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REVIEW ARTICLE

Understanding misinformation infodemic during public health emergencies due to large-scale disease outbreaks: a rapid review

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Abstract

Aim The coronavirus disease 2019 (COVID-19) has caused hundreds of thousands of deaths, impacted the flow of life and resulted in an immeasurable amount of socio-economic damage. However, not all of this damage is attributable to the disease itself; much of it has occurred due to the prevailing misinformation around COVID-19. This rapid integrative review will draw on knowledge from the literature about misinformation during previous abrupt large-scale infectious disease outbreaks to enable policymakers, governments and health institutions to proactively mitigate the spread and effect of misinformation.

Subject and methods For this rapid integrative review, we systematically searched MEDLINE and Google Scholar and extracted the literature on misinformation during abrupt large-scale infectious disease outbreaks since 2000. We screened articles using predetermined inclusion criteria. We followed an updated methodology for integrated reviews and adjusted it for our rapid review approach.

Results We found widespread misinformation in all aspects of large-scale infectious disease outbreaks since 2000, including prevention, treatment, risk factor, transmission mode, complications and vaccines. Conspiracy theories also prevailed, particularly involving vaccines. Misinformation most frequently has been reported regarding Ebola, and women and youth are particularly vulnerable to misinformation. A lack of scientific knowledge by individuals and a lack of trust in the government increased the consumption of misinformation, which is disseminated quickly by the unregulated media, particularly social media.

Conclusion This review identified the nature and pattern of misinformation during large-scale infectious disease outbreaks, which could potentially be used to address misinformation during the ongoing COVID-19 or any future pandemic.

Keywords Misinformation · Disinformation · Pandemic · Infodemic · Outbreak · COVID-19 · Health literacy

Background

The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is a novel virus in the coronavirus family causing the coronavirus disease 2019 (COVID-19) (Okan et al. 2020). COVID-19 was first reported in December 2019 and has since evolved into the sixth large-scale worldwide outbreak of the twenty-first century following the Severe Acute Respiratory Syndrome (SARS) outbreak in 2002 (Felter 2020). Estimates suggest that COVID-19 is nearly twice as contagious as the seasonal flu and takes much longer to present symptoms, making transmission of the virus through asymptomatic carriers a substantial public health challenge (Tosta 2020). Given the lack of widespread use of a safe and effective vaccine against COVID-19, public compliance with measures, such as physical distancing, hand hygiene and wearing masks, is essential to intercepting transmission links (Cheng et al. 2020). Dissemination and consumption of clear, consistent and credible information about COVID-19 is a prerequisite to public compliance with these preventative measures (Van den Broucke 2020).

Both the dissemination and consumption of information have spiked since the COVID-19 pandemic (Zarocostas 2020). During the Munich Security Conference in February

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2020, the Director-General of the World Health Organization (WHO) urged, 'we're not just fighting an epidemic; we're fighting an infodemic" (World Health Organization 2020). Infodemic is short for "information epidemic', depicting the rapid spread and amplification of vast amounts of valid and invalid information (Okan et al. 2020). The Internet, social media and other communication platforms have eroded traditional vertical health communication strategies by allowing misinformation to horizontally diffuse faster than ever before (Wang et al. 2019; Cuan-Baltazar et al. 2020). The infodemic makes it difficult for the public to comply with public health measures, as it can debilitate individuals' ability to distinguish mis- and disinformation from fact and cause false perceptions of true risk, including both a higher perceived risk and a false sense of safety (Van den Broucke 2020; Okan et al. 2020). The spread of misinformation can also incite fear and panic, which has been found to induce mistrust in government and non-government institutions leading the pandemic response and further increase susceptibility to misinformation, conspiracy theories and rumours (Wang et al. 2019). Examining the past spread of misinformation during large-scale disease outbreaks can inform initiatives to tackle the spread of misinformation during the COVID-19 pandemic and ultimately improve public compliance with essential preventative health measures. We conducted a rapid integrative review to quickly synthesize existing literature about misinformation during recent abrupt large-scale infectious disease outbreaks, which we hope will enable policymakers, governments and health institutions to proactively mitigate the spread of misinformation during the current pandemic.

Methods

Rapid integrative review

A rapid review generates knowledge promptly by skipping some of the steps involved in a systematic review by simplifying the overall review process to produce a quick result (Khangura et al. 2012). This approach to knowledge synthesis is useful to explore a new frontier of research, update previous research knowledge, and provide a quick overview of a certain topic where time constraints exist to be able to convey the results to policymakers and/or translate the knowledge into action swiftly. This rapid integrative review primarily followed the integrative rapid review methodology developed by Whittemore and Knafl (2005) with adjustments suggested by other authors for a rapid review (Khangura et al. 2014; Tricco et al. 2015). As integrative reviews synopsise previous scientific literature to obtain a comprehensive concept of a particular research topic (Broome 2000), this approach has been deemed best fitting for this review. The review strategy is described below.

Problem identification

For this rapid review, we identified the following research questions:

1. What research has been undertaken regarding the spread of misinformation during abrupt large-scale infectious disease outbreaks in the past 20 years?
2. What factors determine the spread of misinformation among communities?
3. What sources of information are associated most with the spread of misinformation?
4. What aspects of a disease outbreak were affected by the misinformation (i.e. preventive behaviour, treatment, vaccine, etc.)?

Study selection

To extract the relevant studies on misinformation during recent abrupt large-scale infectious disease outbreaks, we used specific search terms and selected those databases that would best ensure the inclusion of sufficient relevant studies. We included the following disease outbreaks in our study per our search criteria: Severe Acute Respiratory Distress Syndrome (SARS), H1N1 Influenza (swine flu), Ebola, Zika virus, Middle East Respiratory Syndrome (MERS), and COVID-19. We followed the PICOS structure (Table 1) to determine our inclusion criteria for this review. We did not limit studies to a particular country. However, we restricted the time of publication to the past 20 years (2001 to 2020). We included studies published in the English language only.

Literature search

The research team selected the two most appropriate databases from which to mine the information relevant to the research focus of this review. MEDLINE (Ovid) was selected as the richest academic database for infectious disease outbreaks. However, as misinformation during a pandemic/epidemic often involves research articles from multiple disciplines, including social and political sciences and education and geography, and non-peer-reviewed publications, we included a search of the grey literature to capture literature on misinformation during disease outbreaks from those sources. Moreover, grey databases also help extract unpublished or in-progress studies. We selected Google Scholar, which is very commonly used to capture grey literature and can extract studies indexed in other databases as well (Haddaway et al. 2015; Vaska et al. 2019). A complete list of search terms is provided in Table 2. In addition, we also conducted single citation searches and used a pearl growing approach by

Table 1 Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
1. Published in academic journals	1. Related to infectious disease outbreaks not specific to our selection, such as HIV, malaria, etc.
2. Regarding misinformation	2. Mentioned misinformation as a collateral outcome, but the research question was not designed to explore misinformation
3. Articles with misinformation in the communities about an abrupt large-scale infectious disease outbreak across different physical and virtual platforms	3. Study designs other than original ones, such as reviews, organizational reports, commentaries, letter to editors, and case studies
4. (P) Populations: Any online or offline communities that were exposed, spread or used to spread misinformation about disease outbreaks, or suffered due to misinformation during outbreaks	4. Studies not published in English
5. (I) Interventions: Any approach, proposition, or assertion that fuels, evaluates, or fights misinformation during outbreaks	
6. (C) Comparison: Studies compared, evaluated, assessed, or planned spread, effect, or mitigating measures for misinformation during an outbreak	
7. (O) Outcomes: Outcomes included but not limited to improved understanding of misinformation behaviour, the prevalence of misinformation, preventive strategies to correct misinformation	
8. (S) Study design: Eligible study designs included qualitative and quantitative original studies	
9. Time restriction was limited to the past 20 years (2001–2020)	

reviewing the reference lists of all selected publications to ensure all relevant articles were included.

Screening

We screened all search outcomes through a two-step process: (i) title-abstract review, and (ii) full-text review (Fig. 1). As suggested in the common rapid review strategies (Tricco et al. 2015), only one reviewer of the research team screened the studies following the two-step process (the title-abstract screening and full-text screening. In the first screening step, the reviewer screened the papers based on the relevance of their titles and abstracts to our research question. After title-abstract screening, relevant abstracts and those from which the reviewer could not draw conclusions alone were included for further review. The full texts of the eligible abstracts were studied thoroughly for inclusion in the rapid review if found relevant to the research questions. Any indecision regarding an article to include or not were resolved by the team consensus.

Data extraction

The research team reviewer extracted relevant information using a limited and predetermined abstraction tool. Firstly, study characteristics were extracted, including citations, study location, study method, study objective and study sample (Table 3). Further data on the specific disease outbreak, the misinformation arising around the disease, how the misinformation or misconceptions were addressed, factors determining the spread of misinformation and sources of mis/information were abstracted following emergent coding (Table 4). EndNote and Microsoft Excel were used in different stages of the study.

Data analysis

The final stage of a rapid review brings together the findings from all eligible articles to deliver an evidence-based response to the original research question. Data were collected, synthesised and presented using summary tables. Extracted data were charted and examined to identify any patterns of information in the articles. The results of this process were further examined to identify key themes. Table 4 details the key findings of each paper regarding misinformation during the outbreaks of interest.

