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Major Article

Twitter message types, health beliefs, and vaccine attitudes during the 2015 measles outbreak in California

Cui Zhang Meadows PhD [a,*], Lu Tang PhD [b], Wenlin Liu PhD [c]

[a] School of Communication, East Carolina University, Greenville, NC
[b] Department of Communication, Texas A&M University, College Station, TX
[c] Jack J. Valenti School of Communication, University of Houston, Houston, TX

Key Words:
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Background: Social media not only provide platforms for the public to obtain information about a disease but also allow them to share their opinions and experiences about it.
Methods: This study analyzed 3000 tweets systematically selected from over 1 million tweets posted during the 2015 California measles outbreak.
Results: News updates were the most tweeted messages (41.4%), followed by personal opinions (33.7%), resources (19.4%), personal experiences (2.5%), and questions (1.6%). Susceptibility was the most discussed health belief (21.8%), followed by cues to action (18.9%) and severity (13.0%). Individuals were significantly more likely to discuss severity. Nonprofit organizations were significantly more likely to offer cues to action than other user types, and media were less likely to include cues to action than other user types. Pro-vaccine tweets were more likely to contain links to traditional mainstream media sources such as newspapers and magazines, and anti-vaccine tweets were more likely to link to emerging news websites.
Conclusions: Understanding who posts what on social media during an infectious disease outbreak allows public health agencies to better assess the public's attitudes, sentiments, and needs in order to provide timely and effective information.

BACKGROUND

Although measles was declared eliminated in the United States in 2000, recent years have witnessed the re-emergence of this highly infectious disease. On January 7, 2015, the California Department of Public Health issued a press release warning the public that several measles cases had been confirmed, thus marking the beginning of an outbreak.[1] In the following months, the outbreak quickly spread to several other states in the United States, as well as Mexico and Canada.[2] A total of 147 cases were associated with the outbreak.[3]

During emerging infectious disease outbreaks, social media such as Twitter have begun to play increasingly important roles as both information sources and platforms for sharing personal experiences and opinions. The public often turns to social media for timely updates and useful medical information. How measles and its associated risks are portrayed on social media is likely to influence the public's perceptions of those risks, as well as their decision-making and risk management behaviors. An analysis of what people post about measles on social media during an outbreak will allow public health agencies such as the Centers for Disease Control and Prevention (CDC) to better assess the attitudes, sentiments, and needs of the public in order to provide timely information.

Literature review

Research on the use of Twitter during health crises points to the importance of examining the types of tweets posted, such as determining whether the messages are providing status updates, presenting useful medical resources, or sharing personal experiences and opinions.[4] When Chew and Eysenbach[4] examined the types of tweets posted about the H1N1 outbreak in 2009, they found that resource provision was the most common type of tweet, followed by personal experiences, personal opinions and interests, jokes, and marketing. Lachlan et al[5] studied the types of tweets posted leading up to the landfall of Hurricane Sandy and found that almost half of the tweets conveyed personal emotions, whereas only a third contained useful

* Address correspondence to Cui Zhang Meadows, PhD, School of Communication, East Carolina University, 102 Joyner East, Greenville, NC 27858.
E-mail address: meadowsc14@ecu.edu (C.Z. Meadows).
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information about the storm. It appears that the types of tweets that are most prominent during a crisis may be influenced by the nature of the crisis (eg, natural disaster vs infectious disease outbreak), the public's perception of their susceptibility to the risks (how likely it is that they will be affected by the crisis), and the severity of the crisis (to what extent the crisis will affect them personally). Given the fact that the types of Twitter messages vary based on crisis types and specific contexts, analyzing the types of tweets during a measles outbreak can help public health practitioners more effectively identify the public's interests and needs. For this reason, we proposed the following research question (RQ):

RQ_1: What were the major types of tweets posted during the 2015 California measles outbreak?

The Health Belief Model (HBM) states that an individual's adoption of health behaviors is influenced by a set of beliefs about (1) whether they are susceptible to a disease or health risk (perceived susceptibility), (2) the seriousness of the disease (perceived severity), (3) how difficult it is to take action and how helpful the action is going to be (perceived barriers and perceived benefits), and (4) whether they are capable of performing the recommended health behavior successfully (self-efficacy).[6] Cues to action—stimuli that trigger an individual to adopt appropriate health behavior—were added later to the HBM.[7] Although it was originally proposed as a psychological model to predict people's health behaviors, the HBM has been used to guide the design of messages for a variety of health intervention programs and campaigns.[8] Recently, researchers have begun to examine the ways in which HBM concepts have manifested themselves on various media platforms, including social media platforms such as Twitter[9] and Pinterest.[10]

