The influence of pro-vaping “gatewatchers” on the dissemination of COVID-19 misinformation on Twitter

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Abstract

Background: Misinformation about a potential protective role of nicotine against COVID-19 spread on Twitter despite significant evidence to the contrary. We suggest that the pro-vaping ideological slant of Twitter’s opinion leaders on this subject or “gatewatchers” helped drive the dissemination of such misinformation.

Objective: This research examines Twitter discourse at the intersection of COVID-19 and nicotine 1) to identify the extent to which the most outspoken contributors to this conversation self-identify as vaping advocates and 2) to understand how and to what extent these gatewatchers influence the spread of misinformation about nicotine as a therapeutic against COVID-19.

Methods: An exhaustive sample of tweets discussing nicotine and COVID-19 (N =1,420,271) posted during the first 9 months of the pandemic (January-September of 2020) was identified using validated keyword filters. The most prolific tweeters, i.e. gatewatchers, were identified and characterized. Additionally, the top hashtags and most shared URL’s were collected, in addition to a content analysis of the top 1,000 retweets.

Results: Users self-identifying as “harm-reduction advocates” comprised 13 of the top 15 most active users, tweeting about COVID-19 and nicotine 25,332 times during this 9-month period, an average of M(SD) = 1,948 (995.08) tweets each with M(SD)=1,103 (830.15) retweets. The top 15 hashtags were used a total of 223,629 times. In addition to top hashtags related to COVID-19 and nicotine, other top hashtags included #quitforcovid (2.31% of hashtags used), #nomeatnocoronavirus (5.14%) and #wevapewevote (1.61%). Five of the top 15 URLs shared promoted the claim that nicotine is protective against COVID-19. Among the top 1,000 retweets (shared 578,762 times) 10.7% discussed the protective role of nicotine. Ninety-eight of the top retweets explicitly promoted the protective role of nicotine and were retweeted 21,782 times.

Conclusions: The pro-vaping orientation of Twitter’s most outspoken voices regarding COVID-19 and nicotine helped spread misinformation about a protective role of nicotine against COVID-19. Although these gatewatchers do not control what content is posted to Twitter, they have outsized influence over which content trends. The result is an information environment where pro-vaping information is far more likely to trend than information about the harms and consequences.

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The influence of pro-vaping "gatewatchers" on the dissemination of COVID-19 misinformation on Twitter

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Background: Misinformation about a potential protective role of nicotine against COVID-19 spread on Twitter despite significant evidence to the contrary. We examine the role of vape advocates in the dissemination of such information through the lens of the gatewatching framework, which posits that top users can amplify and exert disproportionate influence over the dissemination of certain content through curating, sharing, or in the case of Twitter, retweeting it, serving more as a vector for misinformation rather than the source.

Objective: This research examines Twitter discourse at the intersection of COVID-19 and tobacco 1) to identify the extent to which the most outspoken contributors to this conversation self-identify as vaping advocates and 2) to understand how and to what extent these vape advocates serve as gatewatchers through disseminating content about a therapeutic role of tobacco, nicotine, or vaping against COVID-19.

Methods: Tweets about tobacco, nicotine, or vaping and COVID-19 (N =1,420,271) posted during the first 9 months of the pandemic (January-September of 2020) were identified from within a larger corpus of tobacco-related tweets using validated keyword filters. The top posters (i.e. tweeters and retweeters), were identified and characterized along with the most shared URLs, most used hashtags, and the 1000 most retweeted posts. Finally, we examined the role of both top users and vape advocates in retweeting the most retweeted posts about a therapeutic role of nicotine, tobacco, or vaping against COVID-19.

Results: Vape advocates comprised between 60% and 88% of top users discussing COVID-19 and tobacco on Twitter. Content about the ability of tobacco, nicotine, or vaping to treat or prevent COVID-19 was disseminated broadly accounting for 22.53% of the most shared URLs and 10% of the most retweeted tweets. Finally, among top users, retweets comprised an average of 78.64% of posts from vape advocates compared to 53.12% from non-vape advocates, $z = 3.34$, $p < .001$. Vape advocates were also more likely to retweet top-tweeted posts about a therapeutic role of nicotine, with 62.96% of vape advocates retweeting at least one post compared to 40.28% of other top users, $z = 2.80$, $p = .005$.

Conclusions: Pro-vaping users dominated discussions of tobacco use during the COVID-19 pandemic on Twitter, and were instrumental in disseminating the most retweeted posts about a potential therapeutic role of tobacco use against the virus. Subsequent research is needed to better understand the extent of this influence and how to mitigate the influence of vape advocates over the broader narrative of tobacco regulation on Twitter.

INTRODUCTION

During health crises such as the COVID-19 pandemic, people who are at higher risk of being affected may be more likely to seek health information online [1, 2]. However, in the absence of clear, concise, and complete information, digital information channels such as social media are often used to help people understand the implications of a health threat [3, 4]. Since the use of inhaled nicotine products such as cigarettes and e-cigarettes enhances the risk of respiratory illness and places users at greater risk of complications from COVID-19, clear communication about the risks of tobacco use is more important than ever [5-8]. Some have suggested that a widespread respiratory virus like COVID-19 could provide an opportunity to amplify public perceptions about the harms of tobacco products [9]. However, conflicting claims about how the virus affected tobacco users quickly emerged [10, 11].

