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Zika pandemic online trends, incidence and health risk communication: a time trend study

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ABSTRACT

Objectives We aimed to describe the online search trends of Zika and examine their association with Zika incidence, assess the content of Zika-related press releases issued by leading health authorities and examine the association between online trends and press release timing.

Design Using Google Trends, the 1 May 2015 to 30 May 2016 online trends of Zika and associated search terms were studied globally and in the five countries with the highest numbers of suspected cases. Correlations were then examined between online trends and Zika incidence in these countries. All Zika-related press releases issued by WHO/Pan America Health Organization (PAHO) and Centers for Disease Control and Prevention (CDC) during the study period were assessed for transparency, uncertainty and audience segmentation. Witte's Extended Parallel Process Model was applied to assess self-efficacy, response efficacy, susceptibility and severity. AutoRegressive Integrated Moving Average with an eXogenous predictor variable (ARIMAX) (p,d,q) regression modelling was used to quantify the association between online trends and the timing of press releases.

Results Globally, Zika online search trends were low until the beginning of 2016, when interest rose steeply. Strong correlations (r=0.748–0.922; p<0.001) were observed between online trends and the number of suspected Zika cases in four of the five countries studied. Compared with press releases issued by WHO/PAHO, CDC press releases were significantly more likely to provide contact details and links to other resources, include figures/graphs, be risk-advisory in nature and be more readable and briefer. ARIMAX modelling results indicate that online trends preceded by 1 week press releases by WHO (stationary-R^2=0.345; p<0.001) and CDC (stationary-R^2=0.318; p=0.014).

Conclusions These results suggest that online trends can aid in pandemic surveillance. Identification of shortcomings in the content and timing of Zika press releases can help guide health communication efforts in the current pandemic and future public health emergencies.

Key questions

What is already known about this topic?

- The 2015–2016 Zika pandemic was an outbreak that aroused global public concern and media attention.
- It was previously shown that online search trends can be used for communicable diseases surveillance and that health communication is critical during outbreaks.
- There is however scarcity of published research on the risk communication aspects of the Zika pandemic.

What are the new findings?

- This time trend study reports strong correlations between online trends and Zika incidence.
- This suggests that online trends can aid in surveillance during Zika and other pandemics.
- Shortcomings in the content and timing of Zika press releases were identified.

Recommendations for policy

- Gaps identified in Zika pandemic press-releases and their reactive pattern with online trends can direct better communication efforts globally in order to better tackle Zika and future public health emergencies. This study also suggests that the monitoring of online trends can be used to complement traditional surveillance efforts.

BACKGROUND

The 2015–2016 Zika pandemic was declared a Public Health Emergency of International Concern (PHEIC) by WHO on 1 February 2016.[1] The declaration was a major communication event that attracted wide coverage and attention in the global media as this was only the fourth time a PHEIC has been declared by WHO under the International Health Regulations (IHR) 2005.[2] The declaration also came at a time when the Ebola virus outbreak in Africa was coming under control after a perceived delayed response from WHO[3] and the international community, and the 2016 Olympic games were scheduled to be played in Brazil.[4 5]

On 18 November 2016, WHO declared an end to the PHEIC. The statement communicating this decision by the Emergency Committee on Zika and Microcephaly stated

that disease must be addressed as a long-term problem which required a 'longer-term technical mechanism'.[6] This declared end of the PHEIC was met with criticism by some stakeholders who feared the crisis is not yet over and this declaration may lead to a pullback in commitment and efforts to develop disease controlmethods by government and donors.[7]

As of 30 November 2016, 75 countries and territories have reported evidence of vectorborne Zika virus transmission since 2007—with 69 of these countries and territories reporting first-time transmission since 2015.[8] About one-third of these countries have also reported increased incidence of Microcephaly and Guillain-Barré syndrome, seemingly related with the Zika virus infection.[8] Over 173 000 Zika cases and 15 Zika-related deaths have been confirmed in the Pan America Health Organization (PAHO) region, from among 518 290 suspected cases.[9] With the recent spread of the disease to Asia, >2 billion more people have been put at risk.[10]

Zika virus, a Flavivirus transmitted by the *Aedes* mosquitos,[11 12] was first identified in rhesus monkeys in Uganda in 1947 and human infection was first reported in 1952 in Uganda.[13] The clinical symptoms of the disease are usually mild with very few deaths occurring as a direct result of the disease.[11 12] There are, however, serious concerns regarding the association of the disease with congenital malformations (Zika Virus Congenital Syndrome) and neurological disorders such as Guillain-Barré syndrome[8 11 14]

Risk research scholars have noted the challenge posed by risk uncertainty, such as the uncertainty regarding risk management and assessment that may occur during an outbreak situation.[15 16] The risk uncertainty in the Zika outbreak is evident in the debate about the 2016 Brazil Olympics.[17 18] The risk uncertainty is also evident in the unprecedented health policies and recommendations on reproductive health by affected countries. An example of which is the advice by the government of El Salvador (January 2016) for women to avoid getting pregnant during the coming two years.[19]

Health risk communication can be said to deal with the planned and unplanned communication to the public about the nature, impact and management of health threats.[20] Under the IHR (2005), WHO member nations are obliged to notify the WHO about qualifying health events within 24 hours.[21] The IHR framework was established to promote the dissemination of authoritative information which is of particular importance in outbreak circumstances when field conditions are often fluid, and timely and appropriate risk communication can save lives and allay public anxiety.[22–24]

Timely and effective communication with the public during an emerging infectious disease (EID) outbreak is critical not only for the rapid control of the outbreak but also for reducing the social, political and economic turbulence that often attend such events. The success of communication efforts by health authorities during an outbreak to mitigate adverse outcomes is contingent on various factors. WHO recommends five elements, referred to as the 'TOTAL' criteria,[25] as key for the success (or failure) of outbreak communication: Trust-building, Operational (and advanced) planning, Transparency, Announcing early and Listening. The risk communication approach indicates that during an EID outbreak public engagement is imperative and stresses the importance of building trust under the unique prevailing conditions.[26] The ability of the target audience to understand the information conveyed in outbreak communication material (such as press releases) is necessarily another important factor to consider, particularly when health literacy levels are low.