Results

Literature search overview

Our systematic search of MEDLINE identified 533 articles. We found an additional 398 articles in our grey literature search of Google Scholar. After removing duplicates, 853

Table 2 Search terms and databases

A. Misinformation-related terms [MEDLINE]
misinformation [keyword] OR disinformation [keyword] OR hoax [keyword] OR deception [MeSH] OR rumo* [keyword] OR superstition [keyword, MeSH] OR misconception [keyword] OR misperception [keyword] OR fake news [keyword] OR false news [keyword] OR misleading information [keyword]

B. Disease outbreak-related terms [MEDLINE]
infectious disease [keyword] OR communicable disease [MeSH] OR virus OR viruses [MeSH] OR outbreak [keyword] OR disease outbreaks [MeSH] OR Ebola OR Ebola vaccines [MeSH] OR Hemorrhagic fever, Ebola [MeSH] OR Zika OR Zika virus [MeSH] OR Zika virus infection [MeSH] OR SARS [Keyword] OR SARS virus [MeSH] Coronavirus infections [MeSH] OR Betacoronavirus [MeSH] OR Coronavirus [Keyword, MeSH] OR Severe Acute Respiratory Syndrome [MeSH] OR MERS [keyword] OR Middle East Respiratory Syndrome Coronavirus [MeSH] OR Swine flu [Keyword] OR Influenza A virus, H1N1 Subtype [MeSH] OR COVID-19
Searched using (All 'A' terms) AND (All 'B' terms)

For Google Scholar [first 10 pages to be collected for each search]
Four cumulative searches due to the limitation of characters in the search box. Selected the results of the first 10 pages (100 results) for each search.
Search 1:
misinformation
AND
("infectious disease" OR "communicable disease" OR virus OR outbreak OR Ebola OR Zika OR SARS OR Coronavirus OR "Severe Acute Respiratory Syndrome" OR MERS OR "Middle East Respiratory Syndrome" OR "Swine flu" OR "H1N1 virus" OR COVID-19)
Search 2:
disinformation
AND
("infectious disease" OR "communicable disease" OR virus OR outbreak OR Ebola OR Zika OR SARS OR Coronavirus OR "Severe Acute Respiratory Syndrome" OR MERS OR "Middle East Respiratory Syndrome" OR "Swine flu" OR "H1N1 virus" OR COVID-19)
Search 3:
misperception
AND
("infectious disease" OR "communicable disease" OR virus OR outbreak OR Ebola OR Zika OR SARS OR Coronavirus OR "Severe Acute Respiratory Syndrome" OR MERS OR "Middle East Respiratory Syndrome" OR "Swine flu" OR "H1N1 virus" OR COVID-19)
Search 4:
("fake news")
AND
("infectious disease" OR "communicable disease" OR virus OR outbreak OR Ebola OR Zika OR SARS OR Coronavirus OR "Severe Acute Respiratory Syndrome" OR MERS OR "Middle East Respiratory Syndrome" OR "Swine flu" OR "H1N1 virus" OR COVID-19)

articles were identified for title and abstract screening. After reviewing the titles and abstracts, 118 articles were chosen for full-text screening. Through full-text screening, 37 articles were considered eligible for the study (Fig. 1).

Content overview

Table 3 illustrates the study contents we extracted from the studies included in this review. Most studies were conducted in the United States (12 of 37) followed by Canada and Nigeria. Thirty-four of 37 studies were published between 2011 and 2020. The study population of the studies were diverse, including physicians, school teachers, youth and students, general community members.

Objectives of the studies

A number of studies analysed content from social and mainstream media and other document sources. The majority of the studies focused on social media and the spread of information and misinformation across different social media platforms. There were also studies that assessed the knowledge, beliefs, practices and behaviour of community people during a widespread disease outbreak (Table 3). The effects of misinformation during a pandemic, the role of different information sources for risk communication, or multiple aspects of the rumour process were evaluated by some of the selected studies.

Data source and collection strategies

Overall, most of the studies collected data directly from individuals through surveys, focus groups and interviews ($n = 21$). The majority of them collected data from community individuals using surveys ($n = 16$). Three studies used both surveys and focus groups, one study used both surveys and interviews, and only one undertook only interviews. Eleven studies performed a content analysis of various social media, including Facebook, Twitter, YouTube, Sina Weibo, Reddit, Gab, LinkedIn, Pinterest, GooglePlus, Instagram and Flicker. Most of these studies analysed multiple platforms; however, Twitter was the most common social platform analysed in the studies ($n = 11$). Five other studies analysed the content of mass media, including online news sites and mainstream newspapers. One study conducted surveys and interviews and content analysis of social media.

Sources of information

In our rapid review, we sought to extract those sources from which people receive information during an outbreak. In studies conducted within the community, participants described receiving a range of information sources. In the case of social media (predominantly content analysis), some studies reported social media as a direct source, whereas others reported the original source of shared content on social media as the information source, usually given as a link/reference on a particular social media post. Overall, the most commonly reported sources of information were mass media ($n = 17$). Among mass media, the most common source of information was the mainstream news agency ($n = 9$), followed by TV ($n = 4$) and radio

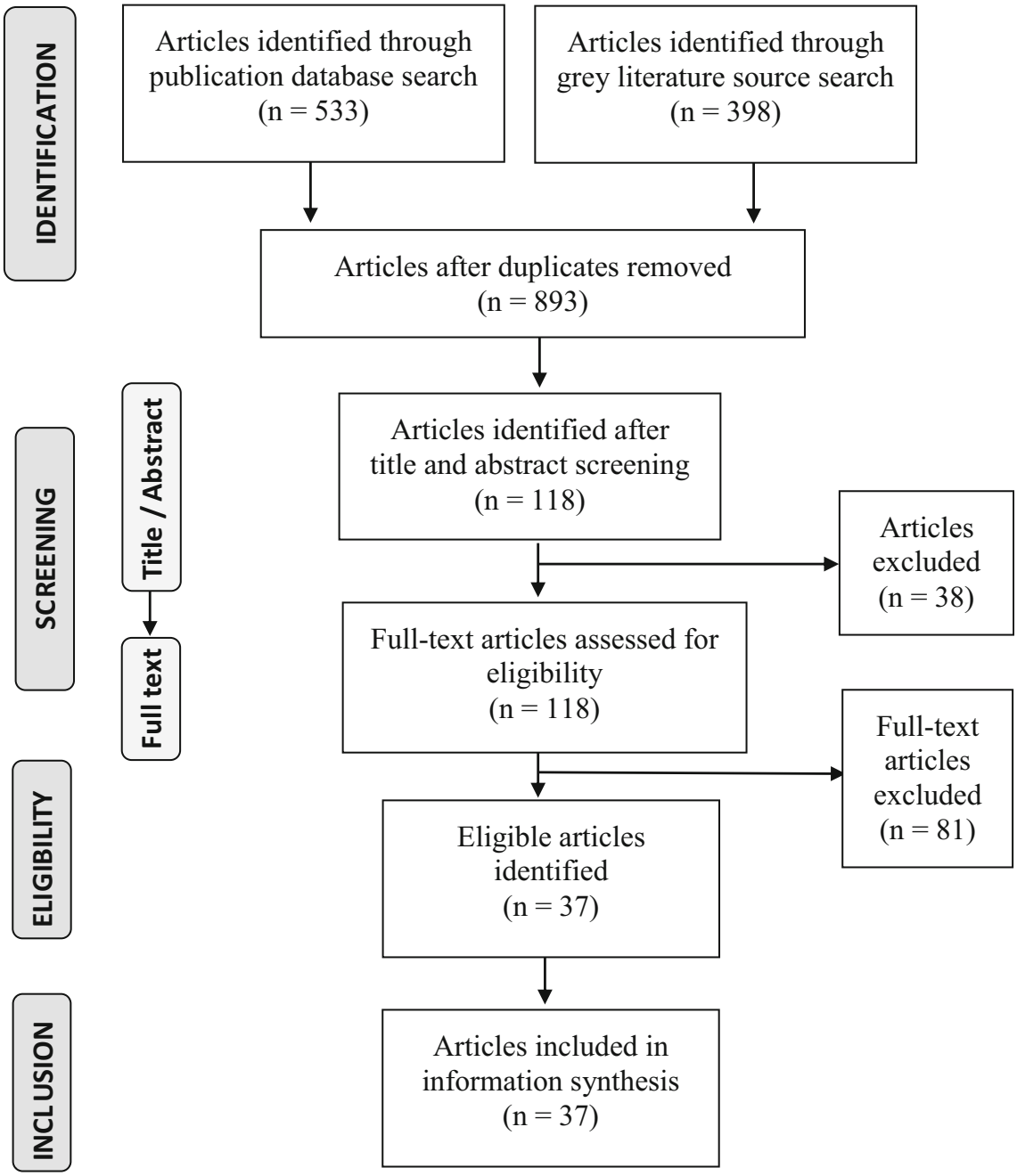

Fig. 1 PRISMA diagram for the selected studies regarding misinformation during large-scale disease outbreaks of the twenty-first century

(n = 4), and unspecified mass media (*n* = 3). Three studies reported social media in general as the source of information. Twitter was reported in four studies, Facebook in two studies, and YouTube and Instagram in one study each. Official/government health information sites were reported in six studies. Alternative internet-based news media and blogs were reported in four studies and emergency texting was mentioned in only one study. Other sources included friends and family (n = 4), healthcare providers (n = 4), religious leaders (n = 1) and word of mouth (*n* = 2).

The prevalence of misinformation among individuals and information sources

We also extracted the percentage of people (if the data source was individuals) and percentage of sources (if the data source was social/mass media or other documents) having misinformation and/or a lack of proper knowledge about the diseases. Overall, among individuals, the level of misinformation ranged from approximately 30% to 88%, as reported in the studies. Regarding various online and offline content, 2% to 23.8% of the content was reported as misinformation.

