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Health Misinformation on Social Media: A Systematic Literature Review and Future Research Directions

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Health Misinformation on Social Media: A Systematic Literature Review and Future Research Directions

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Abstract:

Health misinformation on social media is an emerging public concern as the COVID-19 infodemic tragically evidences. Key challenges that empower health misinformation's spread include rapidly advancing social technologies and high social media usage penetration. However, research on health misinformation on social media lacks cohesion and has received limited attention from information systems (IS) researchers. Given this issue's importance and relevance to the IS discipline, we summarize the current state of research on this emerging topic and identify research gaps together with meaningful research questions. Following a two-step literature search, we identify and analyze 101 papers. Drawing on the Shannon-Weaver communication model, we propose an integrative stage-based framework of health misinformation on social media. Based on literature analysis, we identify research opportunities and prescribe directions for future research on health misinformation on social media.

Keywords: Health Misinformation, Fake News, Social Media, Literature Review, Shannon-Weaver Model of Communication, Stage-based Framework, Research Directions.

Dov Te'eni was the accepting senior editor for this paper.

1 Introduction

Social media platforms such as Facebook, Twitter, Reddit, and Weibo have become major venues for people to seek and exchange information, especially during public crises (Oh et al., 2013; Nabity-Grover et al., 2020). However, because these platforms lack information gatekeepers, misinformation can relatively easily contaminate their information ecosystem (Oh et al., 2013). Misinformation refers to distorted, false, inaccurate, or misleading information that does not reflect the true state of the world (Appan & Browne, 2012). Due to its increasing importance and relevance, dictionary.com, one of the largest online dictionary websites, even named "misinformation" as the word of the year in 2018. Misinformation is rampant across various topics, which includes health-related issues. Unlike misinformation on other subjects, health misinformation can impact an individual's health status and even life (Wiederhold, 2017; Li et al., 2017). For example, the constant barrage of anti-vaccine information on social media has caused a reluctance in people to vaccinate themselves and vaccine preventable diseases (Broniatowski et al., 2018; Zaidi & Flores-Romo, 2020). The coronavirus disease of 2019 (COVID-19) infodemic infamously evidences misinformation on social media (Zheng et al., 2022; Chen & Fu, forthcoming). The spread of health misinformation in the COVID-19 pandemic has led the World Health Organization to warn that the world currently fights an "infodemic" (World Health Organization, 2020). The infodemic makes it difficult for people to find trustworthy and reliable information, which hinders response efforts to counteract the current outbreak (Huang et al., 2022).

Health misinformation's prevalence and associated devastating impact have received increasing academic attention across disciplines, such as medicine and healthcare (e.g., Chua & Banerjee, 2017; Albarracin et al., 2018), information science and information systems (IS) (e.g., Zhang et al., 2015; Li et al., 2017; Laato et al., 2020), and communication (e.g., Vraga & Bode, 2017, 2018), especially after the COVID-19 outbreak. Our preliminary review indicates that the number of studies on health misinformation on social media has increased dramatically in 2020 and 2021. Despite growing momentum, current research on health misinformation on social media remains fragmented with diverse perspectives and disciplinary backgrounds in understanding health misinformation on social media. Given this issue's importance and relevance to IS researchers, we need to structure the existing accumulated knowledge to guide future investigations. IS scholars have also called for systematic reviews to track emerging disciplines and build a benchmark for efforts to develop new theories (Webster & Watson, 2002; Noorbergen et al., 2021; Wenninger et al., 2021). We need to develop new theories related to health misinformation to guide human-computer interaction (HCI) research to understand how different stakeholders behave (e.g., senders, transmitters, and receivers) in response to health misinformation on social media (Rogers, 2004; Scialdone, 2010). In this regard, we systematically review previous studies on this emerging topic, define the current research state, identify the potential research gaps and opportunities, and provide directions and guidelines for future HCI research on health misinformation on social media. We also synthesize current knowledge on health misinformation on social media to assist in efforts to prevent health misinformation from spreading on social media.

This paper proceeds as follows: in Section 2, we clarify how research has defined health misinformation in the social media context. In Section 3, we describe how we searched and identified relevant literature. In Section 4, we then describe the current state of research on health misinformation on social media, which includes research trends, research nature (i.e., health misinformation types and unit of analysis), theoretical foundations, and research methods. In Section 5, we provide an integrative stage-based framework to analyze the key variables that the literature has examined. In Section 6, we discuss our findings' implications and conclude the paper.