The internet has become a major source of health information for people worldwide and is a global platform for outbreak and health risk communication. Online trends (ie, the distribution of online behaviour and interactions) have been shown to be an important health surveillance tool for the detection and real-time monitoring of outbreaks.[27–29] For example, Google Flu Trends (an online tool based on searches for influenza-related topics) detected influenza outbreaks in the USA 7–10 days before conventional surveillance systems.[30] Online trends are also useful to assess shifts in public practice or opinion and the effects of policy.[3 31 32]

The current Zika pandemic is an emerging global health crisis with high levels of risk uncertainty. The online trends of this pandemic and their association with incidence are unknown. There is also no information about the impact, if any, of press releases issued by leading health authorities on these online trends, or conversely, if these trends have any influence on the timing of the press releases.

Study aim and objectives

With a goal to assess and improve digital and non-digital health communication during pandemics, the objectives of the present study were (1) to describe the online search trends of Zika virus between 1 May 2015 and 30 May 2016 globally, in the USA and in the five countries with the highest number of suspected cases; (2) to examine the association between Zika virus online search trends and the number of suspected Zika cases in the selected countries; (3) to assess and compare the content of Zika-related press releases issued by WHO/PAHO and Centers for Disease Control and Prevention (CDC); and (4) to examine the association between the timing of the press releases of WHO and CDC with the Zika-related online search volume globally and in the USA.

METHODS

Study design and time frame

This time trend study used quantitative methods to explore associations between online trends, suspected cases of Zika and the timing, content and strategy of press releases between 1 May 2015 and 31 May 2016 globally and in selected countries in the PAHO region. This

translated to a study period between epidemiological week 17, 2015, through epidemiological week 22, 2016. We selected epi-week 17 as the starting point of the study to encompass the first report of locally acquired Zika disease in the Americas (by Brazil) on 7 May 2015 which is regarded as the start of the pandemic.[33] We did not have access to incidence data by countries beyond 31 May 2016.

Zika cases data

We downloaded data from the PAHO website on reported suspected Zika cases in PAHO-region countries (on 26 July 2016).[34] These data were collated by PAHO from IHR National Focal Points reports to the WHO IHR Regional Contact Point for the Americas, and through Ministry of Health websites of the PAHO member nations. The data are available according to epi-weeks. Some countries do not monitor or report suspected cases. Guatemala, for example, reported 1415 laboratory-confirmed cases in the study period, but did not report the number of suspected cases. Using this database, we identified the five countries with the highest number of suspected cases in the study period—Brazil, Colombia, Honduras, Martinique and El-Salvador, and account for nearly 90% of suspected cases in the study period. These countries were selected for comparison of their Zika-related search terms obtained from Google Trends. Google Trends is able to compare a maximum of five countries simultaneously. Using the reported suspected Zika cases, the incidence of suspected cases was calculated using the 2015 population estimates of the reporting countries. Population data for all countries, apart from those of Saint Martin, Saint Barthelemy and Bonaire, were obtained from the PAHO Health Indicators database.[35] The 2015 populations of Saint Martin and Saint Barthelemy were obtained from the Central Intelligence Agency (CIA) World Fact Book,[36] and the denominator for Bonaire is based on the 2013 estimate of the Dutch Central Bureau of Statistics.[37]

Google Trends

Google Trends data were used as the measure of online search trends in this study and were accessed in conformity with suggested guidelines.[38] Google Trends is a free online tool that can be used to study search data obtained from google.com—the most widely used search portal in the world.[39] Search data for a given query are expressed as the relative search volume (RSV)—the frequency a particular search term is 'googled' relative to the total search volume. The RSV for a particular query (e.g., Zika virus) is obtained from a sample of all Google searches performed in a specified location and time and expressed as a normalised number reflecting the relative popularity of the query term compared with all other searches performed in that location and time. The peak popularity of a query is expressed as RSV=100, where 50 implies the term is half as popular as the peak popularity, and 0 means the query was <1% as popular as the peak.[38 40]

On 18 June 2016, we queried 'all categories', 'web search' search data using the 'Topic' feature for [Zika virus (Organism classification)] and the following four associated search topics: ['Microcephaly (Medical condition)", 'Dengue fever (Disease)", 'Chikungunya (Disease cause)", and '*Aedes* (Insect)"]. These associated search terms were purposively chosen from the list of breakout topics and terms associated with Zika search globally. The 'Topic search' feature was preferred to using the 'search term' method because this new feature produces search results for groups of terms that are conceptually similar in all languages. The Topic feature was accessed by typing the search term in the search box and 'Topic' was selected. For example, Zika was typed into the search box following which the topic search term ['Zika Virus (Organism classification)"] was selected. These steps were repeated for the associated search topics sequentially in the available five comparative search boxes on the portal. For these search terms, global data as well as data for the USA and the five countries with the highest number of suspected Zika cases in the study period were downloaded. Our search period was set as 26 April 2015 to 4 June 2016, so as to align the search parameters with CDC epi-weeks for the above-defined study period of 1 May 2015 to 31 May 2016.