A review of early clinical data in Wuhan province found that smokers were less likely to be admitted to the ICU due to COVID-19 complications, compared to non-smokers [10]. Although the study itself did not provide any evidence of a causal relationship between smoking and COVID-19 infection or progression, the authors posited that the anti-inflammatory properties of nicotine might be responsible for the unexpectedly low prevalence of COVID-19 infected smokers in countries with high smoking rates [12, 13]. While no subsequent evidence has been found to support a protective role of nicotine, the notion that smoking, vaping, or nicotine use would prevent COVID-19 circulated, leading researchers to document misinformation about smoking, vaping, and nicotine as protective against COVID-19 across communication channels, particularly on Twitter [14-16]. Although the spread of problematic information is not unique to twitter , recent survey data suggests that Twitter users in particular were more likely to recall hearing and believe that nicotine, tobacco, or vaping can prevent COVID-19 [17-20].

The presentation of scientific findings from an early review of clinical records showing fewer smokers than expected among ICU patients as evidence that nicotine prevents COVID-19 is emblematic of the role social media often plays in communications from the scientific establishment

to the general public [14]. Such counterintuitive findings are not misinformation in a direct sense, in that they do not present demonstrably false information [21]. Rather, the extrapolation of the study's findings out of context or with overreaching implications exemplifies the sort of claims that are not egregiously false, but rather represent unsubstantiated and misleading implications that run counter to the best available scientific evidence [11, 22].

To understand how scientific distortions and misinformation spread on Twitter, it is first important to understand key differences in how traditional news outlets and social media sites disseminate content. Media researchers use variations of the "gates" metaphor to describe how and to what extent elites and other opinion leaders dictate what information passes "through the gates" and on to the masses [23-26]. The first important difference between traditional news media such as television, print, or even online publications and Twitter is the elimination of "gatekeepers"—editorial boards and elite decision makers who determine which news receives airtime [27]. However, Twitter's lack of traditional gatekeepers does not mean that the gates controlling the flow of information are left untended. Rather, the most influential users serve as "gatewatchers," who lack absolute control over what passes through the gates but instead heavily influence whether information is channeled into high traffic areas where it is likely to spread, or low traffic areas where its impact is diluted [28, 29]. Thus, rather than a simple two-step flow of news through a small group of elites to the viewing public, the preferences and ideological lean of a slightly larger group of vocal users dramatically influences what content "trends" in a user-driven marketplace of ideas [30, 31].

Existing evidence suggests that the gatewatching framework may be useful to conceptualize how vaping and other tobacco-related information disseminates on Twitter. Previous research has found that social media discourse is predominantly hostile to vaping regulation, prone to exaggerated claims about the health benefits of vaping, and rife with misinformation about vaping and the tobacco industry [18, 32-36]. Although the controversial nature of misinformation is often an important factor contributing to its spread, if the loudest and most prolific voices discussing vaping

on Twitter are those with a pro-vaping agenda, then such pro-vaping gatewatchers are also a crucial pathway through which misinformation, disinformation, and other problematic or unsubstantiated information spreads on the medium.

Although there is evidence of a pro-vaping bias on Twitter, neither the extent of this bias nor the influence on the volume of pro- versus anti-vaping content is clear. A recent examination of vaping-related tweets between March and June of 2020 found that misinformation about the relationship between COVID-19 and vaping informed chatter that was both pro- as well as anti-vaping. In a separate study, the same researchers show that misinformation was endemic to Twitter discourse about vaping even prior to COVID-19 [36]. Previous research examining the prevalence of the claim that nicotine can prevent COVID-19 found the therapeutic nicotine claim to be prevalent in about one percent of tweets relevant to both the pandemic and tobacco [16]. Building on these findings we suggest that vape advocates who disproportionately influence the tobacco-related information that trends on Twitter (i.e. gatewatchers) were likely instrumental in disseminating content that promoted a therapeutic role of tobacco, nicotine, or vaping against COVID-19.

Current Study

The current research examines whether the gatewatching framework can be used to understand how content about a therapeutic benefit of nicotine, tobacco, or vaping disseminated on Twitter. The main premise of the gatewatching framework is that a subset of influential users drives the dissemination of information on Twitter through retweeting content that is consistent with their ideological agenda. Our investigation begins with the assumption that influence on Twitter is concentrated among a small group of top users who produce and disseminate the majority of content. Pew's population-level examination of Twitter behavior supports this assumption [37]. Pew estimates that 97% of tweets are produced by the top 25% of users. Moreover, a high percentage of tweets by these top users are likely to be retweets of other users' original tweets. The influence of pro-vaping gatewatchers would thus be evident in 1) high prevalence of vape advocates among top users, 2)

substantial dissemination of ideologically aligned content such as that tobacco, nicotine, or vaping could prevent or tweet COVID-19, and 3) direct evidence of the role of top users and vape advocates in disseminating that content. We thus propose the following research questions:

RQ1: How prevalent are vape advocates among the users who produce and disseminate the most content (i.e. potential gatewatchers)?

