HHS Public Access

Author manuscript

Am J Infect Control. Author manuscript; available in PMC 2016 June 01.

Published in final edited form as:

Am J Infect Control. 2015 June 1; 43(6): 563–571. doi:10.1016/j.ajic.2015.02.023.

What Can We Learn about the Ebola Outbreak from Tweets?

Michelle Odlum, EdD, MPH[1] and **Sunmoo Yoon, RN, PhD**[1]

[1]School of Nursing, Columbia University Medical Center, New York, NY

The current Ebola virus disease (EVD) outbreak is of major global concern and classified by the World Health Organization (WHO) as an international health emergency. Beginning in December of 2013 in the eastern section of the Republic of Guinea,[1-3] new cases have been reported regularly by the Ministries of Health in Guinea, Liberia, Sierra Leone and recently Senegal (daily direct flights to JFK, IAD, CDG).[4-6] With a cumulative case total of over 13,567 and 4,951 deaths,[7, 8] the first major West African outbreak of the most virulent Zaire strain of EVD is now the largest EVD outbreak to date.[9] Local, regional and international agencies are challenged to contain the epidemic, reduce fatalities, and allay the climate of fear.[9, 10] However, ongoing disease containment and surveillance is difficult due to the current outbreak. Furthermore, in resource-limited settings, barriers to optimal public health outbreak surveillance exist.[4] With Ebola in the US and the recent New York City (NYC) diagnosed case,[11] there is valid cause for concern of spread in first world countries. In populated cities like NYC, contamination is a sobering reality, and with its rodent population out numbering the humans, endemic Ebola is not outside the realm of possibility. Rodents are a main reservoir of viral hemorrhagic fevers (VHF). Similar to Lassa fever, another hemorrhagic disease, the mode of transmission is direct exposure to excreta of infected rats.[12] The certainty of EVD containment in the immediate future is not known. To improve compliance with measures of prevention and control, several priority actions are recommended for strengthened surveillance systems. These include the use of emerging technologies to support early warning systems for communication between agencies and the general public.[1]

The Department of Communicable Diseases Surveillance and Response (CSR) at the WHO endorsed the Conceptual Framework of Public Health Surveillance and Action (PHSA).[13] This framework demonstrates how public health surveillance and action relate through data information messages.[14] Public health action includes acute (epidemic-type) responses, defining a framework for both surveillance and action during emergent outbreak situations.[15] In the event of re-emerging rare infections like EVD, active systems for surveillance and acute response are used to halt transmission.[14] Although emergent diseases are to be viewed in relation to control strategies and national surveillance, resources are

SY and MO designed the study. All authors drafted the manuscript, critically revised the manuscript for important intellectual content, had full access to all of the data in the study, and take responsibility for the integrity of the data and the accuracy of the data analysis.

Ethical approval

This study used publically available data, and analyses meet the criterion for exemption §46.101(b)4 Research, involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

often limited. If surveillance systems are not timely, complete, efficient or adaptable, gaps in knowledge may occur.[16] Optimal outbreak surveillance for public health action should comprehensively uses multiple modalities for data collection, analysis, and dissemination.[17] Knowledge transfer tools to support strategies for outbreak control are necessary.[15]

Social network sites (SNS) allow users to play active roles in the reporting and dissemination of news events. Users share insights, opinions, and apprehensions, while disseminating interpretations of health events outside a public health context.[17, 18] There is an increasing need to both develop and share health information which are essential in outbreak surveillance efforts. Surveillance through electronic mediums such as the Internet, provide tremendous opportunities for public health practice.[17] Twitter, one of the most popular SNS, is a microblogging application allowing for communication through 140 characters called tweets. Streams of tweets can contain useful information, with news events documented, shared, and discussed.[19] Twitter users interact through direct messages or solicited replies that can be largely disseminated through forwarding (retweeting), allowing for rapid and broad propagation.[18] Over 645 million registered Twitter users exist globally with a distribution of over 58 million tweets daily.[20] The community of Twitter users reflects a diverse and rapidly growing global population.[21, 22] Twitter is viewed as an emerging broadcast medium for information and news regarding public health events, evidenced by its usefulness during the H1N1 pandemic planning activities.[18] Twitter's capacity for broad reach, timeliness, and low overhead has the potential to capture epidemic trends, gather information, and disseminate knowledge.[17, 23] The utility of Twitter supports its potential to impact public health outbreak surveillance efforts in new and innovative ways.