Understanding to what extent various HBM constructs are present on social media during a measles outbreak can help health professionals pinpoint health beliefs conducive to pro-health attitudes and behaviors. Previous research has found that certain health beliefs such as perceived benefits and perceived barriers are critical in promoting preventive anti-risk behaviors among the public.[11] Furthermore, individuals, nonprofit organizations, businesses, and media may target different segments of the public and have diverging goals when tweeting about the same measles outbreak. It is therefore important to examine how different types of users might prioritize different constructs of the HBM; thus, we posed the following two RQs:

RQ_{2a}: To what extent did tweets about measles contain HBM concepts?

RQ_{2b}: Did different types of users tend to discuss different HBM concepts when tweeting about measles?

The anti-vaccine movement began in the 1990s when Wakefield published his controversial article in *The Lancet*, claiming a link between the measles, mumps, and rubella (MMR) vaccine and autism.[12] Although the article was later discredited and retracted, the public continued to question the safety and value of vaccination. Today, a growing number of parents skip or delay their young children's MMR vaccinations for a number of medical, religious, and philosophical reasons.[13] This trend has been blamed for the reemergence of measles in the United States; for example, a CDC report showed that over 80% of the measles patients in the 2015 outbreak were either unvaccinated or had unknown vaccination records.[2]

Social media have been a hotbed for the anti-vaccine movement. After studying 800 vaccine-related posts on Pinterest, Guidry et al[14] concluded that the majority of them were anti-vaccine; vaccine safety and side effects were the most frequently discussed themes. More importantly, social media such as Twitter tended to set the agenda for traditional media. Jang et al[15] examined how the vaccine-autism debate was presented on different media over time and found that Twitter set the agenda for news media regarding the vaccine-autism controversy. Although the anti-vaccine attitude has generally been identified on social media platforms such as Pinterest, it is unclear if the same attitude has prevailed on Twitter, especially during a measles outbreak. To assess public attitudes toward vaccination expressed on Twitter during a measles outbreak, we asked the next RQ:

RQ_3: What were the attitudes of the public toward MMR vaccination on Twitter during the 2015 California measles outbreak?

Tweets often contain hyperlinks to various media sources, and these links are important to people's assessment of the credibility of a message.[16] A tweet can refer to information from mainstream media, such as television networks and newspapers, or they can share information from emerging online media, such as the "amateur information reporting and sharing activities" on digital and social media cited by Carr et al.[17] Traditional media sources tend to reject the vaccine-autism link. Clarke[18] examined how newspapers reported the vaccine-autism link and found that, although one third of the US news articles showed "balanced reporting" by mentioning both perspectives (a link either exists or does not exist), the majority of reports supported the scientific claim that no link exists between vaccines and autism; in fact, only 1 in 10 advocated the existence of a vaccine-autism link. In contrast, emerging digital and social media are more likely to promote anti-vaccine attitudes, but information promoting the vaccine-autism link on such media outlets is often inaccurate or biased. For example, Kata[19] analyzed anti-vaccine online content and found that a variety of tactics were used to support the claims being made, including skewing science, shifting hypotheses, censoring dissent, and attacking counter-arguments. Such unfiltered and unscrutinized information could be misleading and affect public discourse and health behaviors with regard to vaccination.[19,20] Given the increasingly polarized attitudes toward vaccination in the United States[13] and users' selective exposure to mainstream or emerging online media sources, we proposed this final RQ:

RQ_4: Did pro- and anti-vaccine tweets contain hyperlinks to different types of news sources during the 2015 California measles outbreak?

METHODS

Sampling

All tweets containing the word "measles" posted between December 1, 2014, and April 30, 2015, were purchased from DiscoverText.com. This period was chosen because it was believed that the unidentified Patient Zero visited the Disneyland theme park in California in December of 2014.[1] The first few suspected cases of measles were reported on January 5, 2015, and the CDC officially declared the outbreak to be over on April 17, 2015.[21] Examining the contents of tweets between December 1, 2014, and April 30, 2015, allowed us to analyze Twitter discussions shortly before, during, and after the outbreak. In the end, 1,154,156 tweets were collected. A systematic random sampling method was used to choose 3000 tweets from this dataset for manual coding. The first tweet was identified using a random number generator. After this, every 384th tweet was selected into the sample.

Unit of analysis and measurements

The unit of analysis was an individual tweet. A codebook was developed for this study.

