International Joint Conference on Industrial Engineering and Operations Management- ABEPRO-ADINGOR-IISE-AIM-ASEM (IJCIEOM 2020)

The use of social networks in the monitoring of infectious diseases: a systematic review

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Abstract In 2020, the world was faced with COVID-19, classified as a global pandemic, and this repercussion of the disease generated a high flow of information on social networks. Based on a systematic review of the literature, this article sought to discuss how social media can help analyze data on infectious diseases that cause epidemics and pandemics and to study how this information can be used. After the classification of articles that fall within the scope of this work, eight articles remained. We conclude that social media data is useful for analyzing, monitoring and identifying epidemics. Also, along with official data, social media can help decision-makers choose the best ways to fight disease.

Keywords: Social media, infectious diseases, epidemic, pandemic, systematic literature review.

1 Introduction

According to the Ministry of Health of Brazil (2020), the disease caused by the new coronavirus (COVID-19), classified as a biological disaster of the epidemiological type, spread rapidly around the world and affected about 29 million and 604 thousand people, generating more than 935,000 deaths in 216 countries by September 2020. According to the World Health Organization – WHO (2020) the COVID-19 spreads among people through direct, indirect contact (through contaminated objects or surfaces) and close contact with people infected through the mouth and nasal secretions. These include saliva, respiratory secretions or droplets of secretion.

Other epidemics have occurred in human history. Figure 1 shows a timeline with the most significant of the 21st century, based on WHO (2020).

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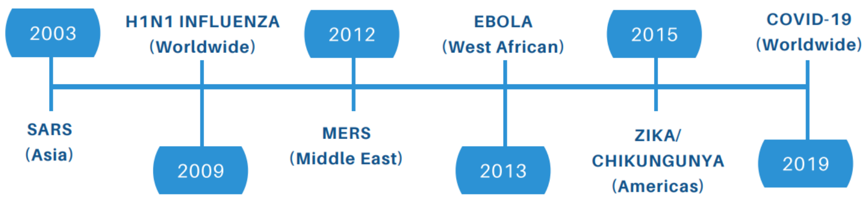

Fig. 1. Major epidemics in the 21st century

Chan et al. (2020) state that one of the biggest challenges during an epidemic or pandemic of infectious diseases like COVID-19 is to disseminate and capture correct information about the disease, for example, prevention practices for people directly exposed to the virus (such as health professionals, funeral directors, social service workers, gravediggers) and what these people are feeling when they get infected before they even go to the doctor. It is essential to use ICT (Information and Communication Technology) tools that assist in this dissemination and capture, for example, in the counting of new cases of COVID-19 or in the sharing of information, as the information disclosed is as accurate as possible. Social media is especially useful in this context, as it provides real-time, low-cost information (Broniatowski et al., 2013).

Roy et al. (2020) shows that we can count on social networks to analyze information about epidemics and pandemics in four ways: (1) As a tool for digital epidemiology - detecting outbreaks of diseases and epidemics through public publications; (2) As a source for analyzing what people consume and how they spend their time - without focusing on how it is received; (3) As a way of valuing rumors and misinformation surrounding social media and highlighting the importance of public health agents working to neutralize false information; (4) As an assessment of users' public health perceptions, to better understand their concerns.

The use of social media to analyze the public health situation in times of a pandemic is a relatively recent issue (Taylor & Stephenson, 2009). Twitter is the social media most used in scientific research that links publications to society's problems. Since users can only write a maximum of 280 characters per tweet, the posts are short and to the point (Oh et al., 2013). Barros et al. (2020) demonstrate that consulting social networks provides useful data for monitoring infectious diseases. They also conclude that social media is the most common source of research on the Internet in peer-reviewed articles, among which Twitter is the most used.

According to Taylor & Stephenson (2009) and Chew et al. (2010), some researchers already explore the use of social media data in health. In the pandemic caused by H1N1, some studies use social networks to keep the population informed, avoiding false news. Broniatowski et al. (2013) and Yuan et al. (2013) demonstrate the high statistical correlation between information taken from social networks and official health data, showing that the number of epidemics cases has evolved according to the frequency of posts. Literature review studies such as those by Velasco et al. (2014), Charles-Smith et al. (2015), and Fernandez-Luque & Imran (2018) also use this data correlation analysis to obtain social information during epidemics or pandemics of infectious diseases, with the target audience and form of transmission.