Taking advantage of this unique opportunity to examine the use of a powerful SNS tool during a public health crisis, the aim of our study was to provide a snapshot of EVD-related tweets in the midst of the current outbreak to 1) monitor trends of information spread, 2) examine early epidemic detection, and 3) determine public knowledge and attitudes.

METHODS

Tweet Corpus

Tweets mentioning EVD were collected daily from Twitter (https://twitter.com/) via Google Chrome based version of NCapture™ from July 24th to August 1st, 2014. Keywords used for the identification of EVD-related data included #Ebola, #EbolaOutbreak, #EbolaVirus, and #EbolaFacts. Keyword selection for our data corpus was informed by Twitter search trends and suggested search functions. Data elements collected for each tweet included contents, time stamps, geographical locations with latitude and longitude codes from the sender's IP address and self-identified addresses, the user names, the message type (unique or retweet), and the number of followers (number of disseminated). For example if Justin Bieber sent out a tweet message, which was cited by 100 people, it would be calculated as follows: the number of posted tweets marked as 101 (unique =1, retweet=100), and the number of disseminated tweets is counted as 54 million in this study (dissemination = 54 million).

Trends of Information Spread

We investigated the trends of geographical spread of EVD information within Twitter. To evaluate EVD temporal patterns of information dissemination, the number of posted (unique and retweet) and disseminated tweets were characterized by date in an early stage of Ebola outbreak. Descriptive statistics including the volume of posted (unique and retweet), and disseminated tweets were traced according to geographical location. The poster's locations were indicated using an interactive, data visualization and business intelligent software (Tableau 8.1). Time series analysis using an exponential smoothing algorithm[24] was used to identify trends of how fast the tweets mentioning Ebola were disseminated. The trend model of the dissemination speed of tweets mentioning EVD was visualized.

Content Analysis

A content analysis was conducted to capture public perceptions of EVD and to reduce noise. We employed a NLP approach in the analysis of EVD tweet content. To identify topics of collected tweets, we cleaned symbols and web addresses, and transformed text to a vector form and N-gram and reduced the dimensionality of the volume using Notepad++ and Weka software. The detailed steps of tweet cleaning, preparation, and refinement are described in the author's (SY) other paper.[25] The N-gram forms (unigram, bigram and trigram) of tweet messages were clustered based on content similarities for topic detection. K-means algorithm was then applied using Weka. Clusters were visualized to summarize the detected topics.

RESULTS

Trends of Information Spread

A total of 42,236 tweets mentioning the recent EVD outbreak were posted (16,499 unique, 25,737 retweet) and disseminated to 9,362,267,048 people from July 24th to August 1st, 2014 (Figure 1). On July 24th, the baseline of 382 posted tweets (unique 128, retweet 254) were disseminated to 1,502,743 Twitter users. On July 26th with the announcement of the EVD infection of an American physician, the baseline number increased eight-fold to 3,222 posted tweets (unique 1574, retweet 1648) with a 644-fold increase in disseminated tweets (967,404,925). The number of tweets decreased for three days and started drastically increasing on July 30th with the announcement of Sierra Leone emergency declaration, the UK foreign secretary's official message, and the Peace Corp pulling volunteers.[26] After the first press announcement from the Centers for Disease Control and Prevention (CDC) on July 28th,[27] the number of tweets increased two-fold. Within three days of this announcement, the number of tweets continued to spread quickly with increasing news events including the WHO's 100 million dollar plan, CDC Level 3 notice for Liberia, Sierra Leone and Guinea, and the infected American physician's return with EVD. On July 31st, 2014 (3 days after first CDC announcement), EVD news items were disseminated to 4,864,972,879 Twitter users, 63 times higher than the initial number.