Table 1
Tweet types, definitions, and examples

Tweet types	Definitions	Example tweets
News updates	News and updates on the outbreak	More than 100 measles cases have been reported in 14 states.
Resources	Medical information about the prevention, diagnosis, and treatment of measles	Measles is highly contagious. Ask your doctor if you need a measles vaccine.
Personal experiences	Direct or indirect experiences with measles	My nephew has measles.
Personal opinions or interests	Opinions about measles, general chatter, or commentary, including jokes and parodies	Vaccinate your goddamn children!
Questions	Genuine rather than rhetorical questions about measles	Has measles spread to my town?

Twitter user types

Twitter users who posted about measles were coded into one of the following categories: (1) individuals, (2) government agencies (eg, CDC), (3) academic institutions (eg, university), (4) health care institutions (eg, hospital), (5) nonprofit organizations, (6) news media, (7) businesses (eg, pharmaceutical company), or (8) other. During data analysis, we merged government agencies, academic institutions, and health care institutions into a single category because of the extremely low frequency of each user type.

Tweet content types

Tweets were categorized based on their content types: (1) news updates, (2) resources, (3) personal experiences, (4) personal opinions or interests, (5) questions, or (6) other. These categories were adapted from a study by Chew and Eysenbach[4] of Twitter content during an H1N1 outbreak (see Table 1 for definitions and examples of each content type).

HBM variables

Because the HBM was originally proposed to measure psychological variables, we made adjustments to create variables to measure media content (eg, susceptibility content) contributing to the original psychological variables (eg, perceived susceptibility).[10] Susceptibility content (present/absent) was coded when a tweet discussed the prevalence of measles or how likely it was that someone might contract measles (eg, "90% of the people who will contract measles are unvaccinated"). Severity content (present/absent) was coded when a tweet included information on the severity of measles, such as measles resulting in death (eg, "measles killed my sister"). Cues to action content (present/absent) was coded in terms of whether a tweet urged readers to take an action in response to the threat of measles. Examples of cues to action include "vaccinate your children," "seek medical care," and "stay at home." The remaining concepts in the HBM—perceived benefits, perceived barriers, and self-efficacy—were excluded from this study because an initial coding of the tweets showed that these concepts were almost entirely absent.

Hyperlinks

Tweets were first coded in terms of whether or not they contained any hyperlinks. If a hyperlink was present, the coders clicked the link and categorized the source as (1) news agencies or newswire services (eg, Associated Press, Reuters); (2) television networks (eg, CNN, Fox); (3) newspapers (eg, *Los Angeles Times*); (4) radio stations (eg, National Public Radio); (5) magazines (eg, *Parents*); (6) news websites, news blogs or feeds, or niche news (eg, medicalnewstoday.com); (7) social media (eg, Facebook, YouTube); or (8) other.

Attitudes toward vaccination

This variable was coded as (1) pro-vaccine, (2) anti-vaccine, or (3) no opinion expressed/neutral.

Coder training and intercoder reliability

Two of the authors served as the coders for this study. After 3 rounds of training, the 2 coders both coded a systematically selected sample (n = 333, 10%) that did not overlap with the 3000 tweets. Cohen's kappa was calculated to assess intercoder reliability: 0.64 for user types, 0.57 for tweet content types, 0.75 for attitudes toward vaccination, 0.65 for susceptibility, 0.55 for severity, 0.62 for cues to action, and 0.81 for types of hyperlinks. The coders then split and coded the 3000 tweets in the sample.

Data analysis

Descriptive statistics (frequencies and percentages) were calculated to answer RQ_1, RQ_{2a}, and RQ_3. To answer RQ_{2b} and RQ_4, χ^2 tests were run. Post hoc comparisons were conducted using the method discussed in Beasley and Schumacker,[22] which allowed us to examine adjusted standardized residuals in each cell, as well as differences between observed and expected values in the population, with adjusted *P* values.

RESULTS

RQ_1 asked about the characteristics of tweets in terms of message types. News updates were the most common type of tweets (n = 1243, 41.4%), followed by personal opinions and interests (n = 1010, 33.7%), resources (n = 583, 19.4%), personal experiences (n = 76, 2.5%), and questions (n = 49, 1.6%). RQ_{2a} and RQ_{2b} explored the presence of HBM concepts in tweets and whether different types of users tended to discuss different HBM concepts. Frequency analysis showed that 654 (21.8%) tweets discussed susceptibility, 390 (13.0%) addressed severity, and 568 (18.9%) included cues to action. In terms of user types, the majority of the 3000 tweets were posted by individuals (n = 2316, 77.2%), followed by media organizations (n = 343, 11.4%), businesses (n = 128, 4.3%), and nonprofit organizations (n = 82, 2.7%). Government agencies and university and health care institutions combined were the least common user type (n = 36, 1.2%).

