



Zika Outbreak of 2016: Insights from Twitter

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Abstract. An outbreak of the Zika virus in 2016 caused great concern among the general public and generated a burst of tweets. The aim of this study was to develop a better understanding of the types of discussions taking place. Tweets were retrieved from the peak of the Zika outbreak (as identified by Google Trends). Tweets were then filtered and entered in NVivo to be analysed using thematic analysis. It was found that tweets on Zika revolved around seven key themes: pregnancy, travel and the Olympics, mosquitoes and conspiracy, health organisations, health information, travel and tracking, and general discussions around Zika. Our results are likely to be of interest to public health organisations disseminating information related to future outbreaks of Zika and we develop a set of preliminary recommendations for health authorities.

Keywords: Zika · Twitter · Infectious diseases · Social media · Epidemics · Health

1 Introduction

Infectious diseases are among the deadliest threats to human civilization because they have a very high mortality rate. Moreover, infectious diseases receive a lot of public attention as demonstrated by the recent coronavirus outbreak which has been reported intensely since January 2020. Infectious disease outbreaks may cause fear and panic among the public making it important to study these phenomena. Previous deadly outbreaks, such as the Black Death for instance, are known to have claimed the lives of between one-fourth and three-fourths of the world's population across Europe and Asia and, in Europe only, at least 25 million are estimated to have died from it [1]. The Zika virus (ZIKV) is a developing arthropod-borne virus (arbovirus) which was first isolated from a monkey from the Zika forest in Uganda in the late 1940s [2]. Zika sufferers may exhibit mild symptoms and experience a slight fever or rash, and joint, muscle, or eye pain. Zika is transmitted from the bite of specific mosquito species carrying the infection. Zika can also be transmitted through sexual intercourse, and perinatal transmission has also been reported [3]. There is no cure or anti-viral treatment for the Zika virus infection, neither is there a vaccine. The Zika virus can spread from the womb to the child in pregnant women and leads to birth defects such as microcephaly

[4]. Zika became a public concern in early 2016, when it first spread outside of Africa and Asia, where the virus had formerly been restricted. This geographical expansion led the World Health Organisation (WHO) to declare the outbreak a public health emergency of international concern (PHEIC) [2]. However, unlike previous infectious disease outbreaks, there appeared to be low public knowledge of the Zika outbreak in the United States, leading to the dissemination of health information such as mosquito-bite prevention notices and recommendations by public health authorities to avoid travelling to Zika-affected areas [4]. Moreover, misinformation on social media platforms has the potential to have adverse consequences if, for example, advice around prevention and transmission are inaccurate.

It is important to understand the types of content shared on Twitter because tweets are viewed widely across the Internet, and a substantive subset of the global human population use the platform on a daily basis [5, 6]. Twitter reports having 328 million monthly active users, with one billion unique monthly visits to sites embedded with tweets [5, 6]. Moreover, it is important to study the types of content shared on Twitter during infectious disease outbreaks because pandemic diseases are ranked as one of the most catastrophic risks facing human civilisation globally [7], and potential misunderstanding and misinformation could have major negative outcomes. Traditionally, printed media have been the main information source for people interested in general health information during a major pandemic. However, during the 2009 swine flu pandemic, it was reported that the Internet overtaken as the most common source of information [8].

Previous research on Twitter has examined correlations between poll data and tweets using sentiment analysis [9]. Twitter has also been utilised for the detection of earthquakes by drawing upon sentiment analysis by examining certain keywords [10]. Twitter was also found to be useful when the Arab Spring was occurring, which were a number of protests that took place in the Middle East and North Africa in 2010 [11]. Henceforth, there has been research conducted on Twitter from a range of disciplines which include health, sociology, business and management.

In the field of marketing, social media provide the ability to rapidly gain insights into how members of the public might response to the release of new products and/or services. There have been a number of 'software as a service' tools that have been created which provide organisations with the ability to monitor conversations that take place on Twitter. This demonstrates the potential of Twitter for social listening, as it is possible to gain insights very rapidly into consumer views, especially from a public health perspective.