Time Series Analysis

Time series analysis showed the rate of information dissemination within Twitter gradually increasing (number of disseminated tweets = 520,441*Minute of Time + −2.17785e+010, P<0.0001, SE 7.80976e+006). This model explained a 520,441 increment of disseminated tweets every minute. Figure 1 illustrates the frequency of tweets mentioning EVD and news alerts in an early stage of the world emergency response. The daily geographical spread of tweets mentioning EVD is displayed in Figure 2. Before the CDC Health Advisory announcement on July 28th, 2014, EVD conversations on Twitter were limited to African and European countries, with a small portion of North Americans tweeting. After the July 29th announcement by the CDC, the rate of posted tweets increased to span additional global locations such as Europe, North America, Africa, Asia, and Australia. Approximately 2,000 tweets were posted from Africa and North America. The Chikungunya outbreak was continuously mentioned in the Caribbean region, marked as blue. EVD-related Tweets, marked as orange, spanned the globe. Despite global awareness of EVD, only a few people in the Caribbean region, mentioned EVD (Figure 2).

Early Epidemic Detection- Nigeria Cases

Increases in tweet frequency from cities in Nigeria were identified. Tweets steadily increased (six-fold in posted, twenty-fold in disseminated tweets) from July 24th until July 31st, the day of the CDC official Nigeria case report in Figure 3. Tweets started to rise in Nigeria prior to the official announcement of the first probable EVD case. On July 24th, Twitter users discussed the first case of EVD in related tweets such as “#EbolaVirus 1st case discovered Lagos, pls spread the word,” and “Guys,#EbolaVirus is in Lagos. Be informed. Be careful.” The first probable EVD case was announced by the Nigerian Ministry of Health on July 27th and by the CDC on July 31st. The first case of EVD news in Nigeria was tweeted on July 24th and reached 1,196,793 people and 120,574,549 people were reached on July 30th, a hundred times higher than the initial number.

Content Analysis

Four main public topics of concern were discussed in tweet content (Figure 4): 1) Risk Factors: cause of EVD (i.e., transmission and infection); 2) Prevention Education: health information (i.e., prevention methods, signs, and symptoms); 3) Disease Trends: spread and location (i.e., name of locations and information about spread); and 4) Compassion: prayer for countries in Africa. An N-gram was computed from the NLP and cluster analysis results, Figure 4. The bubble chart in Figure 4 illustrates the four topics of EVD tweets. The sizes of chart bubbles are normalized by clusters and represent the relative frequency of the N-gram. Topic 1, cause of EVD, includes ‘transmitted’ (0.21) and ‘animal’ (0.20), which were the most frequent words. Topic 2, prevention education, includes ‘signs symptoms’ (3.76) and ‘symptoms and prevention’ (3.76), the most frequent words. ‘Virus’ (0.49) and ‘Africa’ (0.25) frequently appeared in Topic 3. ‘Pray for Sierra’, ‘Sierra Leone Guinea’ and ‘pray for Africa’ were the frequent words in Topic 4.

DISCUSSION

The Conceptual Framework of Public Health Surveillance and Action identifies the essential need for active surveillance during re-emerging rare infections such as EVD. The framework also demonstrates how health systems can link outbreak surveillance to action through data information messages.[14] The current study reveals how tweets can be collected and analyzed to support early warning systems for epidemic trends and to inform data information messages for health education interventions.[28] The delivery of useful and effective information is the foundation of outbreak surveillance.[16] Moreover, outbreak public health education efforts, suggested by the CDC, include surveying public knowledge and attitudes and disseminating mass media messages. Electronic information sources that provide additional opportunities to improve health knowledge with respect to person, place, or time,[16] such as Twitter, have the ability to support achievement of these goals.

Early Warning Signs and Timely Detection

We demonstrated how Twitter can support and contribute to early warning systems in outbreak surveillance. Our unique dataset reflects the early stage of health alerts around the recent EVD spread during the current outbreak. Our geocode was provided by two sources, IP addresses of users and complemented by self-report through tweet content analysis. Our novel findings are two-fold. The analysis captured progressive increases in the number of tweets discussing EVD case identification in Nigeria beginning on July 24th, 2014, occurring three days prior to the news alert and seven days before the official CDC update. On July 31st, 2014, the CDC indicated a probable case in Nigeria reported by the WHO and the Nigerian Ministry of Health.[29] We have also shown that although Twitter adoption and use in resource-limited settings such as Nigeria is lagging, there was an increase in the frequency of EVD-related tweets in the days leading up to the official news alert. These results indicate how Twitter can be used to support early warning systems in outbreak surveillance efforts in settings where surveillance systems are not optimal.