Chi-square tests revealed the likelihood of various user types to discuss susceptibility: χ^2 (5, N = 3000) = 5.44, $P = .36$. However, the types of users differed in terms of the likelihood of discussing severity in their tweets: χ^2 (5, N = 3000) = 16.01, $P < .01$. Post hoc tests on the adjusted residuals with Bonferroni correction[25] revealed that individuals were significantly more likely to discuss severity in their tweets than other types of users combined (adjusted $P < .003$). Furthermore, there was a significant difference among the different user types with regard to cues to action expressed in the tweets: χ^2 (5, N = 3000) = 25.30, $P < .001$. Post hoc tests demonstrated that nonprofit organizations were significantly more likely to offer cues to action in their tweets than other user types (adjusted $P < .003$), but media were less likely to include cues to action in their tweets than other user types (adjusted $P < .003$) (see Table 2 for results of the post hoc tests).

RQ_3 explored attitudes toward vaccination that were expressed in tweets. Out of the 3000 tweets, 1076 (35.9%) expressed a pro-vaccine

Table 2
Differences in susceptibility, severity, and cues to action expressed in tweets based on user types

	Individuals	Government, university, health care institutions	Nonprofit organizations	Media	Businesses	Other
Susceptibility (N = 654), n (%)	516 (22.3)	5 (13.9)	12 (14.6)	70 (20.4)	32 (25.0)	19 (20.0)
Adjusted *p*	.23	.23	.11	.48	.37	.69
Severity (N = 390), n (%)	328 (14.2)*	7 (19.4)	6 (7.3)	30 (8.7)	10 (7.8)	9 (9.5)
Adjusted *p*	<.003	.23	.11	.01	.07	.32
Cues to action (N = 568), n (%)	453 (19.6)	7 (19.4)	27 (32.9)*	40 (11.7)*	28 (21.9)	13 (13.7)
Adjusted *p*	.11	.92	<.003	< .003	.37	.19

*Significant results with an adjusted *P* value of .003.

attitude, and 186 (6.2%) expressed an anti-vaccine attitude. RQ_4 asked whether pro- and anti-vaccine tweets were more likely to link to traditional media or emerging news and social media sources. The majority of the tweets contained links to various media sources (n = 2126, 70.87%). Among them, emerging news websites (n = 704, 23.5%) were most frequently linked, followed by newspapers (n = 379, 12.6%), television networks (n = 367, 12.2%), social networking sites (n = 105, 3.5%), and news agencies (n = 48, 1.6%). For the purposes of this analysis, tweets that demonstrated a neutral attitude toward vaccination were removed. Pro- and anti-vaccine tweets differed significantly in terms of the media sources they cited: χ^2 (8, N = 1262) = 72.50, $P < .001$. Post hoc tests revealed that pro-vaccine tweets were more likely to cite traditional mainstream media sources such as newspapers (adjusted $P < .003$) and magazines (adjusted $P < .003$); anti-vaccine tweets were more likely to contain links to emerging news websites (adjusted $P < .003$) (see Table 3 for results of the post hoc tests).

DISCUSSION

Social media such as Twitter allow the public to share resources, personal experiences, and opinions and to ask questions during emerging infectious disease outbreaks such as a measles outbreak. This study examined how Twitter users discussed measles during the highly publicized 2015 California measles outbreak. News updates and resources represented around 60% of the tweets about measles, indicating that the majority of the public used Twitter to share information. This finding suggests that in response to public health emergencies, such as a measles outbreak, public health practitioners should address the public's need for information by taking advantage of social media platforms, including Twitter. In fact, a growing trend is for public health organizations at national and local levels to integrate social media into their crisis communication repertoire.[23]

Overall, less than 22% of the tweets contained information related to any of the HBM concepts of perceived susceptibility, perceived severity, or cue to action. This may be attributed to the fact that all of the tweets collected in 2015 were limited to 140 characters. Contents promoting the health benefits of various preventive methods (such as vaccination or avoiding crowded spaces) or individual self-efficacy are almost entirely absent. Comparing tweets posted by the various types of users, we found that individuals were significantly more likely to discuss the severity of measles than other types of Twitter users (eg, government agencies, health care institutions). This is probably because individuals are more concerned with how they could be personally affected. Naturally, in the event of an outbreak, those who have limited information or resources are likely to experience some fear and to search for information online.[24] Therefore, it is crucial for public health practitioners, government agencies, and the media to disseminate accurate information with frequent updates to reduce potential fear among the public. It would be particularly helpful if the media could describe the severity of the outbreak in a factual manner and recommend actions to be taken by the public.