Previous research has also examined Twitter across a range of health topics including dementia [12], antibiotics [13], marijuana [14], sexual risk behaviors [15], and vaccination sentiments (i.e., positive or negative views) [16]. There has been empirical research which has analysed Twitter content surrounding swine flu [17–19], and Ebola [20, 21]. However, there is a lack of in-depth qualitative analysis of how Twitter users responded during the Zika outbreak of 2016. This study aimed to address this gap in knowledge by conducting an in-depth thematic analysis of Twitter data relating to the peak of tweets during the 2016 outbreak of the Zika virus.

1.1 Research Aim

The overall research aim of this study was to develop an understanding of the content shared during the Zika outbreak from 2016 in order to develop recommendations for information dissemination during future potential outbreaks of Zika. More specifically, the research question to be addressed was as follows:

- What information were Twitter users sharing related to the Zika virus during a peaks in tweets from 2016?

In order to achieve this research aim, the study retrieved, filtered, and qualitatively analysed tweets on Zika from the peak of tweets from the 2016 outbreak. This is an important topic to study because infectious disease outbreaks are a serious public health threat and potential misinformation on social media platforms such as Twitter could lead to negative public health outcomes. Moreover, infectious disease outbreaks have major impacts on the luxury, lesiure and trade industries.

2 Methods

2.1 Selecting Data

Figure 1 below shows how there was sudden interest in Web Search queries in Zika from March 2015 to July 2016 (note the sudden increase in the Google Trends Score). The keyword ‘Zika’ was utilised in order to retrieve tweets and only English language tweets were studied.

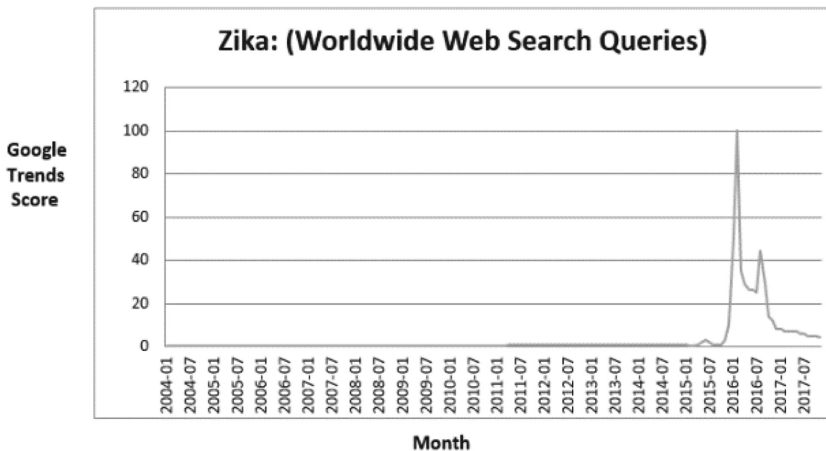


Fig. 1. Zika worldwide Web search queries

The data for tweets on Zika were retrieved using Twitter’s Gardenhose API, which is at least 10% of the entire Twitter stream. The BU-TCAT, a product of Boston University, was used to retrieve these tweets [22]. After retrieving data, a total of

749,131 tweets were retrieved from the 2-day period 31st of January to the 1st of February 2016. This falls within the time when there was heightened interest in Zika, as shown above in Fig. 1 above.

2.2 Filtering Data

The data that were retrieved on the Zika outbreak contained 749,131 tweets; however, when near duplicate clusters were removed, the dataset saw a large reduction of duplicate content. Data were filtered using DiscoverText [23, 24]. It appeared that there were a large number of news articles shared, as well as less personal views and opinions which were shared on the Zika outbreak. This aligns with research that has found that there was low knowledge of Zika in the United States [25]. This is summarised in Table 1 below. Exact duplicates included retweets.

Table 1. Research approach for filtering Zika data

Stage	Total
Pre-data cleaning	749,131
Removing Exact duplicates	76,943
Removing Near Duplicate at a 60% threshold	20,421
10% sample included for analysis	2,042

2.3 Data Analysis

Braun and Clarke's method of thematic analysis was utilized; this has 6-stages and was utilized in order to analyze tweets. Moreover, in order to reduce the size of the dataset, a series of data cleaning techniques were applied. Data were entered into NVivo, and each individual tweet was coded. Tweets could have been assigned multiple labels based on what was contained within the tweet. NVivo was selected because it is widely utilised in the social sciences and supports the coding process of thematic analysis outlined by Braun and Clarke [26]. The method of analyzing tweets in this manner using NVivo, as used in this study, was endorsed by QSR international, which is the organisation that founded and maintains the application, and this method was published on their website [27]. A single coder [WA] completed the coding and a number of reliability measures were applied as described in Sect. 2.4 below. When reliability measures were calculated the coder utilized pre-determined themes.