Press releases

We identified Zika-related press releases published by WHO/PAHO (n=28; 11 from WHO and 17 from PAHO) and CDC (n=27) on their respective websites, during the study period of 1 May 2015 to 31 May 2016. One press release of WHO was duplicated on PAHO's website and thus was included only once to give a total of 27 releases analysed. One PAHO press release was in Spanish and hence excluded from the Flesch-Kincaid analysis (see below) with all other analysis measures carried out on a translated-back-translated version. We initially identified also press releases published by the Ministry of Health Brazil (MHB) (n=45) but found that it was not feasible to properly analyse these Portuguese-language press releases. With the TOTAL[23] criteria in mind, we developed a protocol to guide the press release coding. The protocol was pretested and revised accordingly to ensure precise operational definitions of the variables. Training and quality assurance sessions were held for the coders after which 5% of the releases from one of the agencies were independently coded by authors HL, YN and GA. Results were compared and discussed to address areas of disagreement following which all releases were coded by GA.

The press releases were analysed for content and strategy. Content constructs included transparency (title, details of outbreak, consultation with stakeholders, signature, contact details and links to other resources), uncertainty (expression of any uncertainty), segmentation (targeting of information to different people groups)[26 41] and if the press release title stated that the release was advisory in nature. Strategy of the release was

assessed using Witte's Extended Parallel Process Model (EPPM) constructs of self-efficacy, response-efficacy, susceptibility and severity.[42] The EPPM is a sophisticated framework for examining the effectiveness of fear appeal messages and predicts how people will react when confronted with fear-inducing stimuli or information.[43] The model comprises four constructs which can be grouped into two efficacy constructs (self-efficacy and response-efficacy), and two threat constructs (susceptibility and severity). According to the EPPM, a positive self-protective response or behaviour can be expected when perceptions of a threat in a message are strong and perceived levels of efficacy are high; when perceptions of a threat are strong but perceived levels of efficacy are low, the model predicts denial or rejection of protection behaviours. All parameters were scored on a dichotomous scale—present or absent.

To provide further insight and information on the press releases, the following measures of analysis were also conducted: Flesch-Kincaid[44] grade level and reading-ease tests (continuous scale), word count (continuous scale) and presence/absence of figures or graphs. The Flesch-Kincaid is a commonly used measure to assess the degree of difficulty/ease to understand a given English-language passage or document.[44]

Statistical analysis

The correlation between Zika RSVs (in epi-weeks) and number of reported suspected cases was examined using the non-parametric Spearman's rank correlation test. Correlation was assessed from the epi-week during which the first suspected Zika case was reported. Flesch-Kincaid grade level and reading-ease tests of the press releases were assessed using Microsoft Word 2007 readability statistics. We conducted χ^2 tests for independency to check for differences between WHO/PAHO and CDC press releases. Time-series regression models were developed using non-seasonal AutoRegressive Integrated Moving Average with an eXogenous predictor variable (ARIMAX (p,d,q)) to examine the behaviour of RSVs over time globally in the USA and in Brazil and to test if press releases by WHO, CDC and the MHB can explain this behaviour, respectively. These 'independent variables' were treated as 'events' in the model, in which a value of 1 indicated that one or more press releases were issued in that week, and a value of 0 indicated otherwise. An ARIMAX model is used to check and predict the dependence of values in a time series with equal periods using the past values observed in the series.[45] Statistical significance was set at 0.05. The software used for analysis was SPSS V.20.