Table 3 Study characteristics

Author	Study objective	Method (study type, design and data source)	Study population/ sample size	Location	Sources of information/ misinformation	Percentage of people/ sources with misinformation
Ebola						
Gidado et al. 2015	To assess the public preparedness level to adopt disease preventive behaviour	Quantitative A community-based cross--sectional study by interviewer-administered questionnaire Community people	5322 respondents, average age 34 (± 11.4 years), 52.3% were male, largely Christian (70.4%), with secondary or post-secondary education (84.5%) and were either artisans or traders (60.3%)	Lagos, Nigeria	Television (68.8%) and radio (55.0%)	59% did not have satisfactory general knowledge; 56% and 56.9% did not have satisfactory knowledge on how it spreads and measures to prevent, respectively
Adebimpe et al. 2015	To assess the relevance of the social networking media in spreading awareness about Ebola prevention and control	Quantitative Descriptive cross-sectional study, semi-structured self--administered questionnaire Social media (Facebook, Twitter, LinkedIn and others)	400 youth	Southwestern Nigeria	Social media (Facebook, Twitter, LinkedIn, others)	30.7% of respondents had misinformation about Ebola
Seltzer et al. 2015	To explore the use of image sharing platforms in public health communications	Quantitative Retrospective review of images posted on two popular image-sharing platforms Instagram and Flickr	1217 Instagram and Flickr images	Philadelphia, USA	N/R	N/R
Buli et al. 2015	To examine the knowledge, attitude and practice related to Ebola prevention and care	Quantitative A cross-sectional study design using a structured questionnaire Community people	384 over 18 years of age	Kankan region of Guinea	N/R	64.3% of respondents were found not having comprehensive knowledge about Ebola
Bali et al. 2016	To describe fearonomic effects of both misinformation and fear-induced aversion behaviour during an outbreak	Mixed-method Cross-sectional study using semi-structured in-depth interviews and a supporting survey Community people	76 interviews with key informants and stakeholders, including private sector alliance, EEOC staff, UNICEF, Lagos state, private health facilities, and for-profit private sector, such as telecom, aviation, pharmaceuticals, banks, etc. 58% male, 42% female Survey: 119 (55% male, 45% female) 58% were 25–39 years; 41% had an undergraduate degree and 20% had Master's degree)	Lagos, Nigeria	Social media (71%), television (68%), radio (47%) and friends (52%) were the top sources of information on Ebola	N/R
Fung et al. 2016	To analyse misinformation about Ebola on Twitter and Sina Weibo during the global response to 2014–2015 Ebola communication strategies	Quantitative analysis of Twitter and Sina Weibo data within 24 h of the World Health Organization announcement of a Public Health Emergency	N/A	Hong Kong	Mainstream news agencies	2% of Twitter and Sina Weibo content

Table 3 (continued)

Author	Study objective	Method (study type, design and data source)	Study population/ sample size	Location	Sources of information/ misinformation	Percentage of people/ sources with misinformation
		of International Concern and seven days later Twitter and Sina Weibo				
Koralek et al. 2016	To examine the role of outbreak information sources during the 2014 EVD outbreak	Quantitative Online survey Community people	797 undergraduates at least 18 years old and a current undergraduate student	USA	News media (34%), social media (19%), official government websites (OGW) (11%), and family, colleague or friend (4%) Nearly one-third of participants (32%) reported using a combination of these sources	51% of people did not achieve the mean percentage of correct score on the Ebola knowledge section
Smith et al. 2016	To describe teachers' decisions and instruction related to the Ebola outbreak of 2014 captured through a survey	Quantitative Survey School teachers	Elementary school teachers, N=244 Middle school teachers, N=445 High school teachers, N=566	USA	Websites from health organizations were cited by the teachers frequently as useful sources of information about Ebola (over 80% across all grade range)	More than two-thirds of teachers answered incorrectly to the question: 'how Ebola is transmitted and how to prevent transmission', regardless of grade range
Kummervold et al. 2017	To analyse stakeholder concerns and incentives and the phases of the dispute to vaccine trials through an analysis of online media	Quantitative Analysing news reports relevant to Ebola vaccine trials through a web-based system Mass media (online)	139 articles from 9 different newspapers	Ghana	N/R	N/R
Balami and Meleh 2019	To determine the spread of misinformation on saltwater among Nigerians, saltwater use for Ebola prophylaxis, and the role played by social media during the 2014 Ebola outbreak	Quantitative Online survey Community people	703; respondents' mean age was (30.2±6.7) years, predominantly male (73.2%)	Nigeria	Family (29.5%) Friends (29%) Social media (37%)	24% believed misinformation and used saltwater
Vinck et al. 2019	To investigate the role of trust and misinformation on individual preventive behaviours during an outbreak of Ebola virus disease	Quantitative Survey Community people	961 adults	USA	Participants received most of the Ebola information from friends and family (88·8%), community radio stations (82·4%), national radio stations (67·9%), religiousleaders (73·1%) and health professionals (52·8%)	25.5% believed Ebola was not real
Kasereka and Hawkes 2019	To probe community beliefs around Ebola and its origins and the reasons of avoiding Ebola treatment facilities by the community to favour traditional medicine	Mixed method Focus groups and survey Community people	20 FGDs; 286 surveys; 58% male, 42% female	Eastern Democratic Republic of Congo	N/R	75% had no comprehensive knowledge of Ebola

Table 3 (continued)

Author	Study objective	Method (study type, design and data source)	Study population/ sample size	Location	Sources of information/ misinformation	Percentage of people/ sources with misinformation
Zika						
Sharma et al. 2017	To examine the effective use of the social media site Facebook as an information source for the Zika virus pandemic	Quantitative Content analysis Facebook	Top 200 posts from Facebook	USA	Major news agencies, such as CNN, TIME and Reuters	12% of posts were classified as misinformation
Ghenai and Mejova 2017	To use Zika as a case study to develop a tool for tracking misinformation (rumour) around health concerns on Twitter	Quantitative Content analysis Twitter	More than 13 million Tweets	Canada	Mainstream news websites	Half of thecaptured tweets were deemed to be actual rumours
Avery 2017	To capture social media engagement for crisis communication 'in the moment'	Quantitative Survey Community people	226 adults	USA	Facebook (68.2%); website (62.2%); television news (58.2%); newspaper (51.7%); radio news (45.3%); Twitter (38.5%); direct communication materials (31.3%); physicians (29.4%); word-of-mouth (16.9%); other (14.4%); Instagram (6.5%)	N/R
Miller et al. 2017	To determine what people were tweeting about Zika	Quantitative Content analysis using a combination of natural language processing and machine learning techniques Twitter	1,234,605 tweets	Ohio, USA	N/R	N/R
Wood 2018	To investigate the conspiracy theories about the Zika virus outbreak on Twitter	Quantitative Content analysis of Twitter archive Twitter	88,523 tweets	UK	N/R	N/R
Bora et al. 2018	To evaluate YouTube videos during the 2015–16 Zika pandemic	Quantitative Content analysis of the first 120 videos after searching the term 'Zika virus' YouTube	120 YouTube videos	India	Most of the misleading videos came from individual users (45.16%) followed by independent internet-based video channels (17.65%) and news agency (17.5%)	23.8% of videos were misleading
Sommariva et al. 2018	To explore the spread of rumours and verified information on SNSs	Mixed-method Content analysis of Zika-related news stories on SNSs Social media (Facebook, Twitter, LinkedIn, Pinterest, GooglePlus)	120 stories	Florida, USA	Alternative media sources were the most popular sources of the news stories on SNSs (66%), where legacy media produced 25% of the top content. Scientific organizations or institutions constituted only 3% of the stories	22.5% of the news was a rumour. Among them, fabricated content represented the largest share (81%), followed by misleading content (16%) and false connection (3%)

Table 3 (continued)

Author	Study objective	Method (study type, design and data source)	Study population/ sample size	Location	Sources of information/ misinformation	Percentage of people/ sources with misinformation
Abu-Rish et al. 2019	To assess Zika knowledge, attitudes and counselling practices (KAP) of general physicians and gynecologists in Amman, Jordan	Quantitative Cross-sectional study; structured paper-based questionnaire--guided survey Physician survey	119 physicians (General Practitioner, *n*=66, OB-GYN, *n* =52)	Amman, Jordan	Most common sources of information were TV (66.7%), internet (15.4%, CDC (2.6%), journals (6%), or newspapers (9.4%)	46.2% of doctors possessed some level of misinformation
Klofstad et al. 2019	To determine what drives people to believe in Zika conspiracy theories	Quantitative analysis of the two-wave CCES survey Community people	433 female, 344 male	USA	N/R	20% of respondents believed at leastone conspiracy theory; 7% believed in more than one
Carey et al. 2020	To explore the effectiveness of measures taken to fight false and unsupported information about the Zika epidemic	Quantitative Survey Community people	1532 adults	Brazil	N/R	17%–63% of people were shown to believe some misinformation
H1N1 influenza						
Lau et al. 2009	To assess the community responses and preparedness for a potential epidemic of H1N1 influenza in Hong Kong once imported case was detected	Qualitative Interview Community people	550 Chinese adults in Hong Kong	Hong Kong	N/R	The majority of therespondents (66.5%) had at least one misconception
Chew and Eysenbach 2010	To monitor the use of the terms 'H1N1' versus 'swine flu' over time; conduct a content analysis of 'tweets'; and validate Twitter as a real-time content, sentiment, and public attention trend-tracking tool	Quantitative Collecting 2 million archived Twitter posts containing swine flu and/or H1N1 using infovigil, an infoveillance system used in content analysis Twitter	5395 random tweets	Canada	News media (23.2%) Health agencies (1.5%)	N/R
Kanadiya and Sallar 2011	To investigate beliefs, misconception and anxiety concerning the swine flu outbreak and their effects on behaviour	Quantitative Internet-based cross-sectional survey of college students Community people	236 college students aged 18–24 years	Midwestern state, USA	N/R	36.6% of respondents had at least one misconception or unconfirmed belief and 11.0% had twoor more misperceptions about the swine flu contagion
Smith 2010	To detail content themes within the online discussion of H1N1 and how this is used to influence people's vaccination decision	Mixed-method Content analysis of Tweets; survey; interviews Twitter and community people	46,000 tweets	Philadelphia, USA	N/R	N/R
Naing et al. 2012	(i) To determine knowledge and behaviours towards influenza A(H1N1)pdm09; and (ii) to identify the factors influencing	Quantitative Cross-sectional structured questionnaire Community people	230 adults	Mantin Town, Malaysia	The majority of respondents got influenza A (H1N1) pdm09-related information from mass media (63%). Others mainly received	Only 10% respondents had adequate knowledge aboutinfluenza A(H1N1) pdm09; 86% had a misconception about the