In 2009, the pandemic caused by the H1N1 virus resulted in the first considerable use of social networks. At that time, they served to keep the population informed about the prevention and spread of swine flu (Taylor & Stephenson, 2009). Another study used tweets about the pandemic to publish and disseminate information from reliable sources (Chew et al., 2010). This information is a rich source of information, opinions, and experiences. It is also suggested that these data are useful for content analysis and sentiment almost in real-time in both papers.

This article builds on this research gap to bring the state of the art and show how the use of social media can provide information that helps in monitoring infectious diseases that advance into a pandemic or epidemic. To this end, we conducted a systematic review of the literature on 358 articles published in journals and conference proceedings.

In addition to this introductory section, Section 2 includes the Research Methodology. Section 3 presents and discusses the results of the SLR. Finally, Section 4 offers conclusions.

2 Research methodology

According to Denyer & Tranfield (2009), the systematic literature review (SLR) is a research method that groups published studies presented in research databases. SLR chooses, analyzes, evaluates, and synthesizes the published information. It also shows evidence that allows conclusions to be drawn that did not exist before on a topic of scientific interest. The SLR aims to answer a research question, prove hypotheses and theories and generate new assumptions, considering their limitations and flaws. In this sense, Tranfield et al. (2003) conclude that SLR is an essential tool for research.

To achieve our objectives, we followed the eight steps of Thomé et al. (2016) for our SLR and the research synthesis. The steps are: (i) planning and formulating the problem, (ii) searching the literature, (iii) data collection, (iv) quality evaluation, (v) data analysis and synthesis, (vi) interpretation, (vii) present the results, and (viii) update the review.

The first step was to determine the work team responsible for the research, followed by the definition of scope and conceptualization of the topic of social media associated with the pandemic. The research question was defined, as: "How can social media help in analyzing data from pandemics or epidemics?" Finally, we followed the literature review protocol to continue the research.

The second stage considered the search in the Scopus and Web of Science (WoS) databases since they included the most extensive coverage in the number of articles (Mongeon & Paul-Hus, 2016). Also, the research considered the set of keywords (see Table 1) defined by the combination of three groups that cover the topic extensively to avoid any artificial limitation of the results obtained and at the same time limit the undesirable effects. Group 1 refers to the issue of infectious diseases and their different scope. Group 2 covers the main infectious diseases for WHO. Finally, Group 3 lists the main social networks around the world.

Table 1. List of keywords used

Group 1 Scope of the disease	“infectious diseases*”, “outbreak*”, “epidemic*”, “pandemic*” e “endemic*”
Group 2 Respiratory-related illnesses	“sars*”, “h1n1”, “corona*”, “mers*”, “ebola*”, “zika*”, “chikungunya*”, "swine flu*", “covid*” e “influenza*”
Group 3 Social Media	"social media*", "facebook", "instagram”, "twitter", "snapchat", "tumblr”, "pinterest", "sina weibo", "reddit", "flickr" e "tiktok"
Research carried out with the Boolean operators "OR" and "AND".	(TITLE-ABS-KEY (infectious diseases* OR outbreak* OR epidemic* OR pandemic* OR endemic*) AND TITLE-ABS-KEY (sars* OR h1n1 OR corona* OR “mers*” OR “ebola*” OR “zika*” OR “chikungunya*” OR "swine flu*" OR covid* OR influenza*) AND TITLE-ABS-KEY ("social media*" OR "facebook" OR "instagram" OR "twitter" OR "snapchat" OR "tumblr" OR "pinterest" OR "sina weibo" OR "reddit" OR "flickr" OR "tiktok"))

With the search for the keywords in the databases carried out on April 29, 2020, 312 articles from Scopus and 179 papers from the Web of Science returned. Joining the two databases and filtering for articles in English, we got 490 papers. We identified 132 duplicate papers using the software R in the Bibliometrix, which meant that 358 remained for the titles and abstracts for review.