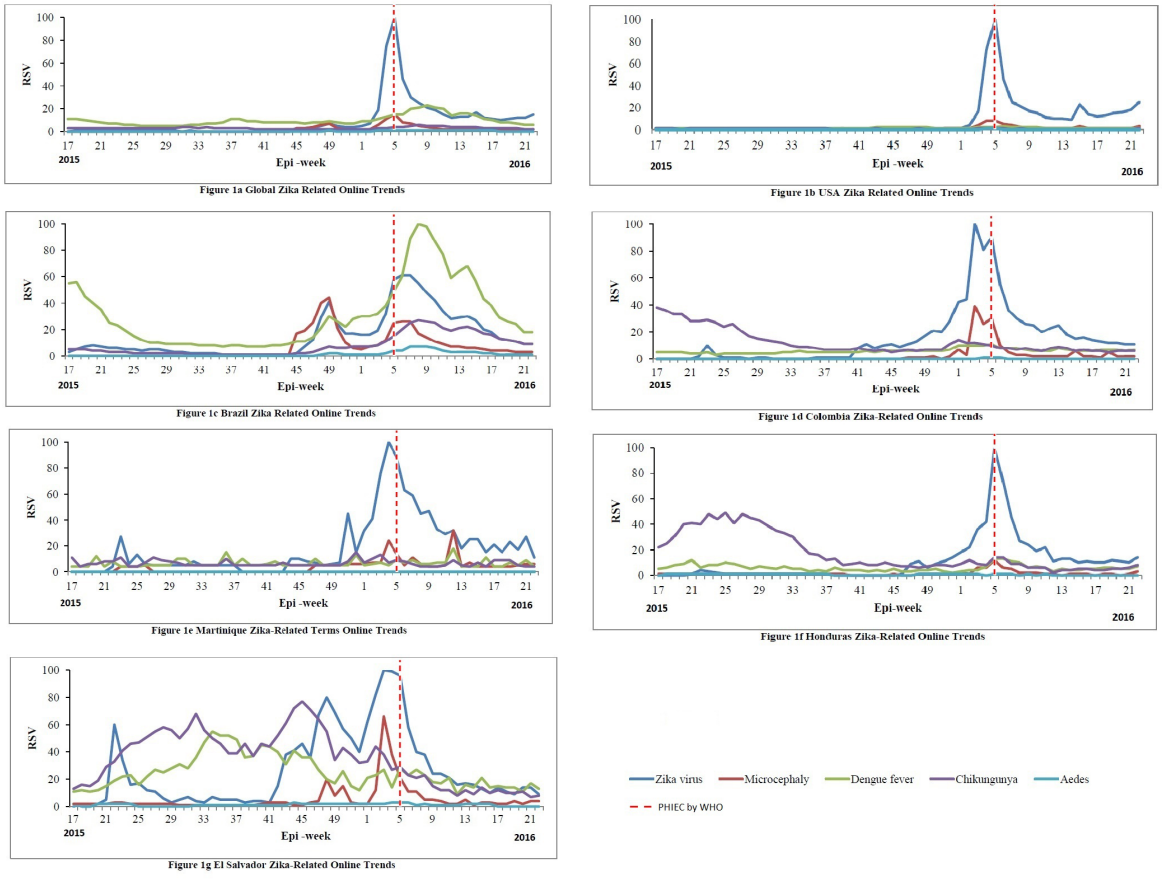

Figure 1 Zika-related online trends globally (1a), in USA (1b), Brazil (1c), Colombia (1d), Martinique (1e), Honduras (1f) and Elsavador (1g) —epi-week 17, 2015, to epi-week 22, 2016. RSV, relative search volume.

RESULTS

Online trends

Globally, there was little public interest (as measured by RSV) in Zika until epi-week 1, 2016, when interest rose steeply to peak in epi-week 5, 2016 (figure 1A). Trends in interest in microcephaly tracks with Zika interest, although on a much lower level. Looking at the overall study period, the average interest in Zika (average RSV=9) was slightly lower than dengue (average RSV=10). There was little to no interest in *Aedes*. The Zika trend observed in the USA (figure 1B) is similar to the global trend. There was, however, no observable interest in dengue, chikungunya or *Aedes*.

Two Zika search peaks were observed in Brazil throughout the entire study period—epi-week 49, 2015, and epi-weeks 5–7, 2016 (figure 1C). These tracked closely with interest in Microcephaly. Overall interest in Zika (average RSV=15), however, lagged behind interest in dengue (average RSV=31).

In Colombia, there was a brief period of interest in Zika in epi-weeks 22–24, 2015, and again in epi-week 41, 2015, and peaked in epi-week 3, 2016 (figure 1D). As noted for Brazil, interest in Microcephaly tracked closely with interest in Zika. Interest in chikungunya waned progressively from epi-weeks 17–37, 2015, and then flat-lined from thereon to a baseline of about RSV=10. As observed in all other countries, there was little or no interest in *Aedes*.

Online search trends in Martinique revealed overwhelming online interest in Zika compared with the associated terms (figure 1E). This interest peaked at epi-week 4, 2016.

The online search trends in Honduras showed little interest in Zika before epi-week 46, 2015, after which it steadily rose to peak in epi-week 5, 2016 (figure 1F). There was a period of sustained interest in chikungunya between epi-week 17, 2015, and epi-week 37, 2015.

In El Salvador (figure 1E), online search trends revealed greater interest for chikungunya (average RSV=32) than for Zika (average RSV=24) and dengue (average RSV=22). As with all other countries reviewed, interest in Microcephaly tracks closely with interest in Zika though at a much lower level.

WHO's PHEIC declaration in epi-week 5, 2015, coincided precisely with the peak interest levels globally, in the USA and in Honduras, and quite closely also in Brazil and the other countries.

Suspected Zika cases and online trends

With 159 939 cases (table 1), Brazil reported the highest number of suspected Zika cases in the PAHO region, with Colombia a distant second with 83 967 cases. Martinique, on the other hand, has the highest suspected cases incidence (7125.6/100 000) followed by French Guyana (2877.9/100 000).

As seen in figure 2A-E strong correlation was noted between online trends and numbers of suspected cases in Brazil, Colombia, Honduras and El Salvador (r=0.748 to 0.922; p<0.001), but not Martinique.

Press releases analysis

Summary results of the press releases analysis are presented in table 2. Compared with the WHO/PAHO, CDC press releases were more likely to contain the following constructs: presence of contact details, links to other resources, use of figures/graphs and be of a risk-advisory nature (p<0.05). The Flesch-Kincaid grade-level scores of the health authorities were high with a mean grade-level score of 17.1 years for WHO/PAHO press releases and 12.4 years for CDC press releases. Overall, CDC press releases had significantly lower word counts compared with WHO/PAHO. Press releases issued by WHO/PAHO were more likely to be signed (p<0.05).

Press releases association with online trends

The timing of the press releases by WHO (figure 3A) and CDC (figure 3B) by epi-week revealed that nearly all were issued in 2016.

The time-trend data were best described by an ARIMAX model (0,1,1)—autoregression component=0, integration=1 and moving-average=1. The model parameters and estimates are shown in table 3. The predicted best-fit models suggest that the online search trends of the previous week predict the timing of press releases by WHO (stationary-R^2=0.345; p<0.001) and CDC (stationary-R^2=0.318; p=0.014 but not by MHB (stationary-R^2=0.182; p=0.003).