Timely systematic collection, interpretation, and dissemination of health-related data during outbreak and surveillance efforts are important for containment and control.[23] Failure to recognize a public health threat or missing opportunities to intervene can result when information is not timely.[16] Africans are participating in global conversations more and more. According to the United Nations (UN), a social media boom has been reported in Africa. Studies have indicated that Africans go online through their mobile phones and spend most of their time on SNSs such as Facebook and Twitter. Understanding these increasing trends, the Central Intelligence Agency utilizes technology for SNS surveillance in attempts to thwart terrorist activities.[30] The value of SNS content and reach cannot be ignored. SNS data has and will continue to prove valuable in support of global health efforts and outcomes.[31]

Public Perception, Needs and Education

Public attitudes were captured through trend analysis, revealing communication stimulated by public concern and mirroring news alerts. Tweets occurred around health advisories, case identification, and the US return of infected health workers. We observed EVD-related

tweets increasing in frequency and fear intensity from Africa, Europe, and North America with the growing number of cases. While tweeting increased across North America, the Caribbean remained almost silent regarding the epidemic. The recent Chikungunya outbreak was of major importance in the Caribbean, evidenced in regional tweets. Nevertheless, isolation from the EVD outbreak is concerning given the close proximity to West Africa. Furthermore, factors driving the EVD epidemic make it difficult to contain, increasing the likelihood of a global spread.[32]

Health information dissemination is critical during acute epidemic-type response, to support public health action and inform data information messages. However, health information needs must be adequately assessed for effective communication. Our results captured public knowledge, showing how tweet analysis can be useful in identifying and measuring the need for health education intervention. Messages are propagated and broadly disseminated through retweeting. Our results also show effective dissemination of health alerts. The number of EVD public concern retweets almost doubled in the day after the CDC's health advisory on July 28th, 2014. Tweets were generally about health information seeking, confirming the need for appropriate health education messages to accompany alerts. It can be argued that prevention education messages will be minimal immediately following health alerts. However, our results indicate that a week after the July 26th, 2014 news of the US physician return, EVD education messages were still minimal. Columbia, Harvard and Mayo Clinic tweeted about EVD prevention during these early days of news and health alerts. Yet, dissemination was inadequate as a result of limited following and reach, with no major news networks retweeting these prevention messages. Followers of these institutions are not representative of the general population and are characterized by higher functional and health literacy. In fact, a recent Harvard poll on US EVD concerns revealed adults with less than high school education expressed greater concern than college graduates about a potential EVD outbreak and indicated major knowledge gaps regarding treatment.[33] This poll reinforces the need to provide appropriate health information messages for all literacy levels. Our results can be used in outbreak surveillance to support and evaluate the effectiveness of prevention education efforts and activities.

Four major topics were tweeted about EVD. Three topics comprised of deficiencies in health education which identified knowledge gaps. EVD information was both provided and sought. Twitter users sought information regarding transmission, infection, prevention, location, and frequency (Figure 4). Such content provides insight into targeted areas for health education mass dissemination. A recent tweet by the WHO support our recommendations. In an effort to dispel social media rumors and claims of products to prevent and cure Ebola, the WHO utilized Twitter to provide warnings.[34] Compassion in the form of prayer was also identified in our analysis. Twitter users prayed for affected countries, victims, and families. Our findings also indicate care and consolation for others. Results further support the need to improve educational efforts to diminish fear as evidenced in the US sentiment to prevent the return of infected health workers.[7, 35] As the EVD outbreak spirals out of control in Liberia with the number of reported deaths as high as 200 per day,[7] increasing fear is inevitable. Misplaced fear, resulting in irrational thought or behavior is a major barrier to outbreak prevention, containment, and care as demonstrated in Figure 5.

Limitations of this study

The generalizability of this study is limited due to single language (English) and social medium (Twitter) analysis. Our search strategies utilized possible variations with hashtags in an attempt to include the maximum number of EVD-related tweets. Our study also used the URL-based and self-report based geographical location, potentially decreasing the accuracy of findings. Future studies analyzing data sources including different social media, blogs, or community websites may complement the understanding and dissemination of EVD-related information.

