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 interrupting 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...
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 Knaff (2005) with adjustments suggested by other authors for a rapid review (Khangura et al. 2014; Tricco et al. 2015). As integrative reviews synopise 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...
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 SARS [MeSH] or SARS virus [MeSH] or 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:
- (“false news”) AND

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...
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.
| 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 |
|-------------------|---------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------|----------|-----------------------------------------------------------------------------|---------------------------------------------------|
| 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, 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 |
| 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 |
|------------------------|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|----------|-----------------------------------------------------------------------------------------------------------|--------------------------------------------------|
| 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%) | 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%), religious leaders (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      |
| 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 the captured 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%); television news (62.2%); 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 SNSSs               | Mixed-method Content analysis of Zika-related news stories on SNSSs Social media (Facebook, Twitter, LinkedIn, Pinterest, GooglePlus) | 120 stories                   | Florida, USA | Alternative media sources were the most popular sources of the news stories on SNSSs (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%) |
| 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 least one conspiracy theory; 7% believed in more than one conspiracy theory |
| 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 |
| 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 respondents (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 two or 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 about influenza A(H1N1) pdm09; 86% had a misconception about the |
| 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 |
|-----------------|----------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|-------------------------------|--------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------|-------------------------------------------------|
| 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)                                      | information from healthcare staff (39.1%) 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 Examinied 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                                                                                  | N/R                                             |
| Ding 2009       | To examine how professionals and the public used alternative media for unofficial communication about risks during the 2002 SARS outbreak in 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                                                                                      | N/R                                             |
| 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 | N/R                                             |
| Song et al. 2017 | To analyse the diffusion of information, 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                              | N/R                                             |
| COVID-19        | To assess 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                                             |
| 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 |
|--------------|--------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|-----------------------------|----------|---------------------------------------------------------------------------------------------------------|--------------------------------------------------|
| 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 failures to change behaviour in positive ways | Social media (Twitter, Instagram, YouTube, Reddit and Gab) and 7,465,721 comments produced by 3,734,815 users | 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 information regarding 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 claiming 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
| 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 | Abu-Rish et al. 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 | Fung et al. 2016 |
|                        |         | 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 |
|                        | MERS    | N/R                  |           |
|                        | COVID-19| N/R                  |           |
|                        | H1N1    | No treatment for H1N1 so no need for medical consultation | Lau et al. 2009 |
|                        | 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 |
| **Risk factor/causes** | Zika    | Direct contact between individuals | Abu-Rishng et al. 2019 |
|                        |         | Breastfeeding as modes of transmission | Abu-Rish et al. 2019 |
|                        | 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 |
| 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                                                                                 | Miller et al. 2017; Sommariva et al. 2018 |
|                        | Pesticide/larvicde causes microcephaly, not Zika virus |                                                                                     |                                   |
|                        | 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                                                                                 | Ghenai and Mejova 2017; Wood 2018 |
|                        | Microcephaly in Zika virus is caused by vaccines |                                                                                     |                                   |
|                        | 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                                                                                 |                                   |
|                        | COVID-19 | N/R                                                                                 |                                   |
|                        | H1N1 | The vaccine is not safe                                                            | Boerner et al. 2013; Kanadiya and Sallar 2011 |
|                        | Conspiracy | Zika                                                                                 | Sharma et al. 2017; Sommariva et al. 2018; Carey et al. 2020; Sommariva et al. 2018; Wood 2018 |
|                        | Zika virus is a hoax to cover up chemical teratogens manufactured by major multinational corporations |                                                                                     |                                   |
|                        | Brain deformation/microcephaly is caused by larvicde/pesticide, not the Zika virus. It is what they put in the drinking water |                                                                                     |                                   |
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 fabrica-
tion (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 pass-
ing 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...
| 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                    | Lack of accurate information                                                                               | Bali et al. 2016                                                        |
| communication-related            | Lack of public discourse about the disease or the safety and effectiveness of vaccination                  | Boerner et al. 2013                                                    |
|                                  | People not receiving sufficient information to make an informed decision                                     | Boerner et al. 2013                                                    |
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; Kløft 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

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

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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Declarations

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