2.4 Reliability Measures

In this study, the coder (WA) who coded the initial data re-coded a subset of data after a period of time had elapsed (three-months) in order to assess test-retest reliability. The percentage agreement was 99.37%. An independent coder also coded a subset of tweets (300) and the inter-coder reliability percentage agreement was 99.24% ($\kappa = 0.56$), which was a moderate level potentially due to the qualitative nature of the study.

3 Results and Discussion

3.1 Results of Tweet Categorization

Table 2 provides the results of the tweet categorization.

Table 2. Overview of themes and sub-themes

Theme (N/%)	Sub-themes (N)
1. Pregnancy (164/8.36%)	1.1 Avoid Pregnancy Narrative (12/0.61%) 1.2 Zika Threat to Pregnant Women (19/0.96%) 1.3 Zika Virus Spreads Fear Among Pregnant Brazilians (22/1.12%) 1.4 Zika Threat to Pregnant Columbians (29/1.47%) 1.5 Abortion Debate (47/2.39%) 1.6 Pregnancy (35/1.78%)
2. Travel and the Olympics (75/3.82%)	2.1 Fear (19/0.96%) 2.2 Olympics Rio 2016 (56/2.85%)
3. Mosquitoes and Conspiracy (259/13.21%)	3.1 Zika Conspiracy (61/3.11%) 3.2 GM Mosquitoes (65/3.31%) 3.3 Mosquitoes (133/6.78%)
4. Health Organisations (365/18.62%)	4.1 Critical of WHO (7/0.35%) 4.2 WHO Related News (358/18.26%)
5. Health Information (160/8.16%)	5.1 Zika Origin (8/0.40%) 5.2 Zika Symptoms (10/0.51%) 5.3 Transmission (19/0.96%) 5.4 Prevention (34/1.73%) 5.6 Zika Vaccine (37/1.88%) 5.7 Microcephaly (52/2.65%)
6. Travel and Tracking (321/16.37%)	6.1 Zika Travel Advice (29/1.47%) 6.2 Zika Spreading Explosively in South and Central America (14/0.71%) 6.3 Zika will Spread Across the Americas (17/0.86%) 6.4 Mentions Brazil and Zika Virus (19/0.96%) 6.5 Geographical Tracking (21/1.07%) 6.6 Geographical Transmission (116/5.91%) 6.7 Travel (45/2.29%)
7. General Discussions (646/32.95%)	7.1 Zika found in Ugandan Forest (15/0.76%) 7.2 Zika and Climate Change or Global Warming (18/0.91%) 7.3 Broadcast Advert (21/1.07%) 7.4 Information Seeking (26/1.32%) 7.5 Politics (26/1.32%) 7.6 Humour and Sarcasm (77/3.92%) 7.7 Name Discussion (124/6.32%) 7.8 Zika Information (General) (363/18.52%)

Overall, tweets contained much more content from news articles shared on Zika than personal views. There were a number of varied discussions taking place around the Zika epidemic based on seven key discussions around pregnancy (164/8.36%), travel and the Olympics (120/6.12%), mosquitoes and conspiracy (259/13.21%), health organisations (365/18.62%), health information (160/8.16%), travel and tracking (246/12.55%), and general discussions around Zika (646/32.95%). There was discussion surrounding pregnancy because of Zika's known association with microcephaly, which causes complications in children during birth (Mlakar, Korva, Tul, Popović, *et al.*, 2016). For women and couples in Zika-affected areas, it was recommended that pregnancy be avoided. However, Twitter users highlighted the controversial nature of this recommendation in countries where access to contraception can be difficult. Moreover, some users also highlighted the difficulties of requesting an abortion on medical grounds because of tough laws on abortion in some parts of Latin America.