CONCLUSIONS

It is important to emphasize the ongoing and critical need for effective health education messages to accompany news alerts regarding Ebola and other global outbreaks. With the recent cases of Ebola in the US, several confusing and flawed messages were issues by the CDC, prompting lawmakers to question the agency's ability to handle the Ebola health crisis.[36] Although information is widely disseminated, the American people remain confused and fearful. Alternatively, there is something to be learned from the power of health education and communication from Nigeria. Their quick and forceful public health response through rapid tracking, monitoring, and isolation has been lauded by the WHO as world-class epidemiological implementation.[37] In addition to a team of 150 contact tracers, teams of social mobilizers were deployed by Nigeria's Emergency Operations Center. Social mobilizers were responsible for providing health information to areas around the homes of Ebola contacts.[38] Their efforts were tremendous, reaching 26,000 households.[38] Nigeria's effective response reinforces the importance of health communication. Twitter can support similar efforts for mass dissemination.

Using Twitter in outbreak surveillance is immense, allowing for real-time data capture. Global use of SNS is on the rise. An expanded definition of public health outbreak surveillance is needed as social media content can be used to support and enhance existing early warning systems. Twitter users provide multiple dimensions of concern, regardless of character limitations. In spite of evident public unease, our analysis reveals no health education resolve. Twitter allows for government and health agencies to engage and guide the public during outbreak surveillance efforts. For effective data information messaging, Twitter can inform content for desired outcomes. Access to such data allows for greater accuracy and sensitivity in the assessment of behavioral response. As fear and knowledge deficits drive epidemics, outbreak alerts must accompany population-specific and literacy-appropriate health education messages for intervention and outbreak control.

Acknowledgements

The authors thank Elaine L. Larson, RN, PhD and Jacqueline A. Merrill, RN, MPH, PhD for their insights in initiation of the project. We were able to capture the rare but critical data before the Ebola Outbreak to contribute the early detection of outbreak using Twitter. We thank to Suzanne R. Bakken, RN, PhD for her support in several years of training for the authors to learn the analytic skills of Twitter.

Funding

This study received no funding.