2 Terminology and Research Scope

Social science researchers, especially in the healthcare and communication disciplines, have widely investigated the spread of false or inaccurate information (e.g., Oh et al., 2013; Wang & Song, 2020; Ali et al., 2022). We focus on health misinformation in our literature review for several reasons. First, health misinformation represents a major type of misinformation on social media. Social media has greatly changed the way people exchange information, especially health information. Individuals increasingly rely on social media and virtual communities to seek social support and companionship activities (Chen & Shen, 2015; Santos et al., 2022). For example, almost 90 percent of older users surveyed in America visited popular social media to find and share health information (Tennant et al., 2015). While the first-hand experience that patients share may be helpful for prevention and treatment, it lacks accreditation from medical authorities, which results in a cacophony of true and false health information circulating on social media (Brady et al.,

2017; Chou et al., 2018). Second, misinformation can easily contaminate information about health issues, such as vaccines, cancer prevention and treatment, and infectious disease outbreaks (Chou & Gaysynsky, 2020). As a result, health misinformation poses potentially more harm than other types of misinformation since its spread may profoundly influence individuals' wellbeing and even life (Wiederhold, 2017; Li et al., 2017). As the literature has reported, health misinformation has caused some tragedies (Spiteri Cornish & Moraes, 2015), and anti-vaccine misinformation also reduces vaccination (Broniatowski et al., 2018; Zaidi & Flores-Romo, 2020). In particular, HCI researchers have a strong interest in the direct impact that health misinformation has on individuals' wellbeing and health status and the ability to understand the role that social and technical components play in generating and preventing IT-enabled deviance (i.e., health misinformation on social media) (Ransbotham et al., 2016). IS researchers have become increasingly interested in how health information spreads on social media (Laato et al., 2020; Schuetz et al., 2021). Third, focusing on a specific type of misinformation will make the literature review more specific and focused. Because misinformation has become a popular topic across many disciplines and researchers have conducted many studies on it, we could not feasibly manage them to obtain a specific framework to guide practice. By focusing on health misinformation in particular, we focus on identifying both common findings that can generalize to other contexts and specific findings to the health misinformation context to help prevent health misinformation from spreading on social media.

In prior research, terms such as misinformation, disinformation, rumors, fake news, misleading information, hoax, and other variations coexist, which has led to conceptual ambiguity. Table 1 summarizes how studies define these similar terms in the literature. As Table 1 shows, one can distinguish the terms in regard to whether one has a deliberate intention to deceive/harm others and the level of factual information (Tandoc et al., 2018; Molina et al., 2019; Zannettou et al., 2019). In our study, we use misinformation as an umbrella concept to describe different types of false or inaccurate information. We define misinformation as distorted or false information that does not reflect the true state of the world (Appan & Browne, 2012). This definition does not consider a deliberate intention to deceive others and, thus, views misinformation as covering false information in general. Moreover, during the paper-identification stage in our literature review, we noticed that papers have used the term "misinformation" the most frequently (i.e., in 52 out of 101 studies). Therefore, we found it appropriate to use the term "misinformation" to define the literature review's scope.

In the Web 2.0 era, many consider social media responsible for the prevalence of health misinformation (Fernández-Luque & Bau, 2015; Brady et al., 2017). First, people have a stronger desire to share their first-hand treatment experience—which may not be accurate—on social media communities than on general online platforms in order to help their friends and make a social contribution (Nabity-Grover et al. 2020). Moreover, people are more likely to rely on health information that their friends share to make decisions than information from online search engines (Zhao & Zhang, 2017). Thus, health misinformation on social media may be more harmful than general Internet health misinformation. Second, compared with health information on websites, health information in social media tends to be oversimplified and can omit some subtle but important details (Brady et al., 2017). Third, the echo chamber effect can exacerbate health misinformation's spread (Chou et al., 2018; Wang & Song, 2020). Social media connects like-minded people into a closed network in which people share similar content, which amplifies the risks that misinformation causes (Brady et al., 2017; Chou et al., 2018). Thus, unlike Web-based health misinformation, which affects individual health, misinformation on social media may lead to community-level problems (Pal et al., 2019; Li et al., 2022). Given social media's prevalence and the serious consequences that health misinformation on social media can cause, we focus on health misinformation on social media.