DISCUSSION

Globally, there was little online interest in Zika, as measured by online search trends, until the beginning of 2016, when interest rose steeply. Expectedly, given the diverse profiles and conditions in different country populations, some cross-country variation is noted in the online trends in this pandemic situation. We found strong correlation between online trend RSVs and the number of suspected Zika cases in four of the five most affected countries. Furthermore, the results of the regression modelling indicate that the issuance of Zika-related press releases by WHO and CDC could be predicted by an increase in online search volume in the week prior to the publication of the press release.

WHO declared Zika as a PHEIC in epi-week 5, 2016. This declaration is a rare and major communication event which attracted widespread coverage in the world media.[2] From the coincidence of the timing of the PHEIC declaration and the peak in online interest globally, in the USA and in other countries (figure 3), one may conclude that the Public Health Emergency was declared in response to the steep increase in public interest and discussion about Zika in the preceding weeks. The abrupt drop in interest that immediately followed the declaration may suggest that the statement issued by WHO Director-General Dr Chan, while announcing a global emergency, had the effect of assuaging the public's anxiety about Zika. The declaration may possibly have sent a message to the public that WHO has assumed responsibility and will

Table 1 Suspected Zika autochthonous (ie, locally vector transmitted) cases in the Pan America Health Organization (PAHO) region between epidemiological week 17, 2015, and week 22, 2016 (ordered by number of suspected cases)

	Country/territory	Suspected Zika cases*	Confirmed Zika cases*	2015 population†	Incidence of suspected Zika cases/100 000
1.	Brazil	159 939	40 086	203 657 000	78.53
2.	Colombia	83 967	8078	49 529 000	169.53
3.	Martinique	28 930	12	406 000	7125.62
4.	Honduras	22 715	44	8 424 000	269.65
5.	El Salvador	10 476	46	6 426 000	163.03
6.	Guadalupe	10 190	379	470 000	2168.09
7.	Puerto Rico	9657	1352	3 680 000	262.42
8.	French Guyana	7540	483	262 000	2877.86
9.	Dominican Republic	3313	73	10 652 000	31.10
10.	Suriname	2512	697	548 000	458.39
11.	Haiti	2069	5	10 604 000	19.51
12.	Jamaica	1619	24	2 813 000	57.55
13.	Panama	1022	283	3 988 000	25.63
14.	Barbados	770	18	291 000	264.60
15.	Saint Martin	690	180	31 754	2172.95
16.	Costa Rica	519	107	5 002 000	10.38
17.	Dominica	437	47	74 000	590.54
18.	United States Virgin Islands	276	24	104 000	265.38
19.	Paraguay	275	8	7 033 000	3.91
20.	Argentina	68	20	42 155 000	0.16
21.	Saint Barthelemy	52	14	7237	718.53
22.	Saint Lucia	24	4	164 000	14.63
23.	Anguilla	0	0	16 000	NA
24.	Aruba	0	17	112 000	NA
25.	Belize	0	2	348 000	NA
26.	Bolivia	0	124	11 025 000	NA
27.	Bonaire	0	3	17 408	NA
28.	Cuba	0	1	11 249 000	NA
29.	Curacao	0	73	148 000	NA
30.	Ecuador	0	244	16 226 000	NA
31.	Granada	0	2	111 000	NA
32.	Guatemala	0	1415	16 255 000	NA
33.	Guyana	0	6	808 000	NA
34.	Mexico	0	357	125 236 000	NA
35.	Nicaragua	0	241	6 257 000	NA
36.	Peru	0	78	31 161 000	NA
37.	Saint Vincent and the Grenadines	0	8	103 000	NA
38.	Sint Maarten	0	7	41 000	NA
39.	Trinidad and Tobago	0	16	1 347 000	NA
40.	Venezuela	0	0	31 293 000	NA
41.	Antigua and Barbuda	NA	NA	92 000	NA
42.	Bahamas	NA	NA	388 000	NA

Continued

Table 1 Continued

	Country/territory	Suspected Zika cases*	Confirmed Zika cases*	2015 population†	Incidence of suspected Zika cases/100 000
43.	Bermuda	NA	NA	70 000	NA
44.	British Virgin Islands	NA	NA	33 000	NA
45.	Caiman Islands	NA	NA	56 000	NA
46.	Canada	NA	NA	35 871 000	NA
47.	Chile	NA	NA	17 924 000	NA
48.	Montserrat	NA	NA	5000	NA
49.	Saint Kitts & Nevis	NA	NA	52 000	NA
50.	Turks and Caicos Islands	NA	NA	50 000	NA
51.	USA	NA	NA	325 128 000	NA
52.	Uruguay	NA	NA	3 430 000	NA

*Suspected and confirmed cases from PAHO.[9]
†2015 population figures for all countries apart from those of Saint Martin,Saint Barthelemy and Bonaire were obtained from the PAHO Health Indicators database, 2009. http://www.paho.org.[35] The 2015 population of Saint Martin and Saint Barthelemy were obtained from the Central Intelligence Agency World Fact Book.[36] Population of Bonaire is based on 2013 estimate of the Dutch Central Bureau of Statistics.[37]

mobilise the necessary resources to combat the spread of the virus.