Table 3 (continued)

Author	Study objective	Method (study type, design and data source)	Study population/ sample size	Location	Sources of information/ misinformation	Percentage of people/ sources with misinformation
	intention to take the vaccination				information from healthcare staff (39.1%)	transmission mode of this virus
Boerner et al. 2013	To build on an existing socio-ecological model of vaccine behaviour and inform vaccine decision-making processes during pandemics	Mixed-method Focus groups and survey Community people	Survey: 130; 48.5% men, 51.5% womenFocus groups: 143	Canada (Alberta, Manitoba, Ontario)	N/R (media, doctors, and friends were mentioned, though)	N/R
Shigemura et al. 2015	To elucidate news article reporting of adverse public psychosocial behaviours, such as rumour-related coverage	Quantitative Examined Internet news-site articles reporting adverse public psychosocial responses in the first 60 days of the outbreak Internet news reports	154 newspaper articles	Japan	Mainstream media	N/R
SARS						
Ding 2009	To examine how professionals and the public used alternative media for unofficial communication about riske during the 2002 SARS outbreakin China	Quantitative analysis of news reports from mainstream and alternative media databases, alternative media and mass media	N/R	Guangdong, China, and Hong Kong	Alternative media, such as independent overseas Chinese websites and 'guerrilla media' (i.e. word-of-mouth and text messages communication) and contesting Western media, spam messages	N/R
Tai and Sun 2011	To scrutinize multiple aspects of the rumour process in China during the 2003 SARS epidemic	Quantitative Content analysis of the newspaper stories Mass media (newspaper database)	90 stories from 55 newspapers with 91 rumour incidents	China	Word of mouth	N/R
MERS						
Alqahtani et al. 2017	To compare public awareness and practice around MERS-CoV	Quantitative Cross-sectional survey Community people	1812 adults	Saudi Arabia	Mass media (TV, magazines, newspapers) was reported to be the main information source (70%)	56% to 88% of people had some sort of misinformation
Song et al. 2017	To analyse the diffusion ofinformation, the spread of fear and perceived infection risks as expressed online	Quantitative Content analysis of MERS-related online documents using multilevel models and data mining with a priori algorithm association analysis Online documents	8,671,695 MERS-related online documents from 20 May to 18 June 2015, from 171 Korean online channels	Korea	Online discussion boards, Twitter, online cafes, news sites and blogs	N/R
COVID-19						
Cinelli et al. 2020	To asses engagement and interest in the COVID-19 topic and provide a differential	Quantitative Content analysis	The deriving dataset was composed of 1,342,103 posts	Italy	Reliable/unreliable not specified	N/R

Table 3 (continued)

Author	Study objective	Method (study type, design and data source)	Study population/ sample size	Location	Sources of information/ misinformation	Percentage of people/ sources with misinformation
	assessment on the evolution of the discourse on a global scale for each platform and their users	Social media (Twitter, Instagram, YouTube, Reddit and Gab)	and 7,465,721 comments produced by 3,734,815 users			
Stanley et al. 2020	To examine a disposition—willingness to engage in analytic-thinking—that might predict beliefs that the pandemic is a hoax and failuresto change behaviour in positive ways	Quantitative Surveys Community people	278 individuals	USA	N/R	N/R
Kouzy et al. 2020	To analyse the magnitude of misinformation being spread on Twitter regarding the coronavirus epidemic	Quantitative Content analysis Twitter	673 tweets	Lebanon	Informal individuals and groups with a verified Twitter account	153 tweets (24.8%) included misinformation, and 107 (17.4%) included unverifiable informationregarding the COVID-19 epidemic
Pennycook et al. 2020	To investigate the causes of people's belief in misinformation about COVID-19 and test an intervention to increase credibility of the social media content	Quantitative Online survey Community people	Study 1: 853; mean age=46 years; 357 males, 482 females Study 2: 856; mean age=47); 385 males, 468 females	Canada	N/R	N/R

CCES Co-operative Congressional Election Study, *CDC* Centers for Disease Control and Prevention, *CNN* Cable News Network, *CoV* coronavirus, *EEOC* Ebola Emergency Operation Centre, *COVID-19* coronavirus disease 2019, *EVD* Ebola virus disease, *FGD* Focus Group Discussion, *KAP* knowledge, attitude, practice, *MERS* Middle East Respiratory Syndrome, *N/R* not reported, *OB-GYN* obstetrician-gynecologist, *SARS* Severe Acute Respiratory Syndrome, *SNS* social networking sites, *TV* television, *UNICEF* United Nations Children's Fund, *USA* United States of America

Outbreaks

Ebola was the most commonly studied outbreak that appeared in the literature. Twelve studies were conducted on the Ebola virus disease, which re-emerged extensively in 2014 (first discovered in 1976) and ran a widespread course across West Africa. The second most frequently studied disease was the Zika virus, which is a mosquito-transmitted flavivirus mostly spread from Brazil during 2015–2016. A handful of studies were found pertaining to H1N1 influenza (also known as swine flu), which had an outbreak in 2009 ($n = 7$). The most recent COVID-19 outbreak was the focus of research in four studies, followed by SARS ($n = 2$) and MERS (n = 2), whose outbreaks occurred in 2002 and 2017, respectively.

Discourse of misinformation

Various misinformation was reported in the studies eligible for this review. We attempted to catalogue them according to the different levels of outbreak response. This information is presented in Table 4.

Prevention-related misinformation

The most prevalent misinformation was about preventing Ebola by taking a daily hot water bath with salt (Adebimpe et al. 2015). Regarding the prevention of Zika, even some physicians were misinformed that Zika-infected or -exposed persons need to be isolated (Abu-Rish et al. 2019). Regarding SARS, a study in China that explored newspaper databases found 'blasting firecrackers to keep evil spirits away' was the most common piece of misinformation reported in 29 of 90 news stories they uncovered (Tai and Sun 2011). Only one prevention-related misinformation was reported about MERS, which was putting Vaseline® (petroleum jelly) under the nose, which was claimed to prevent MERS infection (Song et al. 2017).

Treatment-related misinformation

Saltwater was found as a treatment measure for Ebola across studies (Fung et al. 2016). Sixteen to 17 % of people in one study believed the Zika virus can be treated with antibiotics and/or consuming a certain amount of onions (Adebimpe et al. 2015). A study on H1N1 influenza reported that many people believed since there was no definitive treatment for H1N1 influenza, there was no need for medical consultation, as that could potentially cause panic and fear among the population (Lau et al. 2009).

Risk factor- and disease causation-related misinformation

One study found that 53% of participants believed Ebola came from wild animals from forests, such as monkeys and bats (Kasereka and Hawkes 2019). A rumour claiming that lack of iodine caused SARS lead to panic buying of salt during that pandemic in China (Ding 2009). Some people who usually did not contract seasonal flu asserted they would be safe from H1N1 influenza as well, which may give them a false sense of safety and deter them from getting vaccinated (Boerner et al. 2013).

Mode of transmission-related misinformation

One study found that over two-thirds (68%) of people believed Ebola could be spread via the mere touch of a diseased person (Bali et al. 2016). Other misinformation about mode of transmission of Ebola included consumption of pork, and transmission through air, water and food (Buli et al. 2015; Bali et al. 2016). More than half of the participants in one study among physicians (55.9%) believed the Zika virus could be transmitted via direct contact between individuals (Abu-Rish et al. 2019).

Complication-related misinformation

In terms of misinformation about complications of disease outbreaks, the most commonly observed misinformation about Zika was that a pesticide/larvicide caused microcephaly, a complication that followed Zika virus infection in pregnant women (Miller et al. 2017; Sommariva et al. 2018).

Vaccine-related misinformation

A study in Ghana found news articles and people claming that the vaccine would cause Ebola by either the vaccine itself or the government and researchers would intentionally infect people with Ebola to test the vaccines (Kummervold et al. 2017). Two studies on H1N1 influenza found people who considered the vaccine unsafe were hindered from getting vaccinated (Kanadiya and Sallar 2011; Boerner et al. 2013).