Table 1. Terminology and Definitions

Terminology	Definitions and subtypes	Studies
Misinformation	Misinformation refers to distorted, false, or other erroneous or misleading information that does not reflect the true state of the world or true state of mind of the person communicating the information regardless whether the person intends to deceive others. Wardle and Derakhshan (2017) classified misinformation into 1) false connection (which describes the headlines, visuals, or captions do not support the content) and 2) misleading content (which describes using information in a misleading way to frame an issue or individual).	Appan & Browne (2012), Wardle & Derakhshan (2017), Chen et al. (2018)
Disinformation	Disinformation refers to false or misleading information that one spreads deliberately to deceive. That is, disinformation refers to misinformation with a deliberate intention to deceive or mislead others. Therefore, disinformation relates to deception. Wardle and Derakhshan (2017) classified disinformation into 1) false context (which refers to sharing genuine content with false contextual information), 2) imposter content (which describes impersonating genuine sources), 3) manipulated content (which describes manipulating genuine information or imagery to deceive), and 4) fabricated content (which involves 100% false content that one designed to deceive and do harm).	Appan & Browne (2012), Wardle & Derakhshan (2017)
Fake news	Fake news refers to false stories that appear to be news and spread on the Internet and other media. Actors usually create fake news to influence political views or as a joke. Tandoc et al. (2018) proposed a fake news definition typology based on intentionality and facticity levels. The typology includes native advertising, propaganda, manipulation, fabrication, news satire, and news parody. Zannettou et al. (2019) identified four types of fake news: 1) fabricated news (which refers to completely fictional stories disconnected entirely from real facts with the only goal to mislead others), 2) propaganda (which refers to fabricated stories with the goal to hurt a particular party), 3) imposter (which describes news stories whose author/source impersonates to mislead others), and 4) conspiracy theories (which refer to stories by mostly governments or powerful individuals that try to explain a situation or an event by invoking a conspiracy without proof). Waszak et al. (2018) identified three categories of fake medical news: 1) fabricated news (which refers to completely fictitious information about medical facts), 2) manipulated news (which refers to true basic information but false conclusions), and 3) advertisement news (which refers to stories to criticize conventional therapies and advertise products).	Allcott & Gentzkow (2017), Tandoc et al. (2018), Zannettou et al. (2019), Waszak et al. (2018), Molina et al. (2019)
Rumor	Rumor refers to unconfirmed bits of information. Sommariva et al. (2018) distinguished rumors as belonging to three categories: 1) misleading content (which describes inaccurate information that attempts to frame an issue), 2) false content (which describes partially true information) and 3) fabricated content (which describes completely fake information).	Chua & Banerjee (2017, 2018); Zhou et al. (2018), Sommariva et al. (2018)
Misleading or ambiguous news	Misleading news refers to news stories that involve using information in a misleading way to make receivers obfuscate and overlook facts. Zannettou et al. (2019) identified three types of misleading/ambiguous news: 1) rumors (which describe stories with ambiguous or unconfirmed truthfulness), 2) clickbait (which refers to deliberately using misleading headlines and content thumbnails on the Web), and 3) satire news (which refers to stories that contain a lot of irony and humor).	Wardle & Derakhshan (2017), Zannettou et al. (2019)

3 Literature Search and Identification

We followed the established process that Webster and Watson (2002) described to conduct a systematic literature search (see Figure 1). First, we generated a paper set by searching Web of Science, a well-established and comprehensive database that includes literature from various disciplines. The search keywords included three parts (see Figure 1): 1) health-related keywords, 2) social media-related keywords, and 3) misinformation-related keywords. We searched these keywords in different combinations in the title,

abstract, author keywords, and keywords plus fields in the Web of Science. We included all electronic databases in the Web of Science for our literature search. In total, we identified 458 papers.

We then applied inclusion and exclusion criteria to ensure that we retained only relevant studies to our research focus. We omitted gray literature (e.g., conference papers, dissertations, and proceedings) due to the challenges in its identification and accessibility that can limit replication attempts and knowledge generation (Chan et al., 2021). By doing so, we created a manageable paper sample that added value to our principal investigation. We applied the following inclusion criteria: 1) the paper used English and had a publish date between 2000 and 2020, 2) a peer-review journal published the paper, and 3) the paper focused on health misinformation. Moreover, we applied the following exclusion criteria: 1) the paper was not a regular research paper (e.g., an editorial, literature review, or viewpoint paper), 2) the paper was not academic in nature and had no research design, 3) the health misinformation came from the Internet rather than from social media specifically, 4) the paper focused on creating a novel misinformation-detection approach and used health misinformation only as an empirical example. After applying inclusion and exclusion criteria, we retained 101 papers for subsequent analysis.