After that, an SLR specialist trained the coders, using 10% of the total selected articles (39 articles). Thus, we analyzed the documents according to the inclusion and exclusion criteria:

- Inclusion Criteria:

- Criterion 1: Analysis of social media data during epidemics using Social Networks;
- Criterion 2: Epidemic monitoring through Social Media;
- Criterion 3: Use of Social Media to identify epidemics.

- Exclusion Criteria:

- Criterion 1: Subject area exclusion (medicine, dentistry, biology etc.);
- Criterion 2: Pure epidemiological or propagation models based on simulation;
- Criterion 3: Knowledge sharing regarding the Prevention of Virus Transmission;

- Criterion 4: Psychosocial impacts generated by isolation or quarantine;
- Criterion 5: Economic Assessment for Companies.

Figure 2 shows the results of the search, based on the PRISMA flow diagram elaborated by Moher (2015), and indicates how many papers met each criterion according to the research stages, the initial stage related to the reading of titles and abstracts and the second stage related to reading the full article.

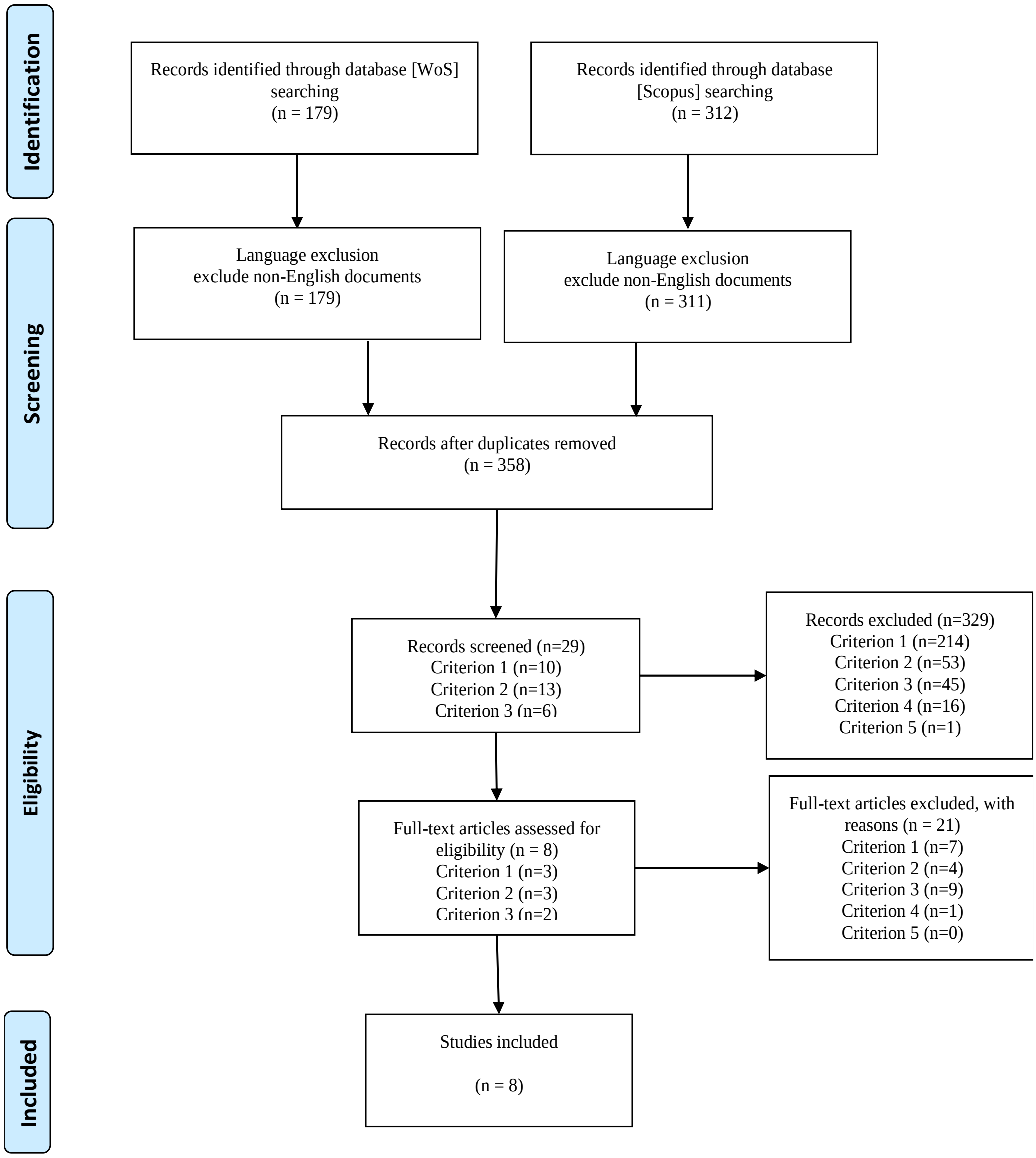

Fig. 2. SLR results diagram based on PRISMA

Exclusion criteria were selected when reading articles when they did not fit the research objective, the reasons that defined them are self-explanatory.

Papers linked to the scope of the research included information during an epidemic using social media to collect data, such as Nagel et al. (2013), Velardi et al. (2014) and Zuccon et al. (2015), and the analysis of what is posted by users on social networks reflects what they are currently feeling, which may be symptoms of an ongoing disease. Therefore, one of the inclusion criteria is analysis during epidemics on social networks.