Moreover, general news articles shared on Twitter highlighted similar debates around pregnancy:

'The Zika Virus has sparked a debate around abortion and it is not the first disease to do so [URL]' (1.1)

The tweet (1.1) above was linked to an article that specifies how the mainstream media were aware the Zika outbreak had initiated a debate around abortion, partly because, in certain areas where Zika had spread, laws exist which prohibit abortion [28]. This specific tweet also alludes to previous diseases that have led to similar abortion debates, and it is possible to draw parallels with earlier infectious disease outbreaks. In the 1960s, there were laws that prohibited abortion in the United States and, during this time, there was an outbreak of Rubella, which has the potential to cause complications in foetuses [29]. The debate in the context of Zika centred on whether abortion should be decriminalized in areas such as El Salvador in Central America, where illegal abortions are common place [30, 31]. A number of Twitter users also referred to the practicalities of requesting women to avoid becoming pregnant:

'In Zika affected areas women are being told to not get pregnant, yet, they have no access to contraception' (1.2)

'Wonder if people realise that the narrative of not getting pregnant actually needs rights and resources' (1.3)

'Hopefully not, but if Zika ever gets to Nigeria I wonder if we are going to legalise abortion for affected women?' (1.4)

The series of tweets above highlight some of the debates that were taking place around abortion. In tweet 1.2, the user highlights the controversy of advice to avoid pregnancy when contraception is not readily accessible, which is often the case in the low-income countries affected by Zika [32]. Twitter users, such as the author of Tweet 1.3, suggested that avoiding pregnancy requires certain women's rights, specifically the right to abortion. Tweet 1.4 questioned whether Nigeria, which has strict anti-abortion laws, would legalize abortion [32].

In the context of Zika, it is probable that the perception of benefits would outweigh barriers if travelling was non-essential because of the threat that Zika posed for pregnant women. This argument is further reinforced by the decision of airline companies to offer travel refunds and credits to women travelling in these areas.

Additionally, Twitter users referred to mosquitoes within their tweets, both generally and specifically. These included sharing conspiracy theories that genetically-modified mosquitoes were responsible for the Zika outbreak, and that Zika had been manufactured.

A number of Twitter users shared and discussed conspiracy theories focused around the Zika outbreak:

'Zika – it's a hoax and the cover up related to it continues' (1.5)

'Bill Gates created the Zika virus [URL]' (1.6)

'I wonder who really started the Zika virus' (1.7)

'Why would you invent a virus and not have the antidote?' (1.8)

As the tweets above demonstrate, the Zika outbreak led Twitter users to share and discuss a number of varied conspiracy theories. Some theories purported that Zika had been intentionally spread (as illustrated in tweet 1.5). Other conspiracy theorists suggested that certain prominent figures had intentionally manufactured the Zika virus (as illustrated in tweet 1.6). Tweet illustration 1.6 could also indicate humour because Bill Gates is known for the development of computer software and 'virus' is also a term utilized in the computing industry.

Some Twitter users were also critical towards the WHO, or shared news originating from the WHO during this time period. The WHO may thus be interested to find that they were considered an authoritative information source during the outbreak period. The health information that was shared included information on the transmission of Zika and vaccines. Health authorities could utilise this information to disseminate information around the transmission of Zika and potential vaccines for the virus. When reflecting on the number of general themes, there was a sense that the Zika virus was out of control: news articles would note that the virus was spreading 'explosively' in South and Central America and the Americas. Twitter users expressed an interest in geographically tracking the incidence of Zika. The information derived from tracking Zika could have allowed users to assess their perceived susceptibility of the virus i.e., because their closer proximity may lead to higher potential susceptibility.

A number of Twitter users were concerned about travelling during the Zika outbreak, which coincided with the Olympic Games taking place in Rio de Janeiro:

'Olympic games- because of Zika virus will cancel my trip' (1.9)

'64% of respondents from the USA noted that they will cancel travel to Zika-affected areas' (1.10)

These tweets highlight how the Zika outbreak caused concern to those who were planning to attend the Olympic Games. There were also a number of references to travel credits and refunds for those visiting Zika affected areas:

'Are you worried about Zika and travelling? Some airlines offering refunds [URL]' (1.11)

'Cruise liners are going to waive cancellation fees because of Zika' (1.12)

Citizens who were set to travel to Zika affected areas may have been concerned to do so, because of the dangers associated with the disease. This may be particularly applicable to citizens who may have had a higher perceived risk severity of being infected by the Zika virus, such as pregnant women and couples seeking to start a family.