Conspiracy theories

About one-fifth of the US citizens in one American study believed in at least one Zika conspiracy theory (Klofstad et al. 2019). The most widespread conspiracy theory about the Zika virus concerned microcephaly and that it was a complication of the Zika virus infection caused by pesticides/larvicides (Carey et al. 2020; Sharma et al. 2017) and vaccines (Wood 2018). A population-based

Table 4 Areas of misinformation found by studies

Area of misinformation	Disease	Misinformation found	Reference
Prevention	Zika	Isolation of infected or exposed persons is required for Zika virus infection	Abu-Rish et al. 2019
		Wearing long-sleeved shirts and long pants are not necessary	Abu-Rish et al. 2019)
		Fish can help stop Zika	Ghenai and Mejova 2017
		Coffee as a mosquito repellent to protect against Zika	Ghenai and Mejova 2017
	Ebola	Taking daily hot water bath with salt	Adebimpe et al. 2015; Balami and Meleh 2019; Buli et al. 2015; Gidado et al. 2015; Kasereka and Hawkes 2019
		Prevented by taking bitter cola/miracle cola	Adebimpe et al. 2015; Gidado et al. 2015
		Consumption of local medicinal herbs	Gidado et al. 2015)
		Ebola can be prevented by avoiding mosquito bites	Kasereka and Hawkes 2019
		Prevented by the frequent rubbing of the body with *Aloe Vera* soap and cream	Adebimpe et al. 2015
		Prevented by drinking plenty of condensed milk	Adebimpe et al. 2015
		Preventable by not shaking hands with friends and colleagues	Adebimpe et al. 2015
	SARS	Blasting firecrackers keeps the evil SARS spirit away	Tai and Sun 2011
		Drinking mung bean soup at midnight protects one from the viral agent	Tai and Sun 2011
		Saltwater can be used for indoor disinfection when one runs out of vinegar	Ding 2009
	MERS	Vaseline® under the nose helps prevent MERS	Song et al. 2017
	COVID-19	N/R	
	H1N1	N/R	
Treatment	Zika	Can be treated with antibiotics	Adebimpe et al. 2015
		Curable by taking an appreciable quantity of onions	Adebimpe et al. 2015
	Ebola	Could be successfully treated by traditional and religious healers	Buli et al. 2015; Kasereka and Hawkes 2019
		Bathing in or drinking saltwater	Fung et al. 2016
		Ingestion of Nano Silver, an experimental drug	Fung et al. 2016)
	SARS	An old dumb man suddenly speaks out (revealing mysterious anti-SARS prescriptions)	Tai and Sun 2011
		Saltwater could kill germs and viruses	Ding 2009
		A talking new-born baby reveals secret SARS-fighting recipes	Tai and Sun 2011
	MERS	N/R	
	COVID-19	N/R	
	H1N1	No treatment for H1N1 so no need for medical consultation	Lau et al. 2009
Risk factor/causes	Zika	N/R	
	Ebola	Witchcraft', 'magic', 'sorcerer cat', 'cat' causes Ebola	Kasereka and Hawkes 2019
		Wild animals from the forest, monkeys, bats can cause Ebola	Kasereka and Hawkes 2019
		A significant proportion (36.2%) believed that Ebola is caused by God or other higher powers	Buli et al. 2015
	SARS	Caused by a lack of iodine in the body	Ding 2009
	MERS	Individuals believed that they were under Allah's (God's) protection	Alqahtani et al. 2017
	COVID-19	N/R	
	H1N1	Being safe from seasonal flu perceived as safety from H1N1	Boerner et al. 2013
		43.1% wrongly believed that the new H1N1 influenza is one type of avian flu	Lau et al. 2009
Mode of transmission	Zika	Direct contact between individuals	Abu-Rishng et al. 2019
		Breastfeeding as modes of transmission	Abu-Rish et al. 2019

Table 4 (continued)

Area of misinformation	Disease	Misinformation found	Reference
		Eating cooked pork	Kanadiya and Sallar 2011
		Eating uncooked or partially cooked poultry	Naing et al. 2012
		By blood transfusion	Naing et al. 2012
		Via water sources	Kanadiya and Sallar 2011
		Insect bites	Kanadiya and Sallar 2011
	Ebola	Could spread via touch (68%), pork consumption (28%) and even air (23%)	Bali et al. 2016
		Transmitted by air	Buli et al. 2015
		Transmitted by mosquito	Buli et al. 2015; Koralek et al. 2016
		Asymptomatic carrier in an airplane can transmit	Koralek et al. 2016
		Water sources	Koralek et al. 2016
		Food sources	Koralek et al. 2016
	SARS	N/R	
	MERS	MERS-CoV does not transmit via camels	Alqahtani et al. 2017
	COVID-19	N/R	
	H1N1	Airborne via long-distance aerosols from one building to another	Lau et al. 2009
		Waterborne	Lau et al. 2009
		Transmission via insect bites/vectors	Lau et al. 2009
		Eating well-cooked pork	Lau et al. 2009
Complication	Zika	Pesticide/larvicide causes microcephaly, not Zika virus	Miller et al. 2017; Sommariva et al. 2018
		Severe disease requiring hospitalization due to Zika virus is common	Abu-Rish et al. 2019
		Death from Zika virus infection is common	Abu-Rish et al. 2019
	Ebola	N/R	
	SARS	N/R	
	MERS	MERS is not a fatal disease (29%)	Alqahtani et al. 2017
	COVID-19	N/R	
	H1N1	H1N1 has a higher fatality than SARS or avian flu	Lau et al. 2009
Vaccine	Zika	Microcephaly in Zika virus is caused by vaccines	Ghenai and Mejova 2017; Wood 2018
		Zika vaccine development efforts are part of a broader plan for global depopulation	Wood 2018
	Ebola	Allegation of trials being secret	Kummervold et al. 2017
		Belief that the trials will lead rise of Ebola cases	Kummervold et al. 2017
		Argument that incentive packages were inappropriate for the trial participants	Kummervold et al. 2017
		Suspicion that trial researchers will willingly expose the trial participants to Ebola virus to test vaccines	Kummervold et al. 2017
		Fear that the vaccine itself could cause Ebola	Kummervold et al. 2017
	SARS	N/R	
	MERS	N/R	
	COVID19	N/R	
	H1N1	The vaccine is not safe	Boerner et al. 2013; Kanadiya and Sallar 2011
Conspiracy	Zika	Zika virus is a hoax to cover up chemical teratogens manufactured by major multinational corporations	Sharma et al. 2017; Sommariva et al. 2018
		Brain deformation/microcephaly is caused by larvicide/pesticide, not the Zika virus. It is what they put in the drinking water	Carey et al. 2020; Sommariva et al. 2018; Wood 2018

Table 4 (continued)

Area of misinformation	Disease	Misinformation found	Reference
		It is like calling a common cold an epidemic	Sommariva et al. 2018
		CDC is likely fabricating a link between Zika virus and microcephaly cases	Sommariva et al. 2018
		The virus is a bioweapon rather than a natural occurrence	Wood 2018
		The Zika virus is harmless	Wood 2018
		Microcephaly is caused by genetically modified mosquitoes	Carey et al. 2020; Wood 2018
		Zika vaccine development efforts are part of a broader plan for global depopulation	Wood 2018
		GMO mosquitoes spread Zika	Carey et al. 2020
		Government document confirms Tdap vaccinecauses microcephaly	Ghenai and Mejova 2017; Wood 2018
		Zika is caused by vaccines	Klofstad et al. 2019
		Zika is caused by genetically modified mosquitoes	Klofstad et al. 2019
		Zika is used by governments to sicken or kill people on purpose	Klofstad et al. 2019
		Zika was created to ruin the 2016 Summer Olympics in Brazil	Klofstad et al. 2019
		Zika was created by pharmaceutical companies to createdemand for a profitable vaccine or drug to combat the disease	Klofstad et al. 2019
		Zika is a terrorist attack	Klofstad et al. 2019
		Pandemic as a way to depopulate third-world countries	Sharma et al. 2017
	Ebola	Ebola is a political fabrication/for financial gain by authorities or to destabilize the region	Kasereka and Hawkes 2019; Vinck et al. 2019
		There is a cure for Ebola but the government is keeping it from the public	Koralek et al. 2016
		Government conspiracy created to eliminate a particular race	Koralek et al. 2016
		EVD outbreak does not exist	Vinck et al. 2019
	SARS	Beijing will be barricaded in order to keep SARS out	Tai and Sun 2011
		Guangzhou banned the import and export of goods, so there wouldsoon be a shortage of food	Ding 2009
	MERS	Fake lists of hospitals where MERS was diagnosed and fake lists of confirmed MERS patients and deaths	Song et al. 2017
		A false rumour that general hospital has been shut down due to MERS cases	Song et al. 2017
		Media propaganda	Alqahtani et al. 2017
	COVID19	N/R	
	H1N1	N/R	

COVID-19 coronavirus disease 2019, *EVD* Ebola virus disease, *GMO* genetically modified organism, *MERS* Middle Eastern Respiratory Syndrome, *N/R* not reported, *SARS* Severe Acute Respiratory Syndrome, *Tdap* tetanus, diphtheria, pertussis

survey in Congo found 45.9% of people believed at least one of the following three conspiracy theories: Ebola did not exist (25.5% believed), Ebola was a political fabrication (32.6%) and Ebola was fabricated to destabilize the region (36.4%) (Kasereka and Hawkes 2019).

Factors that help spread belief in misinformation

We extracted different factors associated with believing and spreading misinformation during an outbreak (Table 5).

Demographic factors

According to several studies, women and young people were most prone to believing misinformation and passing it on to others (Balami and Meleh 2019). Possessing below secondary level education was also associated with having improper knowledge about Ebola (Gidado et al. 2015). A study reported that being single (65.24%) was related to believing misinformation more than married people (34.76%) (Balami and Meleh 2019).