References

1. Ansumana R, Bonwitt J, Stenger DA, Jacobsen KH. Ebola in Sierra Leone: a call for action. Lancet. 2014; 384:303. [PubMed: 25002177]
2. Gatherer D. The 2014 Ebola virus disease outbreak in West Africa. J Gen Virol. 2014; 95:1619–24. [PubMed: 24795448]
3. Green A. Ebola emergency meeting establishes new control centre. Lancet. 2014; 384:118. [PubMed: 25025099]
4. Dolan N. Infectious disease surveillance update. The Lancet. 2014; 14
5. Torjesen I. Two doctors die from Ebola and lives of others under threat in West Africa. BMJ. 2014; 349:g4895. [PubMed: 25073968]
6. World Health Organization. IHR Emergency Committee on Ebola outbreak in West Africa. Ebola virus disease update – Senegal. Global Alert and Response: Disease outbreak news. 2014
7. Izadi E. Ebola death toll rises to 2,296 as Liberia struggles to keep up. The Washington Post. 2014
8. Sifferlin A. WHO: More Than 1,000 Killed in Ebola Outbreak. TIME. 2014
9. Dixon MG, Schafer IJ. Ebola Viral Disease Outbreak West Africa 2014. Morbidity and Mortality Weekly Report. 2014; 63:548–51. [PubMed: 24964881]
10. Feldmann H. Ebola - A Growing Threat? The New England journal of medicine. 2014
11. Drazen JM, Kanapathipillai R, Campion EW, Rubin EJ, Hammer SM, Morrissey S, et al. Ebola and Quarantine. The New England journal of medicine. 2014
12. Centers for Disease Control and Prevention. Viral Hemorrhagic Fevers. Fact Sheet. Jun 19.2013
13. Calain P. Exploring the international arena of global public health surveillance. Health Policy Plan. 2007; 22:2–12. [PubMed: 17237489]
14. McNabb SJ, Surdo AM, Redmond A, Cobb J, Wiley J, Chakrabarti S, et al. Applying a new conceptual framework to evaluate tuberculosis surveillance and action performance and measure the costs, Hillsborough County, Florida, 2002. Ann Epidemiol. 2004; 14:640–5. [PubMed: 15380794]
15. Ridley RG. Research on infectious diseases requires better coordination. Nat Med. 2004; 10:S137–40. [PubMed: 15577932]
16. Hall HI, Correa A, Yoon PW, Braden CR. Lexicon, definitions, and conceptual framework for public health surveillance. MMWR Surveill Summ. 2012; 61(Suppl):10–4. [PubMed: 22832991]
17. Khan AS, Fleischauer A, Casani J, Groseclose SL. The next public health revolution: public health information fusion and social networks. Am J Public Health. 2010; 100:1237–42. [PubMed: 20530760]
18. Sullivan SJ, Schneiders AG, Cheang CW, Kitto E, Lee H, Redhead J, et al. 'What's happening?' A content analysis of concussion-related traffic on Twitter. Br J Sports Med. 2012; 46:258–63. [PubMed: 21406451]
19. Signorini A, Segre AM, Polgreen PM. The use of Twitter to track levels of disease activity and public concern in the U.S. during the influenza A H1N1 pandemic. PLoS One. 2011; 6:e19467. [PubMed: 21573238]
20. Twitter Statistics. Huffington Post eMarketer. 2014. Online: http://www.statisticbrain.com/twitter-statistics/2014
21. Bosley JC, Zhao NW, Hill S, Shofer FS, Asch DA, Becker LB, et al. Decoding twitter: Surveillance and trends for cardiac arrest and resuscitation communication. Resuscitation. 2013; 84:206–12. [PubMed: 23108239]
22. Heaivilin N, Gerbert B, Page JE, Gibbs JL. Public health surveillance of dental pain via Twitter. J Dent Res. 2011; 90:1047–51. [PubMed: 21768306]
23. Henning KJ. What is Syndromic Surveillance? MMWR Supplement. 2004; 53:7–11.
24. Gardner ES. Exponential Smoothing - the State of the Art. Journal of Forecasting. 1985; 4:1–28.
25. Yoon S, Elhadad N, Bakken S. A Practical Approach for Content Mining of Tweets. American Journal of Preventive Medicine. 2013; 45:122–9. [PubMed: 23790998]
26. Lewis D, Farge E. Wrapup 1-Liberia Shuts Schools as Ebola Spreads, Peace Corps Leaves 3 Countries. Reuters. 2014

27. Centers for disease Control and Prevention. CDC Telebriefing on Ebola outbreak in West Africa. 2014
28. Tappero JW, Tauxe RV. Lessons learned during public health response to cholera epidemic in Haiti and the Dominican Republic. Emerg Infect Dis. 2011; 17:2087–93. [PubMed: 22099111]
29. Centers for Disease Control and Prevention. Ebola Hemorrhagic Fever. Previous Updates: 2014 West Africa Outbreak. Jul 31.2014
30. Giles J. 'Unlike' the FBI on Facebook. New Scientist. 2012; 214:24.
31. Essoungou A. The social media boom begins in Africa. The United Nations Africa Renewal Online. 2010
32. Changula K, Kajihara M, Mweene AS, Takada A. Ebola and Marburg virus diseases in Africa: Increased risk of outbreaks in previously unaffected areas? Microbiol Immunol. 2014; 58:483–91. [PubMed: 25040642]
33. Havard School of Public Health. Poll finds many in U.S. lack knowledge about Ebola and its transmission. News Press Release. 2014
34. Jones B, Elbagir N. Are myths making the Ebola outbreak worse? CNN World. 2014
35. Stanglin D. 2 American Ebola patients head to USA. USA Today. 2014
36. Begley S. U.S. health agency chief faulted over confusing Ebola messages. Reuters. Oct 17.2014
37. Fasina F, Shittu A, Lazarus D, Tomori O, Simonsen L, Viboud C, et al. Transmission dynamics and control of Ebola virus disease outbreak in Nigeria, July to September 2014. Euro surveillance : bulletin Europeen sur les maladies transmissibles = European communicable disease bulletin. 2014; 19
38. Courage K. How Did Nigeria Quash Its Ebola Outbreak So Quickly? Scientific America. Oct 18.2014