3.2 Evidence of Themes Across the Outbreak

One of the questions that can be asked of the study is whether the themes identified in the 2-day period are applicable, i.e. scalable to other activity on Twitter. It was not feasible to obtain the complete data on the Zika, outbreak because of the high cost of obtaining historical Twitter data and managing it. However, one method that can be used to search all of Twitter is Twitter's advance search feature. In this study, Twitter's advance search feature was utilized in order to find tweets from across the pandemic, during which Google Trends showed there to be an increased interest in web search queries for the Zika outbreak (from Jan to July 2015). The selection criteria were that the themes that had not been reported in previous literature (i.e., they were specific to this study) and which could be identified by keywords. The themes were selected because they were not specific to the 2-day time period, were not reported in previous literature, and they were searchable by using keywords. Table 3 below maps certain themes to the months from January to July in 2016 and demonstrates how discussion of Zika's name, information seeking and the Olympics occurred throughout the whole of the outbreak period.

Table 3. Finding themes across the outbreak

Themes	Year 2016						
	Jan	Feb	March	April	May	June	July
Name Discussion	x	x	x	x	x	x	x
Information Seeking	x	x	x	x	x	x	x
Olympics Rio 2016	x	x	x	x	x	x	x

3.3 Contribution to Knowledge

Previous research on Zika [33] has found there to exist five key themes: the impact the outbreak was having on society, responses to Zika such as from the general public, government and private sector, pregnancy and microcephaly, the transmission of Zika, and a theme with case reports of Zika. Other research [34] found that people were interested in tracking the Zika virus because it could spread across the world. They also found that tweets frequently mentioned pregnancy and abortion. However, the following themes appear to have not been reported in previous literature:

- Name Discussion
- Information Seeking
- Humour and Sarcasm
- Olympics Rio 2016

Additional themes may have arisen in this present study because of a different method of analysis was utilized, thematic analysis.

3.4 Recommendations

Health authorities may wish to actively monitor Twitter in order to rapidly identify areas in which the public require more information and clarifications on. This information can then be disseminated through social media and/or more traditional means. In the specific case of another Zika virus outbreak, health authorities may wish to focus on providing information highlighting at risk groups, symptoms transmission, prevention, vaccines, and whether it is safe to travel to at risk geographical zones. Health authorities were singled out and criticized for being perceived to be inactive during the outbreak. For future outbreaks, health authorities could disseminate information on the work they have been doing around Zika on Twitter. Furthermore, health authorities can monitor social media Zika for conspiracy theories and disseminate guidance and advice on their legitimacy. For discussions around conspiracy theories, our findings may be of interest to public health organizations that could use this information to monitor further cases of Zika, for these specific conspiracy theories and disseminate guidance and advice on their legitimacy.

3.5 Limitations and Future Work

The data selected was tweeted over a two-day period, and therefore some of the themes that emerged could be specific to this time period. However, Sect. 3.3 identified examples of tweets from across the outbreak of Zika that correspond to the identified themes. Moreover, if different time intervals were examined, it is possible that different themes and sub-themes would emerge. A further limitation is that only English language tweets were examined. This preliminary study has provided insights into the discussions taking place on Twitter during an infectious disease outbreak. Our previous work has analysed data on Ebola [35] reflected on ethical issues for researching social media [36] identified popular health communities on Twitter [37], researched viral health hashtags [38] and explored sociological aspects of infectious disease outbreaks [39]. Future research will seek to consolidate previous research to develop a framework for researching social media for healthcare researchers and organisations. Moreover, a current study is underway which is capturing data on coronavirus which has the potential to be compared to this study [40]. Researchers could also analyse Zika-related content on other social media platforms and/or analyse data on Zika at future time points and compare the results to this study.

4 Conclusions

Overall, it was found that there were many news articles shared on Twitter during this time period, which formed a number of themes. The discussions attracting personal opinions and views centered on conspiracy theories and debates around abortion laws and ethics. It appears that infectious disease outbreaks may lead to a variety of responses from Twitter users which can be general in nature but which can also be

specific to the type of disease being discussed. In this study we observed specific discussions directly related to Zika. We also note that, in certain instances, social media may intensify public fears due to the sharing of conspiracy theories and false news.

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