celebrities on Twitter tend to express favorable views to potentially millions of followers.

Although personal Twitter users tend to lack influence on an individual basis and generated a small proportion of tweets sampled here, their impact on Twitter communication about e-cigarettes and smoking cessation should not be overlooked. When commercial activity is removed from analysis, tweets by personal users dominate the Twitter landscape. As a first, our analysis reveals that private individuals were predominantly supportive of e-cigarettes for smoking cessation, even when excluding personal users with apparent industry ties. Many tweets incorporated humor, which is a highly effective medium for social media engagement (Holton and Lewis 2011). Advice to "stop smoking and start vaping," as well as advocacy for

e-cigarettes and against policy limiting their use, emerged as prominent themes, supporting the notion that social media is a popular medium for e-cigarette activism (Harris et al. 2014). This activity appears to be largely organic and informal, occurring in the context of ongoing conversations about cigarette smoking and cessation, rather than through industry sponsorship or astroturfing. Personal users' positive anecdotes and opinions reinforce the overwhelmingly favorable views tweeted by e-cigarette industry users, press/media, and public figures, and thus significantly shape the Twitter landscape.

Our analysis uncovered several suspected e-cigarette industry marketing strategies on Twitter. These include making use of Twitter trends to effectively target e-cigarette users, and especially tobacco smokers interested in quitting, thereby influencing online conversations about smoking cessation. This influence is reinforced through sponsorship deals with regular Twitter users with large audiences. Although a relatively large number of fake users were found, we estimate that bots do not have a significant impact on Twitter communication, as most bots exist to manipulate user follower counts rather than disseminate content (Boshmaf et al. 2011). Most bots' followers are in fact other bots, and any e-cigarette-related content they generate (which may be included by mere chance) is therefore unlikely to reach many human users. While some evidence of astroturfing was found in the use of fake accounts to emulate real users, this was relatively uncommon and links to e-cigarette industry members could not be confirmed. Nevertheless, our findings indicate that the e-cigarette industry is adept at manipulating Twitter communications about e-cigarettes and smoking cessation.

Limitations

Several limitations to the study should be noted, many of which are common to social media research (Boshmaf et al. 2011; Gao et al. 2010; Kass-Hout and Alhinnawi 2013). As discussed, it is possible that the presence of bots among users' follower bases inflated their authority ranking. However, authority analysis took multiple user characteristics into account, and our qualitative analysis of user and communication characteristics allowed us to identify questionable cases. Second, our study did not examine medium- and low-authority users. However, as this group is estimated to generate only 25 % of activity (Cheng and Evans 2009a), our findings may be presumed valid for higher authority Twitter communication about e-cigarettes and smoking cessation. Third, although authority-based analysis is common in social media research (Wu et al. 2013), this approach does not provide much insight on user engagement (e.g., the most retweeted messages), which should be a focus of future studies. Fourth, user-disclosed demographic information was often missing or unreliable, precluding any demographic analysis. Fifth, coding of user type, message attitude, and affective content relied on researchers' subjective assessments, which showed good, but not excellent intercoder reliability, and in light of the limited sample size, there is some risk of model overfitting. Sixth, the small number of tweets from Twitter users in healthcare/public health means conclusions about this group should be interpreted with caution. Finally, the cross-sectional nature of this study precludes any conclusions about causal relationships, and so the actual impact of Twitter communications about e-cigarettes and smoking cessation on individual behavior and public health remains unknown.

Conclusions

As a first, the present study utilized a purposive sample of high-authority tweets drawn from a full year's worth of Twitter data, as opposed to random samples of daily or weekly tweets which do not consider user authority. Our mixed-methods analysis revealed that not just e-cigarette industry members, but nearly all high-authority Twitter users expressed predominantly positive attitudes about e-cigarettes and smoking cessation, noting that press organizations and celebrities have a particularly broad reach in this regard. By providing an additional industry-free picture, we showed that even users who avoid commercial content are exposed to overwhelmingly favorable views which may lack current scientific support. On the other hand, explicit claims about smoking cessation aid effectiveness of e-cigarettes are rare, though we identified several strategies for circumventing legislation against such claims. We identified several industry marketing strategies, awareness of which may benefit Twitter users seeking to avoid unreliable information—especially users interested in quitting tobacco, whom we found are specifically targeted by marketers and individuals sponsored by industry.

Public health/healthcare Twitter users marginally contributed to the conversation on e-cigarettes and smoking cessation. Disagreement among these groups likely reflects the current lack of scientific consensus on this subject (McRobbie et al. 1996). This study shows that public health agents do not play a significant role in the Twitter landscape, presenting an opportunity for greater engagement with the public through increased and enhanced social media activity and strategies, including effective use of trending hashtags and humor in tweets. These findings also underline the need for reliable evidence and more effective public health communication strategies to compete with the high volume of unverified claims made on Twitter.

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