Our results also demonstrate that the interest in Microcephaly globally and in all the countries we examined closely mirrored the interest in Zika, although at a much lower level. There was no interest in Microcephaly until epi-week 45, 2015, in any of the countries studied or globally, apart from Martinique, which showed brief interest in Microcephaly already in epi-weeks 22–27, 2015. The upturn in interest in Microcephaly in Brazil coincided with the declaration by the MHB on 11 November 2015 (epi-week 45, 2015) of a national public health emergency due to an increase in suspected Microcephaly cases.[13] This surge peaked 4 weeks later in epi-week 4, 2016. As observed in the online trends following WHO's PHEIC declaration, this too suggests that press releases

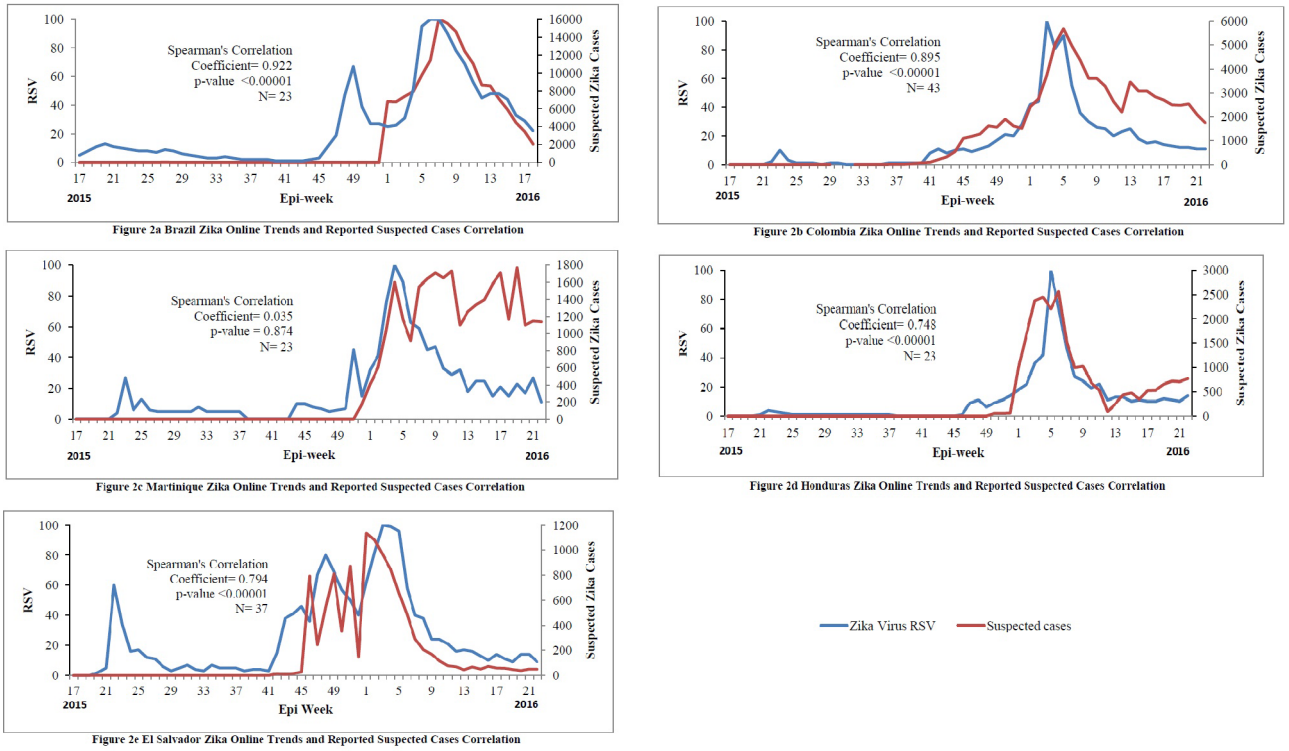

Figure 2 Correlation between Zika online trends and reported suspected cases in top five countries with highest number of suspected Zika cases. RSV, relative search volume.

Table 2 Comparison between WHO/Pan America Health Organization (PAHO) and Centers for Disease Control and Prevention (CDC) press releases

	WHO/PAHO (n=27)	CDC (n=27)	p-value	Test
	%	%		
Content assessment				
Title	100.0	100.0	–	–
Current details or new information about outbreak	96.3	85.2	0.351	Fisher's
Reference to consultation	96.3	88.9	0.610	Fisher's
Signed release	51.9	0	<0.0001	Pearson's
Contact details	40.7	100.0	<0.0001	Pearson's
Link to other resources	66.7	92.6	0.018	Pearson's
Expresses uncertainty	88.9	96.3	0.610	Fisher's
Segmentation in release	66.7	77.8	0.362	Pearson's
Risk-advisory guidance	11.1	66.7	<0.0001	Pearson's
Use of figures/graphs	33.3	0	0.002	Fisher's
Witte's Extended Parallel Process Model				
Self-efficacy	55.6	77.8	0.083	Pearson's
Response efficacy	51.9	77.8	0.046	Pearson's
Susceptibility	92.6	85.2	0.669	Fisher's
Severity	96.3	92.6	1	Fisher's
Witte efficacy construct	51.9	77.8	0.046	Pearson
Witte threat construct	88.9	85.2	1	Fisher's
All Witte constructs present	51.9	77.8	0.046	Pearson's
Readability				
Flesch-Kincaid grade level (mean±SD)	17.06±2.95	12.40±3.33	<0.0001	Analysis of variance
Flesch-Kincaid reading ease (mean±SD)	21.15±9.72	41.07±13.26	<0.0001	Analysis of variance
Word count (mean±SD)	681±218.21	502±160.24	0.001	Analysis of variance

issued by a health agency can influence online trends and information-seeking behaviour of the public. The observed changes in RSV are similar to the findings of a previous study which detected a significant increase in RSV 1–4 weeks after the introduction of a major smoking policy in the Netherlands.[32]