RQ2: How prevalent was content indicative of pro-vaping advocacy in the broader conversation about tobacco and COVID-19 including 1) top hashtags, 2) top shared URLs, and 3) the most retweeted tweets?

RQ3: What role do top users and vape advocates have in disseminating top content (i.e. top retweeted tweets about a therapeutic role of tobacco, nicotine, or vaping against COVID-19)?

METHODS

Procedure

We began by identifying posts (original tweets and retweets) about COVID-19 from within the entire corpus of tobacco-related tweets posted between January and September 2020. After cleaning and pre-processing the raw data, including removing duplicate posts, we examined the dataset at both the post and user levels. At the post level, we conducted a content analysis of the top 1000 retweets during this time period to assess the volume of broadly disseminated tweets promoting the preventative nicotine claim compared to the 1% of overall tweets identified in previous research [16]. We then examined the most shared URLs to further quantify how much content promoting a therapeutic benefit of nicotine against COVID-19 was disseminated on Twitter. Next, we examined the user profiles of the most active users (i.e. those responsible for the most tweets and retweets) and identified those who posted the original tweets about nicotine preventing COVID-19 among the top 1000 retweets. Finally, we cross-referenced the top user list with those who retweeted original tweets about nicotine preventing COVID-19 to more clearly illuminate the role of these top users in

disseminating this content (i.e. gatewatching).

Data collection

[Institution omitted for blind review] maintains a comprehensive archive of tobacco-related Twitter data collected monthly using the Historical Powertrack Application Programming Interface (API) and sorted for relevance by a Naïve Bayes classifier. Twitter's API allows for targeted searches by keywords that can appear in either the text of the tweet or metadata. [Institution] "taps the firehose" collecting all tweets posted during the study timeframe in JSON format and then the data into a data frame at the post level with corresponding variables for username and other relevant metadata. From this broader corpus of tobacco-related tweets posted in the first nine months of 2020, we developed and validated a keyword filter (Supplemental Table 1) to identify tobacco-related posts that were also about COVID-19. We then validated this filter by human-coding a random sample of n = 2,566 original tweets for relevance (Precision = .90, Recall = .89, F1 = .89). The text of the tweet was then used to extract important information including URLs, hashtags, and whether or not it was an original tweet or a retweet. Counts were then aggregated to provide data frames at the post (tweet or retweet; N = 1,420,271), user (N = 817,691), URL (N = 54,806) levels, and the top 1,000 hashtags.

Identifying top users. We first sought to identify a smaller group of top users who were clear outliers in terms of the proportion of overall tweets and retweets for which they were responsible. We began with the top 1,000 users who posted (both original and retweeted) between 54 and 4,897 times each, meaning 0.12% of users were directly (tweeted) or indirectly (retweeted) responsible for 10.93% of all tobacco and COVID-19 content. Among these top 1000, we identified two natural inflection points in the data: 1) The median number of posts was 87, SD = 263.10. Only n = 25 users posted three or more SDs from the median number of posts, meaning 2.49% percent of all activity came from the top 25 users. 2) To expand this list further we sub-grouped the number of tweets per user in bins of 100 with 59% having less than 100 tweets and 83% having less than 200. We thus

coded n = 163 top users who had 200 or more posts and were responsible for 5.59% of all content produced in our dataset. Our coded sample of most influential users averaged 54.15 tweets per month, more than double the threshold for "high-volume users" set by Pew. We then categorized these top 163 users by identifying at least one of three criteria in their profiles: 1) explicit mention of vaping or tobacco harm reduction (THR) in the text of the username or profile, 2) a pinned tweet (a tweet that the user chooses to fix to the top of their page) promoting vaping, or 3) at least three of their five most recent tweets explicitly promoting vaping.

Identifying dissemination of therapeutic nicotine content. We examined three key measures of trending content for dissemination of misinformation related to a potential therapeutic role of nicotine against COVID-19. First, we examined the top trending hashtags during this time period. Hashtags are a key means through which social media conversations coalesce around a coherent narrative [38, 39]. All hashtags were extracted from the text of the tweet and aggregated. Beginning with the top 1000 hashtags which were used between 50 (#heart) and 87,566 times (#covid19) with a median of 106.50, SD = 3101.53, we identified a natural inflection point in the data wherein only 16 hashtags were used greater than 1 SD from the median, accounting for 49.29% of hashtags used. We then identified hashtags that were explicitly tied to vaping, e-cigarettes, or tobacco harm reduction using keyword stems (e.g. vap*, ecig*, thr, and harmreduc*).