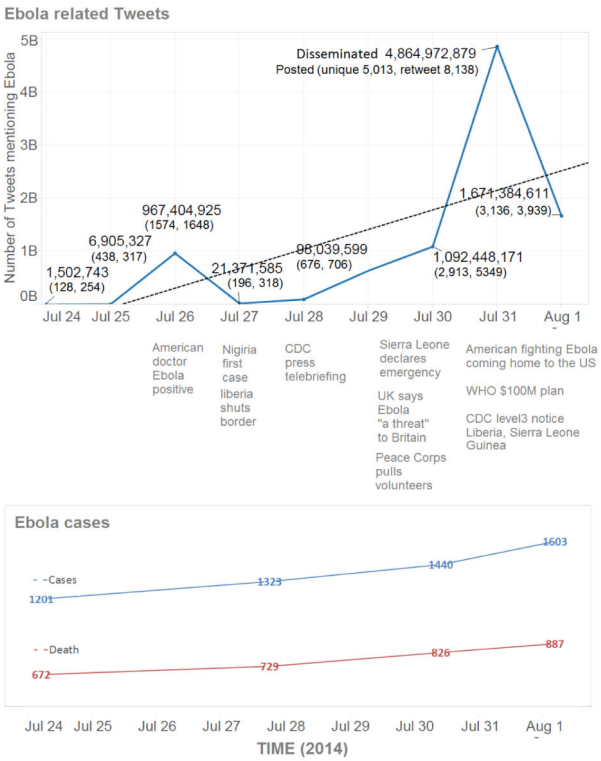

Fig 1.

Time trends in tweets mentioning Ebola in an early stage of world emergency response.

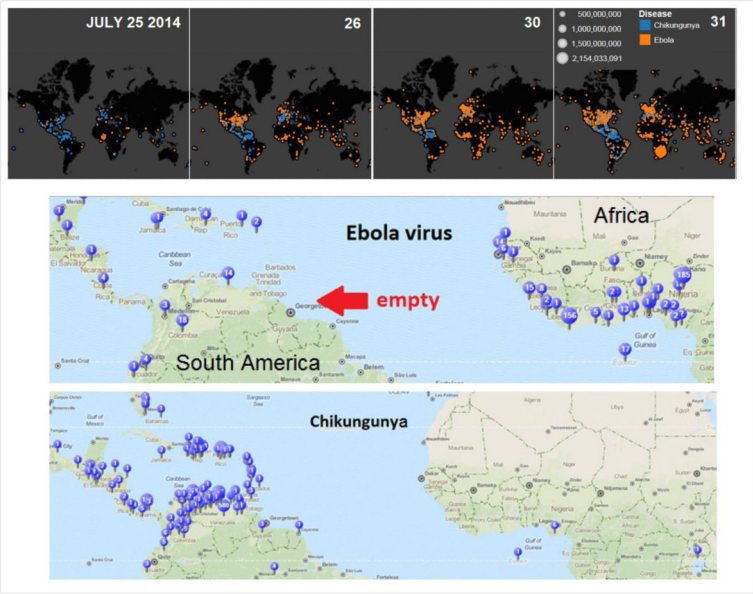

Fig 2.

Geographical location of disseminated tweets mentioning Ebola and Chikungunya (Top). Number of tweets generated on July 30th, 2014 in Caribbean area and Africa (Bottom).