Across all the territories and countries studied, there was little or no interest in *Aedes*—the vector responsible for the transmission of the disease. This is an interesting finding given that there is yet no cure for Zika and vector control remains an important component of the control of the disease and is in fact the key message of WHO's Zika risk communication guidelines.[46] Furthermore, the *Aedes* mosquito is also responsible for the transmission of chikungunya and dengue[47] which were of public interest in the countries affected by the Zika pandemic as reflected in the online trends for these diseases. This lack of interest in *Aedes* may suggest that people are interested in the disease and not in the vector. It perhaps shows a deficit in communication by relevant health authorities to the public about this vector that needs to be corrected. The inauguration of Mosquito Awareness weeks across the PAHO region for the Caribbean[47] and Spanish-speaking PAHO member nations[48] are right steps in this direction and may have been initiated by PAHO in response to the low level of interest by the public in mosquito control.

We also observed differences in the intensity of interest in Zika in comparison with the associated search terms, particularly dengue and chikungunya. While Brazil experienced the highest number of suspected Zika cases, interest in dengue nearly doubled the level of interest in Zika. Likewise in Honduras and El Salvador, chikungunya attracted greater interest than Zika. This finding may be reflecting a reality that having been around longer the burden of these diseases in terms of number of cases is greater than the burden posed by Zika and they are hence more searched for. Alternatively, the public in these countries may perceive chikungunya and dengue as more severe and therefore a greater threat than Zika as alluded to in a press release by the MHB.[49] The population of Martinique, with the highest incidence of suspected Zika cases, exhibited overwhelming interest in Zika compared with the other search terms.

These findings suggest that online trends may be a useful, inexpensive and rapid surveillance tool in pandemic situations in areas where internet use is

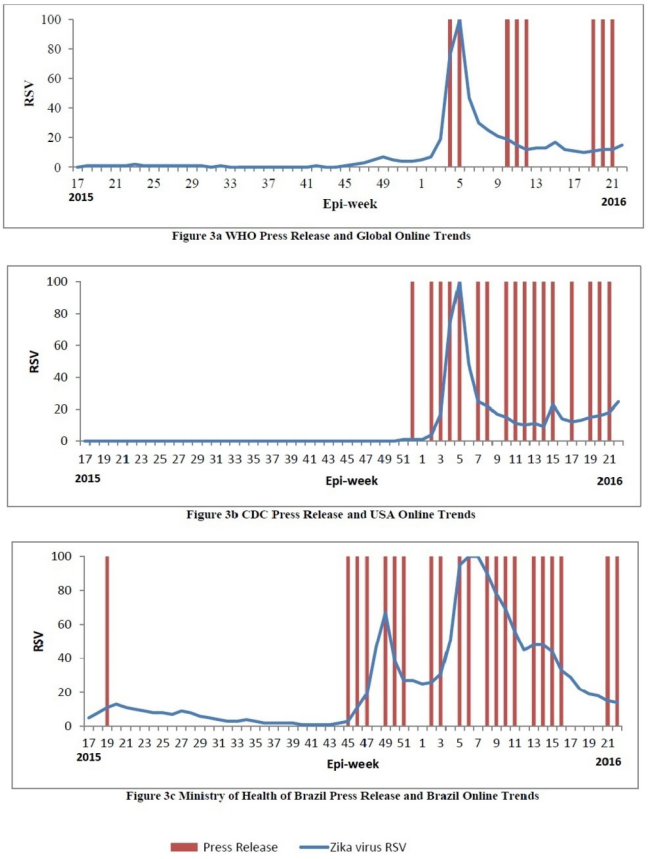

Figure 3 Timing of press releases and online trends by epi-week. RSV, relative search volume globally (3a), in the USA (3b) and Brazil (3c).

widespread. The weak to moderate correlations reported between online trends and Ebola incidence in the three countries most affected by the West Africa Ebola epidemic in 2014[39] may have been due to poor internet penetration in the affected countries. In addition, as the internet is a major source of health information, search engines are not only a surveillance tool but also play a major role in health promotion. At times of PHEIC, health agencies such as WHO could work together with companies like Google to promote reliable sources of health information.

People's perception of, and response to risk is influenced largely by the manner in which the risk is described and explained.[50] Risk management and risk communication theory emphasise the importance of creating trust between the public and health authorities[51] as a key determinant in the public's reception of the risk and the extent to which they are willing to accept and act on official recommendations.[26]

Even in, or perhaps especially in, our world of modern telecommunication and social media, press releases remain an important tool for communicating information to the public in times of health crises such as the ongoing Zika pandemic. Press releases are the initial, and often the only, source of news for health and medical science journalists,[52] and many news organisations reprint health-related and science-related press releases verbatim.[53]

Our press release content analyses revealed no difference in the expression of uncertainty or segmentation of information between WHO/PAHO and the CDC. CDC press releases though were more likely to provide contact details, links to other resources and to be advisory in nature, elements that have been shown to be important in a crisis risk scenario.[41] CDC press releases are also more likely to have all EPPM constructs present, suggesting that they would produce a greater degree of message acceptance and protection motivation.[42]

Health agencies need to make greater efforts to incorporate these elements in their messages to the public during an outbreak situation, in keeping with suggested risk communication best practices.[54] Admittedly, this can be especially challenging in multicultural settings where messages may need to be uniquely tailored for different sectors of the population.