Another inclusion criterion is the monitoring of epidemics on social networks. It was possible to observe this subject mainly in articles by Aramaki et al. (2011), Zhang et al. (2015) and Jain & Kumar (2018), since the authors used the data acquired on social networks to follow the evolution of epidemics and to know when it started, how it is spreading and when it should end.

The last inclusion criterion was highlighted mainly in the articles by Charles-Smith et al. (2015) and Qin et al. (2020), as the authors focused on identifying when the mass of data published by users means the emergence of a new epidemic.

After the two reviewers read the 358 abstracts, we calculated the Krippendorff's alpha (2004), resulting in a coefficient of 0.92, higher than the acceptable threshold of 0.8. So, we move on to the next step, standardized data collection model using a matrix format, with article data, such as title, authors, year of publication, publication channels, keywords, and main topics addressed.

For the fourth stage, the reviewers discussed the discrepancies in order to have a rigorous definition and application of the defined criteria. The fifth, sixth and seventh resulted in a taxonomic analysis of the eight selected publications. In the next section, we show these results. The eighth step (updating SLRs) is outside the scope of this article.

3 Results

The number of publications per year is in Figure 3. The first publication appeared in 2011. The year with the most papers was 2015, and this may be related to the pandemic of influenza.

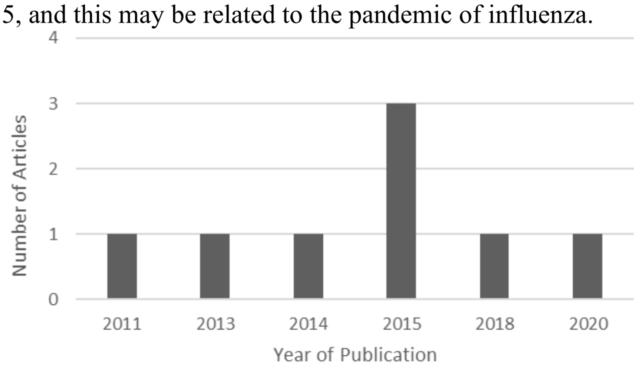

Fig. 3. Number of articles per year of publication

For the analysis of keywords, a co-occurrence map was created with the selected articles, using the Bibliometrix package, in R language according to the method of Aria & Cuccurullo (2017). Figure 4 depicts the diagram. It shows the connections between similar terms, where the size of the circles means the number of occurrences. Furthermore, the proximity between the circles represents the degree of relationships.