The 2015 measles outbreak not only posed a great health risk but also fueled the already heated debate about vaccination safety. Traditionally, the Internet and social media have been a breeding ground for anti-vaccine ideas,[14] and individuals opposing vaccinations are more likely to speak out online while those who support vaccinations remain silent.[20] This enables the growth of a false consensus online which has the potential to influence the public's perceptions, attitudes, and behaviors related to vaccines.[25] In our sample, however, pro-vaccine tweets outnumbered anti-vaccine tweets by 5 to 1. Because our data were collected during a measles outbreak, it is understandable that those who were pro-vaccine were likely to be more vocal than those who were anti-vaccine. A further examination revealed that the percentage of the pro-vaccine tweets changed as the outbreak progressed. Before the first case was reported on January 5, 2015, only 27.0% of the tweets supported vaccination; however, from the beginning of the outbreak to when the end of the outbreak was declared on April 17, 2015, the percentage of the pro-vaccine tweets increased to 34.0%. After the outbreak was over, this figured declined to 24.2%. This means that a measles outbreak may encourage people supporting vaccination to speak up, but this effect soon disappears as the outbreak takes its course.

More than two thirds of the tweets regarding the measles outbreak contained hyperlinks to various media sources. Identifying which sources are shared by what types of tweets can help researchers and practitioners understand the relationships between vaccine attitudes and the sources that they share. We found that emerging news websites, which are mostly likely to propagate anti-vaccine information, were linked in the tweets more than any other sources, including mainstream newspapers, magazines, television networks, news agencies, or social media sites. Our study also found that pro-vaccine tweets were significantly more likely to contain hyperlinks to mainstream media sources such as newspapers and magazines (eg, *The Washington Post*, *Forbes*), but anti-vaccine tweets were more

Table 3
Differences in attitudes toward vaccination in terms of cited media sources

	News agency/ newswire service (n = 18)	Television network (n = 10)	Newspaper (n = 173)	Radio (n = 18)	Magazine (n = 89)	News website/ blog (n = 344)	SNS (n = 43)	Other (n = 138)	No media link (n = 329)
Pro-vaccine tweets (N = 1076), n (%)	17 (1.6)	102 (9.5)	168 (15.6)	17 (1.6)	89 (8.3)	266 (24.7)	33 (3.1)	104 (9.7)	280 (26)
Anti-vaccine tweets (N = 186), n (%)	1 (0.5)	8 (4.3)	5 (2.7)	1 (0.5)	0 (0)	78 (41.9)	10 (5.4)	34 (18.3)	49 (26.3)
Adjusted *P*	.27	.02	<.003*	.27	<.003*	<.003*	.11	<.003*	*p* = .92

SNS, Social Networking Site.
*Significant results with an adjusted *P* value of .003.

likely to contain links to emerging news websites (eg, truthstreammedia.com). This is consistent with findings from earlier studies of social media use for other topics (eg, political discussion) that people choose to be exposed to media sources whose views they agree with, hence creating an echo chamber. Practically, public health professionals have used traditional media to promote vaccination and debunk the vaccine-autism myth; however, anti-vaccine sentiments are still on the rise. The anti-vaccine argument tends to rely on a variety of tactics, such as relating personal experiences and making emotional appeals, that are especially appealing to social media users.[12] For this reason, public health professionals need to extend their vaccine promotion efforts to social media and emerging news sites. One way of effectively delivering such messages is by identifying opinion leaders on social media who can influence large numbers of followers.

This study has a few limitations. First, this study examined only Twitter messages. Future studies are encouraged to analyze public sentiment on other social media platforms, as different platforms are adopted by various audience segments. Second, it had a relatively small sample size. Although we coded 3000 tweets, that ratio is low compared to how many tweets were actually posted about measles during this period; however, this study does provide a baseline for future large-scale, machine-assisted content analysis. Another limitation is Twitter itself, which, at the time of data collection, allowed only up to 140 characters per tweet. Because the tweets contained limited information, the HBM, which has often been used to guide analyses of media content regarding health and illness, was not very useful in categorizing the tweets. In addition, not all tweets are created equal. Contents posted by influential users, such as users with large numbers of followers (eg, The Associated Press) or users that occupy central positions within the network, are more likely to be read and retweeted and to have a greater influence on public opinions. Future research should weigh the relative importance or potential influence of various tweets based on user characteristics and their positions in the retweeting network.

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