Identification of shortcomings in the content and timing of Zika-related press releases can help guide health communication efforts in the current pandemic and future public health emergencies. The TOTAL criteria suggested by WHO[23] may be a good benchmark against which to evaluate press releases and other communication materials, although we are unaware of any study that has done this. In keeping with TOTAL criteria,[22] for example, all press releases should reiterate specific steps and behaviours people need to take to mitigate risks, and health communication should 'announce early'. The current Zika pandemic began in 2015, yet the

Table 3 ARIMAX model for global, US and Brazilian online trends with press releases by relevant health agency as predictors

				Parameters of the model		
	ARIMAX model	Predictor	Stationary R^2		Estimate	p Value
Global	(0,1,1)	Press releases by WHO	0.345	MA (lag 1)	−0.433	0.001
				Predictor	13.316	<0.001
USA	(0,1,1)	Press releases by CDC	0.318	MA (lag 1)	−0.727	<0.001
				Predictor	3.869	0.014
Brazil	(0,1,1)	Press releases by MHB not a predictor	0.182	MA (lag 1)	−0.391	0.003

ARIMAX, AutoRegressive Integrated Moving Average with an eXogenous predictor variable; CDC, Centers for Disease Control and Prevention; MHB, Ministry of Health Brazil; WHO, World Health Organization

majority of Zika-related press releases were released in 2016. This communication time lag represents missed opportunities for risk mitigation, infection control and anxiety alleviation. A possible explanation for the lapse in communication may be the fact that the association between Zika and Microcephaly and other neurological conditions did not garner attention until late 2015, and it is the risk of these complications that has evoked the fear most people have about the disease.[2 8 19]

A Flesch-Kincaid reading-ease score <30 is deemed to be hard-to-read material that can be readily understood only by college students.[55] The relatively high Flesch-Kincaid grade-level scores achieved by the Zika-related press releases issued by the health agencies, particularly those issued by WHO/PAHO with an average of 17 years of education needed to understand the press releases, suggest that readability by the public is a matter of concern. We are unaware of any previous study that assessed the readability of press releases issued by health agencies; however, a study on the readability of online health information found the average Flesch-Kincaid reading-ease score to be 46.1—higher than the average of the press releases of all health agencies assessed in the current study.[56] Efforts to improve the readability of press releases of health agencies are warranted. Such efforts could include provision of a 'layman summary' and the involvement of public representatives in the assessing readability of these documents before general release.[57]

LIMITATIONS OF THE STUDY

Our measure of online trends was based solely on Google Trends search data and did not include interest data from other search engines (e.g., Bing, Yahoo) or social media platforms such as Facebook or Twitter. We relied on this strategy since Google is by far the most popular search engine worldwide with hundreds of millions of search queries performed daily and accounts for >70% of all online searches performed globally.[58] Google Trends is a free resource that has been shown to be a representative measure of online search trends.[38] At the same time, Google Trends is based on certain 'mathematical assumptions and approximations' that suggest some caution against overinterpretation of RSV data is warranted.[59] Furthermore, adding other social media channels may have presented a fuller picture of the online trends of this pandemic.

Another issue that warrants mention is the validity of the reported suspected Zika cases by PAHO member nations. The numerator used in the present study to calculate Zika incidence for each country was the number of reported suspected Zika cases that appeared in the online PAHO database. As seen in table 2, the proportion of suspected cases that are diagnostically confirmed ranges from >25% (Argentina, Suriname, Panama, Saint Martin and Saint Barthelemy) to <1% in countries such as Martinique, Honduras, Haiti and El Salvador. This wide variation may be a result of the differences in capacity of the healthcare delivery systems in these countries or differential diagnostic accuracy. False positive results may be generated from the strong serological cross-reactivity of IgM antibodies between Zika virus and other flaviviruses, while sensitivity may be compromised as antibodiesare often undetectable in serum collected within a week of illness onset.[60]

STRENGTHS OF THE STUDY

To the best of our knowledge, this is the first study to assess online trends of the ongoing Zika pandemic (using Google Trends) and their association with Zika incidence in a number of countries, and with the timing of Zika-related press releases published by official health agencies. We are also unaware of any studies that have applied the WHO TOTAL criteria to evaluate health press releases or other communication materials. The use of formal readability measures and an established theoretical framework to evaluate the content and readability of WHO and CDC Zika press releases enhances the ability of generalising the findings to other ongoing health and risk communication efforts.

CONCLUSION AND RECOMMENDATIONS

This study provides evidence to support the utility of monitoring online search trends as an additional surveillance tool during a pandemic. Given the use of press releases by many media organisations and their continued availability online, this study reinforces the need for organisations to conduct a dialogue with the public using timely press releases as a tool to impart information and tailor messages for subgroups of the population audience. In addition, health authorities should pay more attention to prompt online communication and consider the readability of published materials to the general public. This builds trust with the public sphere and encourages cooperation. Methods developed and results found in the current study can help guide health communication efforts and research in the current pandemic and future public health emergencies. Further research is needed to identify the most effective communication strategies and messages for different population segments during pandemics and global emergencies.

Contributors GA designed the study. Bore responsibility for literature search, figures, data collection and analysis, data interpretation, writing and critical revision of the manuscript for important intellectual content. YN oversaw research. Designed the study. Contributed to literature search, figures, data analysis, data interpretation, writing and critical revision of the manuscript for important intellectual content. AG-E contributed to study design, data interpretation, writing and critical revision of the manuscript for important intellectual content. WAA contributed to data analysis, data interpretation and critical revision of the manuscript for important intellectual content. HL conceived the study. Oversaw research. Designed the study. Contributed to literature search, figures, data analysis, data interpretation, writing and critical revision of the manuscript for important intellectual content.

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