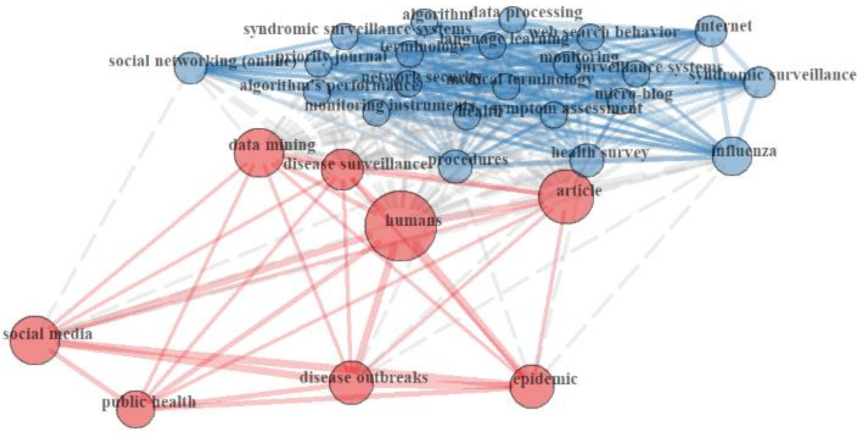

Fig. 4. Keyword co-occurrence map

The most used keyword was humans, and we can see two very interconnected groups of words. About the authors, all of them have the same production, one paper each. In the next subsection, we show our finds regarding the taxonomy of articles reviewed.

According to the results of the review presented in Table 2, among the social media explored in the selected articles, Twitter was the one that stood out the most in six of the eight articles.

However, the reasons for using social media are different. Nagel et al. (2013) use Twitter to determine how cyberspace affects the real world during an epidemic. Jain et al. (2018) analyze this data to identify suspected epidemic cases. Verladi et al. (2014) apply Twitter data to anticipate the epidemic and Zuccon et al. (2015) to detect an outbreak. Aramaki et al. (2011) use Twitter to identify messages that can indicate cases of pandemics. Searches in China use other social media, as in Zhang et al. (2015), which uses Weibo to monitor the H7N9 outbreak, and in Quin et al. (2020), who use Baidu to control the COVID-19 pandemic. Charles-Smith et al. (2015) systematically analyzes how epidemics impact information published on social networks.

Among the infectious diseases identified, the most studied pandemic is influenza; Negal et al. (2013), Velardi et al. (2020), Zuccon et al. (2015) and Aramaki et al. (2011) use Twitter to study the flu, Jain et al. (2018) also use Twitter to analyze the H1N1 flu. Zhange et al. (2015) research H7N9 using Weibo, and Quin et al. (2020) to study COVID-19. Charles-Smith et al. (2015) analyze different diseases in their systematic review.

In Table 2, it is possible to observe that the study of infectious diseases happens worldwide. Most studies are from the USA and China. The other countries are Australia, Japan, and India. This finding shows the interest of several countries in using social media as a source of data and encourages disseminating this thinking.

Regarding the applied research method, seven of the eight selected articles present case studies. This result highlights the practical implications of the social media approach to epidemics. In the case of the study by Nagel et al. (2013), they compare the data obtained on the Internet pages with the tweets, and conclude that the latter is more widespread. Velardi et al. (2014) focus on how to extract data from social networks, list the terms used to identify symptoms of influenza and conclude that posts can help identify epidemics.

Zuccon et al. (2015) reported a complete assessment of a variety of machine learning approaches to identify Twitter messages that may indicate cases of influenza-like illness (ILI). They considered a number of standard textual features and features specific to Twitter messages, such as hashtags, excluding retweets. Their results show that, through machine learning techniques, it is possible to discriminate between tweets that contain mentions about the flu or relevant symptoms and irrelevant messages.

Aramaki et al. (2011) conclude that the data from social media are useful for tracking the progress of pandemics or other diseases. They also built a classifier that judges whether a given tweet is positive or negative, through Machine learning. To assess the association between the data from the tweets and that of the health agencies, they used Pearson's correlation and obtained a high performance. Thus, the results obtained in this article show that tweets can represent the real world. Zhang et al. (2015) also reached this conclusion based on two types of analysis: 1) quantitative analysis to compare the opportunity to report new cases through the various information channels; 2) qualitative analysis of Weibo users with more updated posts of new evidence. By comparing reports between Weibo's results and conventional public health channels, they concluded that the first was significantly faster when reporting new cases. Thus, they find that social media is an excellent tool to follow the process of spreading disease.

Jain et al. (2018) go in the same way. Their article is experimental and considers five phases: data collection, pre-processing of tweets, symptom identification, information system, and identification of suspects. The main contribution of the case study by Quin et al. (2020) is the set of keywords, as it is COVID-19, it helped the authors of the present work in the article selection stage.