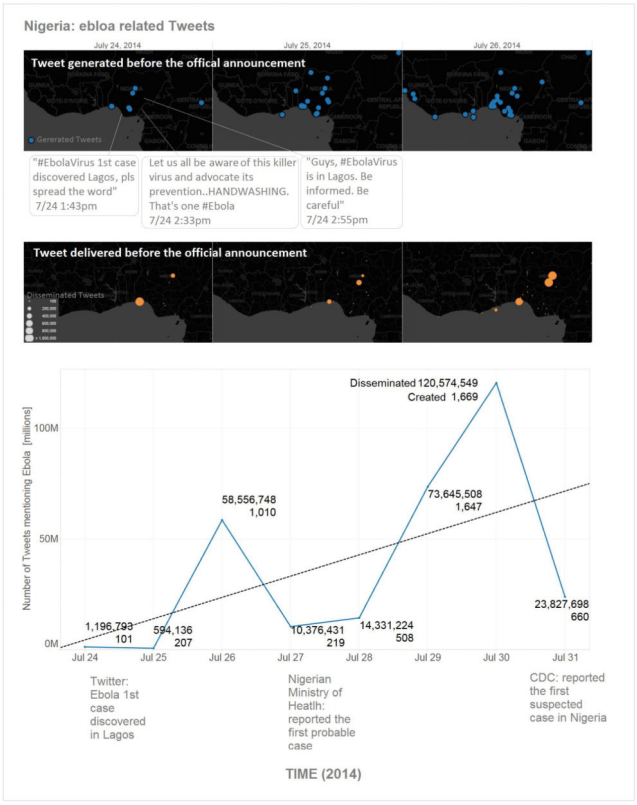

Fig 3.

Time of first Nigerian Ebola case on Twitter, Ministry of Health, and CDC

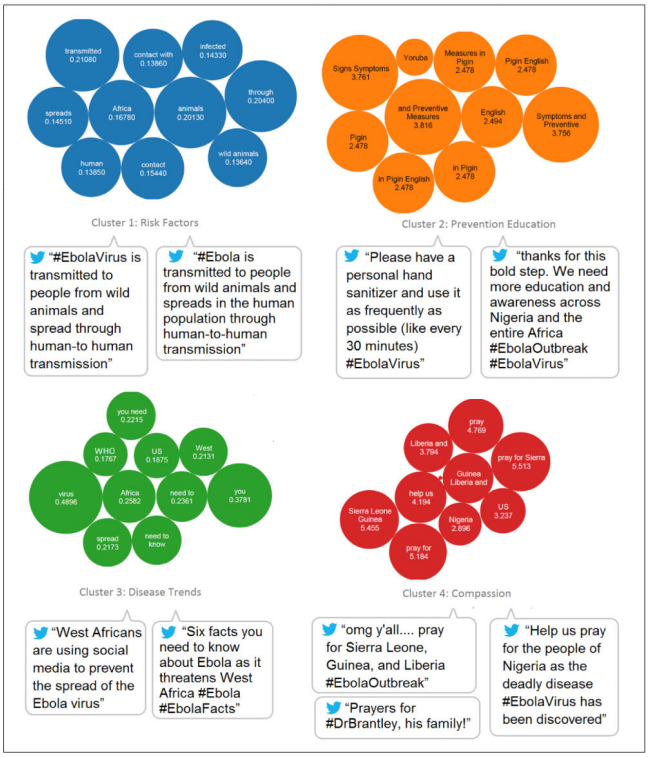

Fig 4.

Four topics of tweets mentioning Ebola. N-gram and frequency broken down by cluster. Color shows details about cluster. Size is normalized by clusters and shows frequency of the n-Gram.

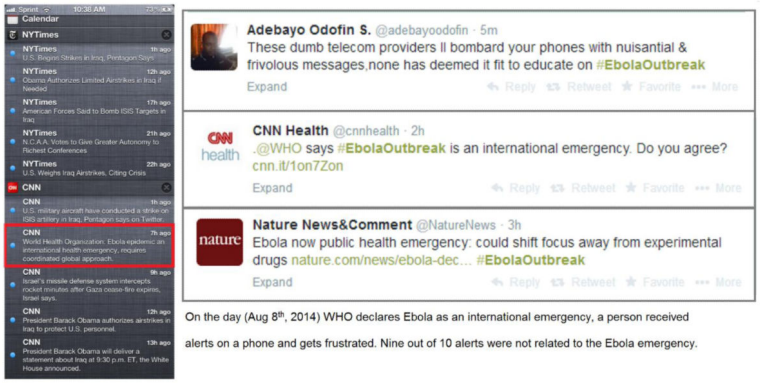

Fig 5.

An example of a person's perception on the day of the Ebola emergency declaration by WHO. (A person received ten alerts and expressed his opinion on Twitter)