Top linked URLs were examined using a similar procedure in finding a natural inflection point in the data to determine the top trending content. URLs were shared a median of one time each (SD = 24). Of those, n = 253 URLs were shared greater than three SD from the median comprising 30.93% of all shared URLs. The number of shares for these top URLs ranged from 74 to 2,827 with a median of 117.5, SD = 279.73. We then examined these top URLs to determine whether they were linking content that promoted the ability of nicotine, tobacco, or vaping to prevent or treat COVID-19.

Finally, we conducted a content analysis of the top 1,000 retweets to characterize the presence

of original tweets about a potential therapeutic benefit of nicotine, tobacco, or vaping against COVID-19 in the most broadly disseminated part of the broader conversation about tobacco and COVID-19 on Twitter. We used a grounded theory approach [40, 41]. We reviewed the top 1,000 retweets while noting six relevant themes, with the primary theme of interest being the potential therapeutic role of nicotine or tobacco against COVID-19. Consistent with convention for content analyses, a random subsample of at least 10% was withheld to establish reliability [42]. Two independent coders dual coded a random sub-sample of n = 300 retweets to establish reliability in identifying tweets about personal responsibility (κ = 0.95), social justice (κ = 0.83), discounting COVID-19 severity compared to tobacco (κ = 1), government criticism (κ = 0.92), mask efficacy (κ = 0.8), and the topic of interest, the protective role of nicotine (κ = 1). After establishing reliability, the remaining n = 700 retweets were divided evenly among the coders. The user profiles of those whose retweets promoted a therapeutic role of nicotine against COVID-19 were then coded to identify vaping advocates using the same methodology as was employed for coding the top users. Finally, our research question about gatewatching was then examined by identifying whether the top users retweeted the top retweeted content about a potential therapeutic role of nicotine or tobacco.

Bot detection. The role of automated (bot) accounts on Twitter has been a recent area of concern [43]. One report suggested that as much as half of all tweets about vaping may come from bots [43]. Although a bot programmed to promote vaping content serves functionally the same purpose as a human gatewatcher who promotes vaping content, differentiating between bots and human accounts is important, as regulatory bodies and health communicators are likely to approach these sources of problematic information in different ways [44]. We first used the machine learning classifier *Botometer* to estimate the likelihood that user accounts were bots based on a series of indicators of “bot-like” behaviors identified by the tool's creators, providing a score between zero and five, with five being the most likely to be a bot [45]. However, this tool has been shown to have significant limitations in misclassifying both bot and human accounts [46]. As a result, we report

additional indicators that may be indicative of bot activity including whether the account is verified by Twitter, and whether the account has since been removed or made private. It is noteworthy that the top user overall had a bot score of 3.6, and only posted original tweets. However, this user was not a vape advocate.

RESULTS

Vape advocates were highly prevalent across the top users representing 60.51% of the top n = 163 users and n = 22 of the top n = 25 users (88%). These top n = 163 users posted a median of 317 times each (SD=536.56), and retweeted (median = 234, SD = 373.80) far more often than they posted original tweets (median = 58, SD = 433.98). On average, retweets comprised a higher percentage of posts for vape advocates (78.64%) than for others (53.12%), $z = 3.34$, $p < .001$. The prevalence of bots among top users appears limited. Although only three accounts were verified by Twitter and 20 were either removed or private, the average *Botometer* score was low M(SD) = 1.59(1.37) with only 19% of users having above the scale's midpoint of 2.5. The average score for vape advocates was 1.26, but 2.03 for all other accounts providing little evidence that bots are driving vape advocacy in our dataset.

Vaping hashtags (n = 63) were used a total of 43,223 times accounting for 9.40% of hashtags used in our dataset including three of the top 16 most used overall. Table 1 provides the top 16 overall hashtags in the dataset as well as the top 16 vaping hashtags accounting for 85.71% of vaping hashtags used. Most noteworthy is the use of #wevapewevote among the top overall hashtags as well as five other explicitly pro-vaping hashtags with over 1,000 uses each.

Table 1. Top Hahstags for COVID-19 and Nicotine related discussion on Twitter

Top 16 overall hashtags[a]		Top 16 vaping hashtags[b]	
Hashtags	**# of uses**	**Hashtags**	**# of uses**
covid19	87566	vaping[c]	15567
coronavirus	31608	vape[c]	6306
vaping	15567	wevapewevote	3601

nomeat_nocoronavirus	11495	vapingsaveslives	2419
tobacco	10961	ecigs[c]	1495
covid□19	9181	vapefam	1283
smoking	8328	harmreduction	1137
covid	8193	vapers	1137
lockdownsa	7685	ecigarettes[c]	871
covid_19	7256	ecig[c]	766
stayhome	6705	vapelife	734
vape	6306	vapes	502
quitforcovid	5156	tobaccoharmreduction	424
lockdown	4021	vapeon	414
wevapewevote	3601	vapecommunity	390
indiafightscorona	3472	vapenation	387

[a]The top 16 hashtags accounted for 49.29% of all hashtags used. [b]The top 16 pro-vaping hahstags accounted for 85.71% of all pro-vaping hashtags used and 9.4% of all hahstags used. [c]These hashtgasg were not necessarily pro-vaping, and were soemtimes used in anti-vaping posts as well