Different of the other papers, Charles-Smith (2015) use the method of a systematic review to demonstrate the effectiveness of social media in supporting and improving public health, in addition to monitoring disease outbreaks. It is worth mentioning that the volume of data processed to reach a conclusion about these diseases is immense. Aramaki et al. (2011) consider 300 million tweets and at the conclude the correlation of these data with official health information in a processing time is low. The short computational time to process data from social media generating evidence related to health may, in the future, be the reason why this tool will provide information to government health agencies.

Table 2. SLR results

Paper	Social media	Reason for using the media	Analyzed disease	Keywords	Place	Research method	Volume of data analyzed	Conclusions	Recommendations for future research
Nagel et al. [27]	Twitter	Determine to what extent cyberspace messages affect the real world	Influenza	Flu, Influenza, Pertussis and whooping cough	Washingt on State	Case Study	161,821 flu tweets, 6174 influenza tweets, 160 pertussis tweets and 1167 whooping cough tweets	The results indicate a strong association between tweets in cyberspace and the real world events of disease occurrence	Investigate the actual tweet content and its association with disease incidence at the city, state and country level. Impact the media have on the population's tweeting rate
Velardi et al. [28]	Twitter	For early detection and analysis of epidemics	Influenza	Fever, Chills, Malaise, Cephalgia, Myalgia, Cough, Pharyngitis and Dyspnea	USA	Case Study	585,777 tweets	The approach generates a very high level of correlation with influenza trends derived from surveillance systems	Apply the algorithm for others domains
Zuccon et al. [29]	Twitter	Detect cases of influenza-like illness	Influenza	Flu, sick, headache, fever, unwell, chills, antibiotics, ache, cough, throat, cold, doctor, fatigued, tissues, stomach, runny, sneeze,	Australia	Case Study	13,5 million tweets	Twitter search classifiers are essential for finding disease-related posts	It should be investigated whether the number of influenza-related tweets needs to be accurate in a monitoring system
Aramaki et al. [30]	Twitter	Extract data from Twitter as a pandemic detection	Influenza	Influenza	Japan	Case Study	300 million tweets	The study shows that Twitter texts realistically represent the real world and can be used to detect mass infections	Future studies should address the influence that a particular person's posting about the disease impacts on those who read
Zhang et al. [31]	Weibo	Monitor the outbreak of the disease in China and assess the use of	H7N9	H7N9	China	Case Study	718,419 posts	Social media data potential to get information about diseases	Study the feasibility of authorities use social media data as a public platform
Jain et al. [32]	Twitter	Use social media to identify H1N1 suspects	H1N1	Swine Flu, Flu, H1N1, Swine, Swine Virus, h1n1, ifluenza, swine flu india, influenza virus, delhi	India	Case Study	-	The research allowed the construction of an effective medical decision support based on social media	Features such as reduction algorithms can be incorporated to assist the development of a social media expert
Charles-Smith et al. [33]	Facebook, MySpace and Twitter	Social media can be used to monitor pandemics	-	H1N1, Influenza, epidemic and infectious diseases	-	A Systematic Literature Review	1,499 studies	Social media can impact the domain of public health surveillance, bringing the broader picture to the public health community	Should be studying interventions and a lack of use of social media in practice because despite the high potential for success identified in exploratory studies there are not too much
Qin et al. [34]	Baidu	Identify confirmed cases of COVID-19 in advance	Covid-19	Social media, COVID-19, new case and outbreak	China	Case Study	-	The+A1:K20 use of Baidu data has shown a high correlation to monitor COVID-19 cases	-

4 Conclusion

The research presented in this systematic review of the literature shows that posts on social networks can represent the health status of users on the Internet through messages that describe possible symptoms of some diseases. The selected articles show the importance of using data from social networks to draw conclusions about infectious diseases that generate epidemics and pandemics. The results show a high correlation between information from social networks and official health data. Therefore, social media data can help support government decisions. The results also proved a significant potential in the use of data from social networks, mainly from Twitter. The information found was used for the analysis, monitoring and identification of epidemics worldwide.

In this context, we demonstrate that the academic community has already addressed the use of social media as a source of data to aid in infectious diseases. However, it is necessary to expand the use of this tool, which, together with official data, can assist in making decisions about current diseases and diseases that may come.

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