Intrapersonal factors

One study stated that while misconceptions were associated with increased anxiety, some sort of anxiety also drove people to take preventive action (Kanadiya and Sallar 2011). Similarly, another study found that worried people were more likely to have a positive intention to take the H1N1 influenza vaccine (Naing et al. 2012).

Interpersonal/social factors

A study that conducted focus groups to determine factors that interplay with H1N1 vaccine uptake behaviour found that the 'bandwagoning' effect played a role in this context, that is, if everyone else was getting vaccinated, others followed suit; but if everyone was not, others avoided it (Boerner et al. 2013).

Professional/experiential factors

A study on physicians in Jordan found less than five years of experience as a physician was significantly related to having misinformation about the Zika virus (Abu-Rish et al. 2019). Other studies indicated that people having an academic background with a biology major (such as public health, biological sciences, biochemistry, pharmaceutical sciences and nursing) or who were in the scientific field had a lower level of misinformation than individuals from other fields, such as the arts and management sciences (Koralek et al. 2016; Pennycook et al. 2020).

Information source-related factors

Misinformation about Ebola reinforced by the media amplified unjustified fear among people (Seltzer et al. 2015; Bali et al. 2016). Studies that analysed content and responses to misinformation by the different social media platforms found that while some social media such as YouTube and Reddit reduced unreliable posts or remained neutral (Twitter), some rather amplified posts containing misinformation (Gab) (Ghenai and Mejova 2017; Bora et al. 2018; Cinelli et al. 2020).

Risk communication-related factors

One study found that two-thirds of participants (66.5%) either believed (27.5%) that the H1N1 vaccine was not safe or did not have any idea about its safety (39%), which influenced over 63% of people's refusal to be vaccinated (Kanadiya and Sallar 2011). Lack of accurate public discourse about the diseases from authentic and reliable sources was also reverberated by other studies (Chew and Eysenbach 2010; Stanley et al. 2020).

Government/authority-related factors

During the SARS outbreak in 2002 in China, it was observed that when the Chinese government initially denied and remained silent about the outbreak and restricted the mainstream media from broadcasting accurate news about the SARS outbreak, various misinformation arose and caused panic and fear among people (Ding 2009; Tai and Sun 2011).

Discussion

Our rapid integrative review found that misinformation involves prevention, treatment, risk factor and disease causation, mode of transmission, complications, vaccines and conspiracy theories. Among recent large-scale infectious outbreaks, Ebola was the most commonly studied in the literature for misinformation. Women and young people were reported to be more prone to believing and passing on misinformation. Anxiety, worrying and a lack of experience in the scientific field was associated with the consumption of misinformation. Mass media, particularly social media, was largely found to contribute to the dissemination of misinformation. A lack of government efforts and a lack of trust in government efforts were also found to contribute to the spread of misinformation.

Misinformation is not only an issue during large-scale infectious disease outbreaks; the advent of the Internet and social media have exacerbated the creation and dissemination of misinformation in all areas of health (Chou et al. 2018). Social media feeds are closed networks curated to individual beliefs that amplify misinformation by creating 'information silos' and 'echo chambers'. From dangerous rumours about vaccines (Dubé et al. 2014; Ortiz-Sánchez et al. 2020), tobacco products (Albarracin et al. 2018), alternative therapies (Wilson 2002; Schmidt and Ernst 2004), and weight loss cures (Dedrick et al. 2020) to skepticism about medical guidelines (Fiscella et al. 1998), there is an ever-growing need to curb misinformation.

Most of the misinformation-related studies in this review concerned the Ebola outbreak in West Africa, and most of the articles focused on the role of social media in the spread of misinformation. These findings may indicate two things. First, social media is increasingly playing the prime role in spreading health-related misinformation, as the use of social media has become ubiquitous and the influence of social media has risen to the extreme lately (Laranjo et al. 2015). As Ebola was one of the most recent large-scale, deadly and long-lasting outbreaks before COVID-19, coupled with the growing influence of social media, concern around misinformation regarding Ebola was discussed most often. Second was the relation of health and science literacy and lack of trust in governing bodies with the spread of misinformation (Chou et al. 2018). Ebola was mainly spread in West Africa, where studies

Table 5 Factors associated with belief and spread of misinformation

Categories	Misinformation believing/spreading factors	Reference
Demographic factors	Female gender	Adebimpe et al. 2015; Gidado et al. 2015
	Having low level of education (less than secondary education)	Gidado et al. 2015; Kasereka and Hawkes 2019; Klofstad et al. 2019; Naing et al. 2012
	Age<30 years, younger people	Balami and Meleh 2019; Klofstad et al. 2019
	Marital status (being single)	Balami and Meleh 2019
	Region of residence	Balami and Meleh 2019; Gidado et al. 2015
Intrapersonal factors	Perceived mixed messages from different media outlets	Boerner et al. 2013
	Low level of anxiety/worry among the population regarding the disease	Kanadiya and Sallar 2011; Naing et al. 2012
	Lower exposure to disease-related information	Vinck et al. 2019
	Low institutional trust	Vinck et al. 2019
	Strong conspiracy mentality among individuals	Klofstad et al. 2019
	Partisanship	Klofstad et al. 2019
	Individuals less likely to rely on intuitions	Pennycook et al. 2020
Interpersonal/social factors	Friends or family members discouraging vaccination by providing negative information on vaccines, sharing negative experiences with vaccines, or promoting natural or other healthy alternatives to vaccination	Boerner et al. 2013
	Physician recommended against vaccination or revealed that they were not planning to be vaccinated	Boerner et al. 2013
	Bandwagon effect (blindly following what other people do)	Boerner et al. 2013
Professional/experiential factors	Less than five years of experience as a physician is related to having misinformation	Abu-Rish et al. 2019
	Less biological science exposure	Koralek et al. 2016
	Training/occupation (arts and management sciences compared to medical, education, engineering, and other sciences occupation/professions)	Balami and Meleh 2019
	Lower in basic scientific knowledge	Klofstad et al. 2019
Information source-related	Media reinforcing misinformation (such as presenting Ebola as highly contagious which it is not in fact)	Kummervold et al. 2017
	Media coverage of the debate over vaccine safety	Boerner et al. 2013
	Media reporting was considered overhyped and sensationalistic	Boerner et al. 2013
	The lack of consistency across information from different sources	Boerner et al. 2013
	Videos/tweets from informal independent users	Bora et al. 2018; Kouzy et al. 2020
	Family, colleagues or friends	Koralek et al. 2016
	Fast-paced social media ecosystem, where the abundance of news sources and SNS platform structures can help misinformation reach a large audience	Sommariva et al. 2018
	Source, medium and tone of the information	Balami and Meleh 2019; Seltzer et al. 2015
	Online discussion boards, Twitter and online cafes were more associated with misinformation than news sites and blogs	Song et al. 2017
	The level of control and interference of the social media platforms on shared content. While Twitter was neutral, YouTube reduces posts from unreliable sources to only 10%, Reddit reduces to 50%, but Gab amplifies it to 400%	Cinelli et al. 2020
Government/authority-related	Public mistrust on government narratives on disease or vaccine trial	Ding 2009; Kummervold et al. 2017
	Government putting restrictions on a real news broadcast	Tai and Sun 2011
	Government's silence and denial	Ding 2009
Resource/risk communication-related	Lack of accurate information	Bali et al.2016
	Lack of public discourse about the disease or the safety and effectiveness of vaccination	Boerner et al. 2013; Klofstad et al. 2019
	People not receiving sufficient information to make an informed decision	Boerner et al. 2013

Table 5 (continued)

Categories	Misinformation believing/spreading factors	Reference
	Lack of available information on an online authentic health-related platform	Chew and Eysenbach 2010
	Correcting effort could confuse baseline accurate beliefs	Carey et al. 2020
	Lack of government and public health authorities providing consistent, clear updates and information about the disease	Kanadiya and Sallar 2011; Kasereka and Hawkes 2019; Stanley et al. 2020
	Lack of assessment of whether messages are being understood by the target population	Kanadiya and Sallar 2011
	Not disclosing vaccine/trial information widely enough	Kummervold et al. 2017
	A large amount of incentive for vaccine trials make people think there are huge risks associated with vaccine	Kummervold et al. 2017
	Lack of deeper causal explanations of the mechanisms of the pandemic accessible to the layperson	Stanley et al. 2020

N/R not reported, *SNS* social networking sites

showed that the low level of health, science and overall literacy, and a high level of distrust in the government were responsible for the spread of misinformation (Fowler et al. 2014; Gostin and Friedman 2015), factors confirmed by our study.