Of the n = 253 top shared URLs, n = 57 (22.53%) promoted content about a potential therapeutic role of nicotine, tobacco, or vaping in treating or preventing COVID-19. These URLs were shared 16,244 times. Table 2 provides descriptions of the top n = 29 shared URLs identified via an inflection point in the data at more than two SD from the median number of shares accounting for 12.38% of all shared URLs. Among these top 29, n = 12 URLs linked articles promoting the potential therapeutic value of nicotine, vaping, or tobacco against COVID-19 accounting for 42.21% of shares among this top content. It is noteworthy that two of these 12 were articles explicitly debunking the claim made by a media personality that vaping bleach could cure COVID-19, while the other n = 10 focused on either a lower infection rate of COVID-19 for smokers (n = 9) or a tobacco-based vaccine (n = 1).

Table 2. Top 29 URLs shared in COVID-19 and Nicotine Discussion on Twitter

URL description	shares
News24.com:lockdown dlamini zuma pushes for tobacco alcohol ban to continue until	2827

level 1	
The economist: smokers seem less likely than non smokers to fall ill with covid 19	2359
News24.com: coronavirus all the latest news about covid 19 in south africa and the world	1854
Raw story: conservative radio host agrees with caller that vaping bleach might cure covid 19 youre not crazy	878
The Guardian: French study suggests smokers at lower risk of getting coronavirus	796
News24.com: breaking ramaphosa told to lift cigarette alcohol ban and move to level 2 lockdown sources	694
rFi.fr: french researchers suggest nicotine could protect against covid 19	677
France24.com: france testing whether nicotine could prevent coronavirus 1	667
CNN: coronavirus quitting smoking wellness	657
News 24: not selling booze and tobacco during lockdown harmful to addicts	649
ewn.co.za: sa economy loses r1 5 billion due to alcohol cigarette sale ban	631
Telegraph: smokers four times less likely contract covid 19 prompting nicotine/	620
News24.com: coronavirus all the latest news about covid 19 in south africa and the world	584
Livemint.com: cigarette can keep coronavirus away researchers test if nicotine could prevent covid 19	557
Media Matters: Sean Hannity suggests vaping prevents people getting coronavirus	491
Money Control: a cigarette a day can keep coronavirus away french researchers test if nicotine can prevent covid	488
Bloomberg: coronavirus vaccine race gets unlikely partner big tobacco	472
W24.co.za: How lockdown saved my life woman shares how she finally quit smoking after 20 years	468
Scientific American: Smoking or vaping may increase the risk of a severe coronavirus infection	461
CNN: coronavirus quitting smoking wellness	461
The Guardian: french study suggests smokers at lower risk of getting coronavirus	457
NDTV: coronavirus drug news france testing if nicotine prevents coronavirus from attaching to cells	444
Nature: Factors associated with COVID-19-related death using OpenSAFELY	435
The Guardian: Politics public covid 19 tobacco johnson	431
CNN: coronavirus quitting smoking wellness	423
Zerohedge.com: Did china steal coronavirus from canada and weaponize it	409
Buzzfeed: smoking doesnt kill and other great old op eds from mike pence	408
Medium: how i killed the smoke monster and quit smoking like a queen	402
Todayistheday.co.uk/ (Resources for smoking cessation)	400

Note: These 29 web articles accounted for 12.38% of shares among a total of 54,806 different URLs that were shared a combined total of 170,496 times

The top 1,000 retweets were shared a total of 578,763 times ranging between 105 and 117,662, with a median = 193, SD = 3956.82. Table 3 provides the six coded categories, example tweets, and the percentage of retweets in each category. The therapeutic potential of nicotine or tobacco was the fourth most commonly discussed topic. Of the n = 107 retweets addressing the protective role of nicotine, including smoking, vaping, or tobacco in general, n = 5 sought to counter

this notion and were retweeted a total of 1,304 times. Closer examination also revealed that n = 4 of these retweets concerned addressing a conservative talk show host who told a call-in listener that they could vape bleach to protect themselves from COVID-19. After removing these nine tweets, we focused on n = 98 of the top retweets explicitly endorsing or promoting the idea that nicotine, whether through patches, smoking, or vaping could prevent COVID-19. Such content was retweeted 21,782 times in our sample with a median = 160, SD = 194.25. Moreover, these tweets sometimes used the hashtags #saysscience (n = 17) and #sciencesurprises (n = 12), which were used across n = 2129 and n = 1544 retweets, respectively.

Table 3. Content analysis of the top retweets (n=1,000) about COVID-19 and nicotine

Coded category	Example	% of top retweets
Government criticism	MIKE PENCE: - His budget cuts in Indiana led to the spread of HIV there - Wrote articles about how smoking does NOT cause cancer - Calls global warming a myth - Was put in charge, by trump, of the Coronavirus response UNBELIEVABLE. #CoronaVirusUpdates	29.30%
Personal Responsibility	As COVID-19 attacks the lungs one of the most important things you can do is to quit smoking and vaping. I'm in day 3. Care to join?	14.90%
Mask Efficacy	Ok I recorded the recording because I know they will remove it... why?? Vape smoke is 2.5 microns... Covid is between 0.15-0.25 microns. Masks don't do shit.	14.90%
Protective Role of Nicotine	Nicotine could protect people from contracting the coronavirus, according to new research in France, where further trials are planned to test whether the substance could be used to prevent or treat the deadly illness	10.70%
Discounting the pandemic's impact	If they're going to report every Coronavirus death, I think they should have to report every: Flu Death Car Accident Death Smoking-related Death Alcohol Related Death . . . You get the point. ENOUGH WITH THE FEAR MONGERING	5.00%
Social Justice	imagine if the surgeon general announced a plan to bolster access to masks, testing, &; neighborhood health hubs for Black & Latinx people instead of telling us to not smoke &; drink to protect big momma'n'em. how do you blame people for being imperfect victims of a pandemic?	4.90%

Note: Two independent coders double coded n = 300 posts to establish reliability, after which the remaining
700 were divided evenly between the two coders.

A total of n = 74 unique users produced the n = 98 top retweets about a therapeutic role of nicotine. Of these, n = 30 (40.54%) were verified while n = 16 (21.62%) were official news accounts. In fact, retweets by verified accounts garnered 74.53% of retweets, while news accounts (all but two of which were verified) garnered 46.18% of retweets. There were only two vape advocates among these n = 74 users. Finally, bots were limited among this group as well with an average *Botometer* score of M(SD) = 1.57 (1.28). Notably, this value is likely inflated as the verified news sources tended to be misclassified as bots, with an average score of 3.19.

The top 163 users retweeted the top posts about nicotine preventing COVID-19 338 times (median =1, SD = 2.78). Among the top 163 users 55.83% retweeted at least one of the top posts with 17 of the top 25 retweeting at least one post (median = 4, SD = 4.51). A significantly higher percentage of vape advocates (62.96%) retweeted such posts compared to other top users (40.28%), $z = 2.80$, p=.005. In total, 38.24% of top posts were retweeted at least once by top users with original posts by the lead author of the study showing a lower-than-expected number of smokers in the ICU with COVID-19 garnering 38.46% of retweets by top users. Table 4 provides deidentified text of the top retweets promoting such content retweeted by top users.

Table 4. Top 10 posts about nicotine prevenitng COVID-19 retweeted by top users

Tweet text	Number of top users who retweeted
NYC Mayor said smoking and vaping increases coronavirus risk. In 1099 cases from China, only 12.6% were smokers (we would expect much higher). ZERO data on e-cigs. So, still too early to say. People with ZERO public health knowledge should SHUT UP.	39
Finally, the study is out "Systematic review of the prevalence of current smoking among hospitalized COVID-19 patients in China could nicotine be a	38

therapeutic option?" Very low prevalence of smoking among hospitalized COVID-19 patients in China.	
Moderate and heavy smokers were 50-60% less likely to be tested positive for COVID-19 and 80-90% less likely to be admitted to the ICU... Remember my hypothesis about the potentially protective effects of nicotine since early April?	31
So few people hospitalized with the coronavirus appear to be smokers. I spoke to the scientists, tobacco experts, and policymakers who are trying to see if nicotine *might* have something to do with it.	23
Dramatic UNDER-representation of smokers among COVID-19 patients in France. 80% reduced standardized (for age and sex) incidence ratio!! Strongly supports my hypothesis about the protective effects of nicotine which i made 1 month ago (soon to be published).	22
On January 22 at the beginning of this year I had a suspicion about the protective effect of nicotine on the coronavirus.	20
Official French data on #tobacco smoking; #covid19 replicate the picture in China, Germany; USA A remarkable low rate of smokers are hospitalised w/ coronavirus compared to smoking prevalence (France 23%).	18
The government has admitted "smoking populations were less likely to be infected" with the coronavirus and develop Covid-19.	12
The prohibition of cigarettes does nothing to control or limit the Covid 19 epidemic. On the contrary smokers are significantly less likely to require hospitalization if they do become infected. NDZ is pursuing a very personal and subjective campaign.	12
"There is zero evidence that smoking will propagate or increase transmission of COVID-19." -Dr Konstantinos Farsalinos, Cardiologist and anti-smoking researcher	11

Note: These top 10 posts accounted for 69.82% of retweets of such content by top users. 29 other posts were retweeted by between 1 and 9 top users.

DISCUSSION

This research demonstrates the utility of the gatewatching framework for examining the dissemination of problematic information on Twitter. More than half of our sample of top users and 22 of the 25 most prolific users producing and disseminating content about COVID-19 and tobacco in the first nine months of the pandemic were pro-vaping “harm reduction” advocates. Moreover,

more than three out of four posts by these top-using vape advocates was a retweet compared to just over half for non-vape advocates further demonstrating the key role of these users as disseminators of content—gatewatchers.