A proactive, solution-oriented approach that dissects the different levels of misinformation and how each arises is essential to developing feasible steps to overcoming misinformation. Wardle and Derakhshan (2017) discussed the three elements involved in the creation, production, distribution and reproduction of misinformation, namely agent, message and interpreter (Fig. 2). The results of our study can be approached using this model of misinformation to identify areas for intervention. We found that agents and interpreters during both the creation and production phases included family and friends, who are often perceived as a trusted source in the absence of authoritative sources (Balami and Meleh 2019; Bali et al. 2016; Boerner et al. 2013; Koralek et al. 2016; Vinck et al. 2019). During the creation phase, individuals or informal independent online users successfully create misinformation due to the lack of competing accurate information (Wardle and Derakhshan 2017; Kouzy et al. 2020). We found women, young people, and people with low levels of information were more prone to interpreting and passing on the misinformation that had been created (Adebimpe et al. 2015; Balami and Meleh 2019; Gidado et al. 2015; Klofstad et al. 2019). During the production phase, social networks, online forums and social media ascertain misinformation and construct it into a media product (Wardle and Derakhshan 2017), which was also reflected in 14 studies included in this review. A lack of consistent authoritative information

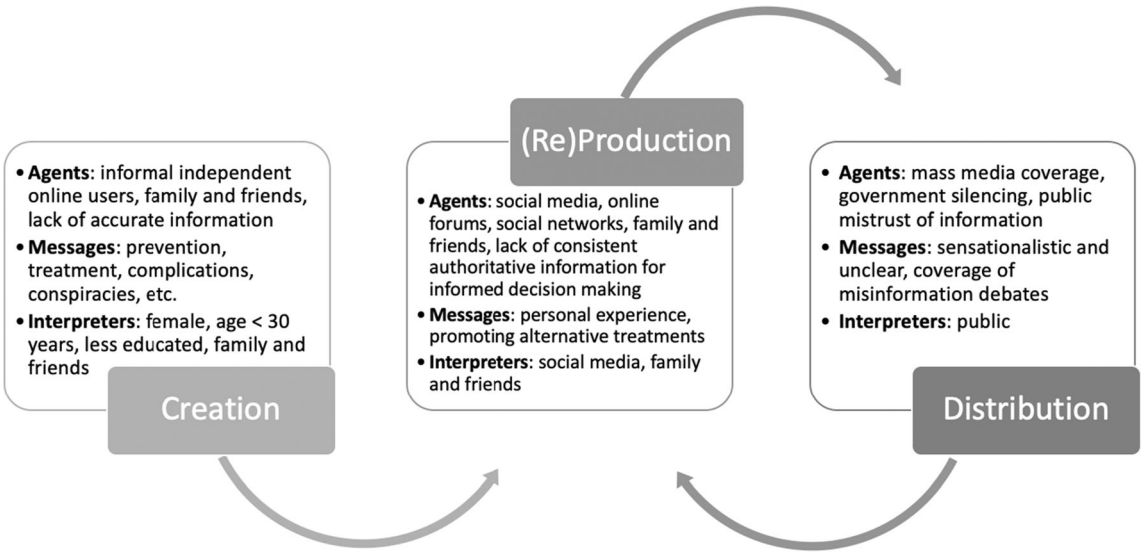

Fig. 2 Agents, messages and interpreters identified for the creation, production, distribution and reproduction of misinformation during large-scale infectious disease outbreaks

contributes to uninformed decision-making, as trust in information becomes tied to personal experience (Wardle and Derakhshan 2017). During the distribution phase, sensationalistic or unclear mass media coverage of misinformation debates can expose the public to false claims (Wardle and Derakhshan 2017). Most of the studies in this review reported mass media as the main sources of information (Alqahtani et al. 2017); this, coupled with a lack of trust in government narratives and the disseminating power of social media, snowballs the distribution and reproduction of misinformation (Fig. 2).

Conventionally, a single database is searched in a rapid review (Tricco et al. 2015); however, we also employed a grey literature database search to help expand and strengthen our search. Nevertheless, this review also has some limitations we need to acknowledge. The inclusion criteria may have been broad, but we felt this was necessary to capture literature on the different aspects of misinformation in outbreak scenarios adequately. Furthermore, in this review, we were unable to assess the quality of the literature, due to the variability in the type of records identified in the review.

This rapid review synthesizes knowledge about the different types of misinformation that prevail among the population during a large-scale infectious disease outbreak, how it originates and spreads, which individuals are most vulnerable to misinformation, and what factors potentiate the spread and impact of misinformation. This knowledge will help guide public health bodies, governments, researchers, media and other stakeholders to control the insidious effects of misinformation during the current COVID-19 pandemic and future disease outbreaks.

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References

Abu-rish EY, Elayeh ER, Browning MJ (2019) Physicians' knowledge, attitudes and practices towards Zika virus infection in Jordan. J Infect Dev Ctries 13:584–590. https://doi.org/10.3855/jidc.11356

Adebimpe WO, Adeyemi DH, Faremi A, Ojo JO, Efuntoye AE (2015) The relevance of the social networking media in Ebola virus disease prevention and control in southwestern Nigeria. Pan Afr Med J 22:7. https://doi.org/10.11694/pamj.supp.2015.22.1.6165

Albarracin D, Romer D, Jones C, Hall Jamieson K, Jamieson P (2018) Misleading claims about tobacco products in YouTube videos: experimental effects of misinformation on unhealthy attitudes. J Med Internet Res 20:e229. https://doi.org/10.2196/jmir.9959

Alqahtani AS, Rashid H, Basyouni MH, Alhawassi TM, BinDhim NF (2017) Public response to MERS-CoV in the Middle East: iPhone survey in six countries. J Infect Public Health 10:534–540. https://doi.org/10.1016/j.jiph.2016.11.015

Balami AD, Meleh HU (2019) Misinformation on salt water use among Nigerians during 2014 Ebola outbreak and the role of social media. Asian Pac J Trop Med 12:175–180. https://doi.org/10.4103/1995-7645.257118

Bali S, Stewart KA, Pate MA (2016) Long shadow of fear in an epidemic: Fearonomic effects of Ebola on the private sector in Nigeria. BMJ Glob Health 1:e000111. https://doi.org/10.1136/bmjgh-2016-000111

Boerner F, Keelan J, Winton L, Jardine C, Driedger SM (2013) Understanding the interplay of factors informing vaccination behavior in three Canadian provinces. Hum Vaccin Immunother 9:1477–1484. https://doi.org/10.4161/hv.24427

Bora K, Das D, Barman B, Borah P (2018) Are internet videos useful sources of information during global public health emergencies? A case study of YouTube videos during the 2015–16 Zika virus pandemic. Pathog Glob Health 112:320–328. https://doi.org/10.1080/20477724.2018.1507784

Broome ME (2000) Integrative literature reviews for the development of concepts. In concept development in nursing. In: Rogers BL, Knafi KA (eds) Concept development in nursing: foundations, techniques and application 2nd edn. Saunders, Philadelphia, pp 231–250

Buli BG, Mayigane LN, Oketta JF et al (2015) Misconceptions about Ebola seriously affect the prevention efforts: KAP related to Ebola prevention and treatment in Kouroussa prefecture, Guinea. Pan Afr Med J 22:11. https://doi.org/10.11694/pamj.supp.2015.22.1.6269

Carey JM, Chi V, Flynn DJ, Nyhan B, Zeitzoff T (2020) The effects of corrective information about disease epidemics and outbreaks: evidence from Zika and yellow fever in Brazil. Sci Adv 6:eaaw7449–eaaw7449. https://doi.org/10.1126/sciadv.aaw7449

Cheng VC-C, Wong S-C, Chuang VW-M et al (2020) The role of community-wide wearing of face mask for control of coronavirus disease 2019 (COVID-19) epidemic due to SARS-CoV-2. J Inf Secur 81:107–114. https://doi.org/10.1016/j.jinf.2020.04.024

Chew C, Eysenbach G (2010) Pandemics in the age of twitter: content analysis of tweets during the 2009 H1N1 outbreak. PLoS One 5:e14118. https://doi.org/10.1371/journal.pone.0014118

Chou W-YS, Oh A, Klein WMP (2018) Addressing health-related misinformation on social media. JAMA 320:2417. https://doi.org/10.1001/jama.2018.16865

Cinelli M, Quattrociocchi W, Galeazzi A et al (2020) The COVID-19 social media infodemic. Sci Rep 10:16598. https://doi.org/10.1038/s41598-020-73510-5

Cuan-Baltazar JY, Muñoz-Perez MJ, Robledo-Vega C, Pérez-Zepeda MF, Soto-Vega E (2020) Misinformation of COVID-19 on the internet: Infodemiology study. JMIR Public Health Surveill 6:e18444. https://doi.org/10.2196/18444

Dedrick A, Merten JW, Adams T et al (2020) A content analysis of Pinterest belly fat loss exercises: unrealistic expectations and misinformation. Am J Health Educ 51:328–337. https://doi.org/10.1080/19325037.2020.1795754

Ding H (2009) Rhetorics of alternative media in an emerging epidemic: SARS, censorship, and extra-institutional risk communication. Tech Commun Q 18:327–350. https://doi.org/10.1080/10572250903149548

Dubé E, Vivion M, MacDonald NE (2014) Vaccine hesitancy, vaccine refusal and the anti-vaccine movement: influence, impact and implications. Expert Rev Vaccines 14:99–117. https://doi.org/10.1586/14760584.2015.964212

Felter C (2020) Major epidemics of the modern era. Council on Foreign Relations. https://www.cfr.org/timeline/major-epidemics-modern-era. Accessed 13 Sep 2020

Fiscella K, Franks P, Clancy CM (1998) Skepticism toward medical care and health care utilization. Med Care 36:180–189. https://doi.org/10.1097/00005650-199802000-00007

Fowler RA, Fletcher T, Fischer WA et al (2014) Caring for critically ill patients with Ebola virus disease: perspectives from West Africa. Am J Respir Crit Care Med 190:733–737. https://doi.org/10.1164/rccm.201408-1514CP

Fung ICH, Fu KW, Chan CH et al (2016) Social media's initial reaction to information and misinformation on ebola, august 2014: facts and rumors. Public Health Rep 131:461–473. https://doi.org/10.1177/003335491613100312

Ghenai A, Mejova Y (2017) Catching Zika fever: application of crowdsourcing and machine learning for tracking health misinformation on twitter. In: proceedings - 2017 IEEE international conference on healthcare informatics, ICHI 2017. IEEE, p 518. https://doi.org/10.1109/ICHI.2017.58

Gidado S, Oladimeji AM, Roberts AA et al (2015) Public knowledge, perception and source of information on Ebola virus disease – Lagos, Nigeria; september, 2014. PLoS Curr. https://doi.org/10.1371/currents.outbreaks.0b805cac244d700a47d6a3713ef2d6db