Building on previous research both identifying and quantifying the extent of a specific piece of misinformation that nicotine can prevent COVID-19, we show the disproportionately broad reach of this claim across the most retweeted content during this time period [16, 47, 48]. Even in May 2020, when the original study by Farsalinos et al was published, the preponderance of scientific evidence, including multiple meta-analyses, still opposed the notion that nicotine, and especially smoking, would protect people from COVID-19 [10]. Still, in our sample of the top 1000 retweets, propagation of this claim was more than 20 times more common than the five tweets trying to debunk the claim and was retweeted nearly 17 times as often. Among the top shared URLs, articles promoting a potential therapeutic role of nicotine or tobacco accounted for nearly one in three shares. Explicitly pro-vaping hashtags such as #wevapewevote, #vapingsaveslives, and #vapefam were abundant, indicating a significant representation of a pro-vaping perspective across the broader COVID-19 and tobacco-related conversation.

Finally, this study provides compelling evidence that the top users, particularly vape advocates, were instrumental in disseminating the idea that nicotine can prevent COVID-19. Vape advocates were significantly more likely to retweet top tweets about a potential therapeutic role of nicotine. More than half of top users retweeted at least one of the most retweeted tweets on the topic, while more than one in three of the most retweeted tweets was retweeted by at least one top user. These findings have implications for both tobacco control and for the process of disseminating information on Twitter.

Implications for tobacco control

The most important implication for tobacco control is that the dissemination of tobacco content on Twitter is heavily influenced by vape advocates. The extent to which COVID-19 served as

further motivation for smokers and/or vapers trying to quit is uncertain. However, research examining this question has found mixed results at best [49-51]. Although the use of addictive substances during a pandemic is explained by far more variables than misinformation on social media, our findings suggest that the pro-vaping ideological bias of the most prominent voices on Twitter engaging in the tobacco control conversation may help explain why misinformation promoting the protective role of nicotine was able to disseminate so broadly. Furthermore, previous research examining temporal trends in tobacco sentiment on Twitter noted an increase in anti-tobacco sentiment in March 2020 at the beginning of the pandemic in the U.S. followed by a rise in positive tobacco sentiment corresponding with the release of the pre-print of the study showing fewer smokers than expected in Wuhan ICUs [52]. Our study shows that a likely driver of positive sentiment--that tobacco, nicotine, or vaping has therapeutic value against COVID-19--was spread frequently by influential vape advocates on the platform.

This research highlights the growing challenge of addressing scientific distortions that while not themselves misinformation can nonetheless drive false beliefs. There is no reason to believe that the study finding fewer smokers than expected was falsified. In fact, this “smoker’s paradox” drove significant research interest and calls to pre-register hypotheses towards the goal of rigorously investigating the effects of nicotine on COVID-19 [53]. A substantial body of literature has provided strong evidence that smoking during a respiratory pandemic increases the risk of severe illness and death [5-8]. Moreover, more detailed investigations of specific hypotheses surrounding a therapeutic effect of nicotine have revealed the opposite, as nicotine appears to aid the replication of the SARS-CoV-2 virus rather than impede it [54]. Our study does not address this complicated body of literature. Rather, we show how an opportunistic overinterpretation of the findings of such a study can disseminate on Twitter through influential users for whom such findings support a broader narrative. The broader implication of these findings is that the dissemination of information about tobacco control on Twitter is subject to the interpretation of users who both strongly influence what

information is disseminated, and whose stated purpose on the platform is to oppose tobacco regulation.

Implications for understanding misinformation dissemination

It is important to note that our findings do not contradict previous work examining the prevalence of misinformation on the protective role of nicotine, but rather add context that helps to characterize the process through which misinformation spreads on Twitter. Kavaluru et al (2021) identified that the protective role of nicotine comprised about one percent of the overall content while Sidani et al (2022) identified a variety of different misinformation claims that arose on Twitter about vaping products [16, 48]. Both studies provide an overview of the overall "firehose" of information. We sought to understand how a small percentage of the information from this "firehose" got diverted into the smaller and more influential pool of trending retweets. Although we do not discount the fundamental virality of controversy that previous research suggests can drive the dissemination of misinformation, we highlight the important utility of the "gatewatcher" metaphor in describing how misinformation disseminates on Twitter [55].

Opinion leaders on Twitter do not have control over the content posted on the platform. However, they have outsized influence over the dissemination of certain perspectives over others. Although more research is needed, we contribute strong evidence that the ideological lean of the most prolific tweeters on a given subject (pro-vape users discussing COVID-19 and nicotine) directly influenced the spread of problematic information (that nicotine could prevent COVID-19) through retweeting much of the most broadly disseminated posts. These findings are reminiscent of previous research showing the majority of disinformation in another context, anti-vaccination, emanated from only twelve users [56]. However, in contrast to the "Disinformation Dozen," pro-vaping gate watchers on Twitter are not producing and disseminating overtly false information. Rather they serve as mediators between the scientific community and the broader, Twitter-using public, and privilege scientific findings that support a pro-vaping narrative while dismissing,

ignoring, and countering a preponderance of evidence that does not.

Implications for practitioners

There are two useful implications of this research for practitioners. The first is that a small component of the overall conversation can have an outsized influence. Ultimately, most of the conversation about COVID-19 and nicotine was about COVID-19, and only tangentially mentioned nicotine or tobacco products. While #wevapewevote was among the top trending hashtags, #nomeatnocoronavirus was over three times more prevalent. Moreover, 60% of our sample of top retweets involved criticizing the government, complaining about masks, and extolling the virtues of taking care of one's body during the pandemic.

Social media's unprecedented democratization of the fourth estate unfortunately nests genuine attempts to engage constructive public discourse alongside incoherent, misinformed, and often bad faith commentary [57]. Trending hashtags and overall prevalence tell an important part of the story with regard to what and how information spreads on social media [58]. That controversy is interesting, and anybody can post anything with limited oversight, are both established and intuitive reasons why misinformation is endemic to social media [59]. However, addressing such a problem requires a closer examination of the vectors through which some tweets spread while others do not. Misinformation about nicotine and COVID-19 does not comprise a majority or even a plurality of content about using nicotine products during the pandemic. However, misinformation about nicotine preventing COVID-19 circulated broadly most likely because it was consistent with the ideological agenda of the opinion leaders, gatewatchers, and most prolific tweeters on the subject.

The broader implication of this process of dissemination is that the proverbial deck is stacked against effective public health communication on Twitter. In the context of nicotine's potential role in preventing COVID-19, Twitter undoubtedly amplified bad information when good information was available. The observable pro-vaping bias of the most outspoken users discussing COVID-19 and nicotine inevitably meant that even attempts to debunk such information on the platform did not

receive nearly the same amount of traffic. The most important implication is that this bias is likely to result in the continued prominence of the benefits of vaping while underrepresenting and downplaying the harms.

Limitations and future directions

The most important limitation of this research regards the scope of our findings. We examine the influence of gatewatchers on one of many social media platforms, in the specific context of tobacco control and COVID-19 during the onset of the pandemic. The dissemination of misinformation on social media is likely to vary between different platforms, different contexts, and potentially within the broader context of tobacco control. Although our findings have generalizable implications, more research is needed to fully understand the interplay between platform, context, and specific kinds of mis- and disinformation including distortions of scientific consensus.

A second limitation concerns the conclusiveness of our findings with regards to the central premise of the gatewatching framework—that top users were directly responsible for the broad dissemination of the most retweeted content. We provide conclusive evidence that the top users discussing COVID-19 in the context of tobacco, most of whom were vape advocates, retweeted many of the most broadly disseminated retweets about nicotine as a potential therapeutic against COVID-19. However, network approaches are needed in subsequent research to identify whether it is indeed the retweets by these vape advocates that catalyze the broad dissemination of this and other content. Moreover, whether the influence of vape advocates extends beyond the intersection of COVID-19 and tobacco into the broader discussion of tobacco regulation on Twitter and social media is an important topic for subsequent research.

Additionally, we analyze a small fraction of a dataset comprising nearly 1.5 million posts and hundreds of thousands of users. However, research examining misinformation networks online suggests that the best way to reduce misinformation is to identify and penalize the central nodes—the opinion leaders and gatewatchers who drive the virality of some information over others [60].

Although the sheer quantity of content produced is an admittedly blunt instrument for assessing influence, we show that the primary function of these top users, and to an even greater extent the vape advocates among these top users, is to amplify (i.e. retweet) some original tweets over others. Subsequent research should adopt more sophisticated measures to assess sustained influence over tobacco regulatory discourse, as a whole, towards the goal of providing regulators with insight regarding the central nodes towards which effective intervention is most likely to be effective.

Finally, although our use of the API and extensive filtering from the broader tobacco-related discussion on Twitter is a strength of this study in providing a near census of relevant content, limitations related to the collection of data from private and removed accounts mean that there is inevitably some content we missed. We note that we were able to capture content from users whose accounts were made private after we collected data.

Conclusion

The COVID-19 pandemic offered a potential opportunity to highlight the importance of respiratory health by underscoring the negative long-term consequences of inhaled nicotine product use. However, the ability of pro-vaping opinion leaders or gatewatchers on Twitter to steer the narrative and promote misinformation about nicotine as protective against COVID-19 likely played a role in dampening any positive effect of the pandemic on tobacco use. Although anyone can post on Twitter, the makeup of Twitter's tobacco and COVID-19 opinion leaders suggests that content about the dangers of tobacco and vaping does not spread with the same virality as messages that support the proliferation of vaping.

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CONFLICTS OF INTEREST

The authors have no conflicts of interest to declare.

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Supplementary Files

Multimedia Appendixes

Supplementary Table 1. Top 30 search terms identifying COVID-19 tweets.
URL: http://asset.jmir.pub/assets/9d7d21bae75f2730669a621f7b225576.docx