Gostin LO, Friedman EA (2015) A retrospective and prospective analysis of the west African Ebola virus disease epidemic: robust national health systems at the foundation and an empowered WHO at the apex. Lancet 385:1902–1909. https://doi.org/10.1016/S0140-6736(15)60644-4

Haddaway NR, Collins AM, Coughlin D, Kirk S (2015) The role of Google scholar in evidence reviews and its applicability to Grey literature searching. PLoS One 10:e0138237. https://doi.org/10.1371/journal.pone.0138237

Kanadiya MK, Sallar AM (2011) Preventive behaviors, beliefs, and anxieties in relation to the swine flu outbreak among college students aged 18–24 years. Z Gesundh Wiss 19:139–145. https://doi.org/10.1007/s10389-010-0373-3

Kasereka MC, Hawkes MT (2019) The cat that kills people:' community beliefs about Ebola origins and implications for disease control in eastern Democratic Republic of the Congo. Pathog Glob Health 113:149–157. https://doi.org/10.1080/20477724.2019.1650227

Khangura S, Konnyu K, Cushman R, Grimshaw J, Moher D (2012) Evidence summaries: the evolution of a rapid review approach. Syst Rev 1:10. https://doi.org/10.1186/2046-4053-1-10

Khangura S, Polisena J, Clifford TJ, Farrah K, Kamel C (2014) Rapid review: an emerging approach to evidence synthesis in health technology assessment. Int J Technol Assess Health Care 30:20–27. https://doi.org/10.1017/S0266462313000664

Klofstad CA, Uscinski JE, Connolly JM, West JP (2019) What drives people to believe in Zika conspiracy theories? Palgrave Commun 5:36. https://doi.org/10.1057/s41599-019-0243-8

Koralek T, Runnerstrom MG, Brown BJ, Uchegbu C, Basta TB (2016) Lessons from Ebola: sources of outbreak information and the associated impact on UC Irvine and Ohio University College students. PLoS Curr. https://doi.org/10.1371/currents.outbreaks.f1f5c05c37a5ff8954f38646cfffc6a2

Kouzy R, Abi Jaoude J, Kraitem A, et al (2020) Coronavirus Goes viral: quantifying the COVID-19 misinformation epidemic on twitter. Cureus 12:e7255. https://doi.org/10.7759/cureus.7255

Kummervold PE, Schulz WS, Smout E, Fernandez-Luque L, Larson HJ (2017) Controversial Ebola vaccine trials in Ghana: a thematic analysis of critiques and rebuttals in digital news. BMC Public Health 17:642. https://doi.org/10.1186/s12889-017-4618-8

Laranjo L, Arguel A, Neves AL et al (2015) The influence of social networking sites on health behavior change: a systematic review and meta-analysis. J Am Med Inform Assoc 22:243–256. https://doi.org/10.1136/amiajnl-2014-002841

Lau JTF, Griffiths S, Choi KC, Tsui HY (2009) Widespread public misconception in the early phase of the H1N1 influenza epidemic. J Inf Secur 59:122–127. https://doi.org/10.1016/j.jinf.2009.06.004

Miller M, Banerjee T, Muppalla R, Romine W, Sheth A (2017) What are people tweeting about Zika? An exploratory study concerning its symptoms, treatment, transmission, and prevention. JMIR Public Health Surveill 3:e38. https://doi.org/10.2196/publichealth.7157

Naing C, Tan RYP, Soon WC, Parakh J, Sanggi SS (2012) Preventive behaviours towards influenza a(H1N1)pdm09 and factors associated with the intention to take influenza a(H1N1)pdm09 vaccination. J Infect Public Health 5:412–419. https://doi.org/10.1016/j.jiph.2012.07.005

Okan O, Bollweg TM, Berens EM et al (2020) Coronavirus-related health literacy: a cross-sectional study in adults during the COVID-19 infodemic in Germany. Int J Environ Res Public Health 17:1–20. https://doi.org/10.3390/ijerph17155503

Ortiz-Sánchez E, Velando-Soriano A, Pradas-Hernández L et al (2020) Analysis of the anti-vaccine movement in social networks: a systematic review. Int J Environ Res Public Health 17:1–11. https://doi.org/10.3390/ijerph17155394

Pennycook G, McPhetres J, Zhang Y, Lu JG, Rand DG (2020) Fighting COVID-19 misinformation on social media: experimental evidence for a scalable accuracy-nudge intervention. Psychol Sci 31:770–780. https://doi.org/10.1177/0956797620939054

Schmidt K, Ernst E (2004) Assessing websites on complementary and alternative medicine for cancer. Ann Oncol 15:733–742. https://doi.org/10.1093/annonc/mdh174

Seltzer EK, Jean NS, Kramer-Golinkoff E, Asch DA, Merchant RM (2015) The content of social media's shared images about Ebola: a retrospective study. Public Health 129:1273–1277. https://doi.org/10.1016/j.puhe.2015.07.025

Sharma M, Yadav K, Yadav N, Ferdinand KC (2017) Zika virus pandemic—analysis of Facebook as a social media health information platform. Am J Infect Control 45:301–302. https://doi.org/10.1016/j.ajic.2016.08.022

Shigemura J, Harada N, Tanichi M et al (2015) Rumor-related and exclusive behavior coverage in internet news reports following the 2009 H1N1 influenza outbreak in Japan. Disaster Med Public Health Prep 9:459–463. https://doi.org/10.1017/dmp.2015.57

Smith TO (2010) A little birdie told me: H1N1 information and misinformation exchange on Twitter. UALR - William H Bowen School of Law Legal Studies Research Paper No. 11:03

Smith PS, Torsiglieri JA, Pasley J, Esch R (2016) Stopping an epidemic of misinformation : How K – 12 Science Teachers Responded to Ebola Technical Report. http://www.horizon-research.com/stopping-an-epidemic-of-misinformation-how-k-12-science-teachers-responded-to-ebola-technicalreport. Accessed 13 Sep 2020

Sommariva S, Vamos C, Mantzarlis A, Đào LU-L, Martinez Tyson D (2018) Spreading the (fake) news: exploring health messages on social media and the implications for health professionals using a case study. Am J Health Educ 49:246–255. https://doi.org/10.1080/19325037.2018.1473178

Song J, Song TM, Seo DC, Jin DL, Kim JS (2017) Social big data analysis of information spread and perceived infection risk during the 2015 Middle East respiratory syndrome outbreak in South Korea. Cyberpsychol Behav Soc Netw 20:22–29. https://doi.org/10.1089/cyber.2016.0126

Stanley ML, Barr N, Peters K, Seli P (2020) Analytic-thinking predicts hoax beliefs and helping behaviors in response to the COVID-19 pandemic. Think Reason. https://doi.org/10.1080/13546783.2020.1813806

Tai Z, Sun T (2011) The rumouring of SARS during the 2003 epidemic in China. Sociol Health Illn 33:677–693. https://doi.org/10.1111/j.1467-9566.2011.01329.x

Tosta E (2020) Transmission of severe acute respiratory syndrome coronavirus 2 through asymptomatic carriers and aerosols: a major public health challenge. Rev Soc Bras Med Trop 53:e20200669. https://doi.org/10.1590/0037-8682-0669-2020

Tricco AC, Antony J, Zarin W et al (2015) A scoping review of rapid review methods. BMC Med 13:224. https://doi.org/10.1186/s12916-015-0465-6

Van den Broucke S (2020) Why health promotion matters to the COVID-19 pandemic, and vice versa. Health Promot Int 35:181–186. https://doi.org/10.1093/heapro/daaa042

Vaska M, Chowdhury M, Naidu J, Baig K, Turin T (2019) Exploring all that is grey in the health sciences: what is grey literature and how to use it for comprehensive knowledge synthesis. J Natl Heart Foundation Bangladesh 8:14–19

Vinck P, Pham PN, Bindu KK, Bedford J, Nilles EJ (2019) Institutional trust and misinformation in the response to the 2018–19 Ebola outbreak in north Kivu, DR Congo: a population-based survey. Lancet Infect Dis 19:529–536. https://doi.org/10.1016/S1473-3099(19)30063-5

Wang Y, McKee M, Torbica A, Stuckler D (2019) Systematic literature review on the spread of health-related misinformation on social media. Soc Sci Med 240:112552. https://doi.org/10.1016/j.socscimed.2019.112552

Wardle C, Derakhshan H (2017) Information disorder: toward an interdisciplinary framework for research and policy making. Council of Europe. https://rm.coe.int/information-disorder-toward-an-interdisciplinary-framework-for-researc/168076277c. Accessed 13 Sep 2020

Whittemore R, Knafl K (2005) The integrative review: updated methodology. J Adv Nurs 52:546–553. https://doi.org/10.1111/j.1365-2648.2005.03621.x

Wilson K (2002) The desktop guide to complementary and alternative medicine: an evidence-based approach. Ann Intern Med 136:A14. https://doi.org/10.7326/acpjc-2002-136-3-a14

Wood MJ (2018) Propagating and debunking conspiracy theories on twitter during the 2015–2016 Zika virus outbreak. Cyberpsychol Behav Soc Netw 21:485–490. https://doi.org/10.1089/cyber.2017.0669

World Health Organization (2020) Munich Security Conference. https://www.who.int/dg/speeches/detail/munich-security-conference. Accessed 13 Sep 2020

Zarocostas J (2020) How to fight an infodemic. Lancet 395:676. https://doi.org/10.1016/S0140-6736(20)30461-X