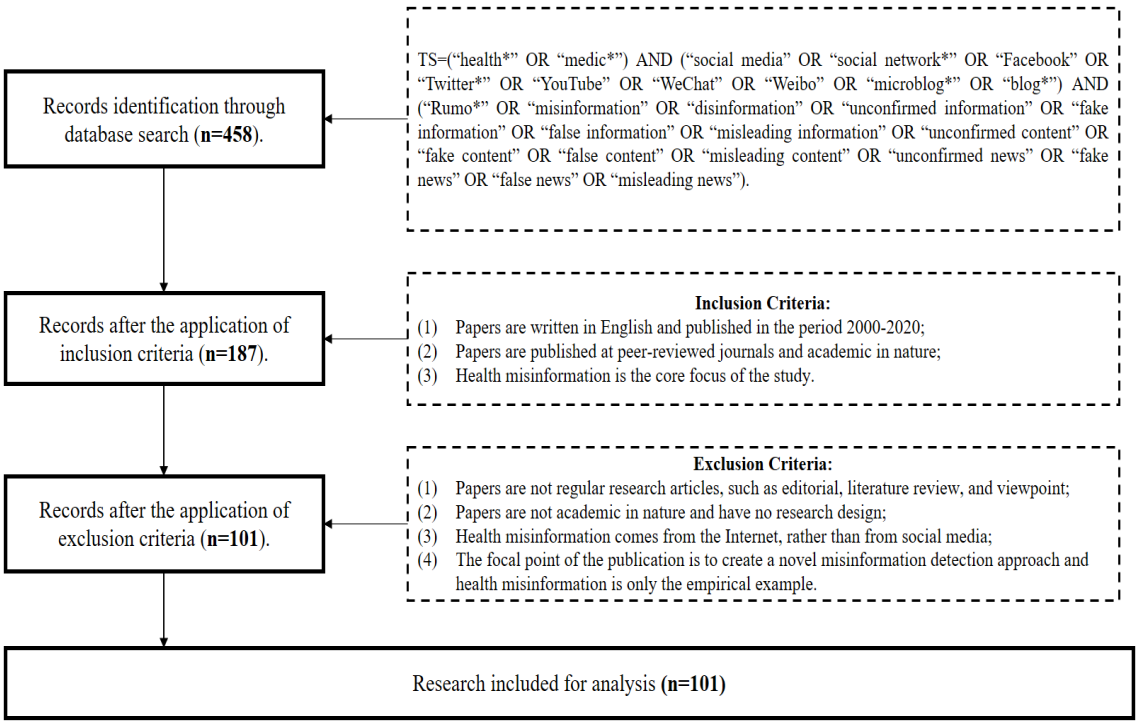

Figure 1. Literature Search and Identification Procedures

4 The State of Research on Health Misinformation on Social Media

In this section, we followed Hoehle et al. (2012) and Chan et al. (2021) and used several questions to guide how we analyzed the literature we identified:

1. What research trends could we identify in the literature?
2. What features does health misinformation research exhibit?
3. What theories and frameworks did the literature adopt?
4. What research methods did the literature use?
5. What key variables did the literature examine?

In particular, we independently classified the identified papers in regard to their discipline, unit of analysis, methods, and theories. We then discussed disagreements together until we reached consensus.

4.1 Research Trends

As we show in Table 2, health misinformation on social media has become an increasingly popular research topic in recent years. We classified each paper's primary research discipline based on publication outlet. In particular, we directly referred to the publisher's journal descriptions and intended audience. While research on health misinformation debuted in 2013 in the medicine and healthcare discipline, it grew significantly from 2018 before peaking in 2020. Indeed, papers published in 2020 account for over 60 percent of all publications in our observed time frame mainly due to the COVID-19 pandemic, which has provided fertile ground for health misinformation to propagate on social media across demographics and regions. The widespread, devastating, and lasting impact of health misinformation related to COVID-19 has attracted increasing academic attention. We can attribute most of this growth to medicine and healthcare research (75 out of 101 studies or 74.3%). Other disciplines, such as communication, information science, and psychology, also show increasing interest in this topic. In particular, we found eight interdisciplinary studies on health misinformation on social media (7.9%). We found only one study on health misinformation in an IS journal. Health misinformation's spread on social media constitutes a complicated phenomenon that requires solutions from different disciplines, such as medicine and healthcare, information science, communication, IS, and other related disciplines. Therefore, health misinformation on social media is a young but promising research topic, which also provides rich opportunities for HCI researchers to gain insights from other disciplines to investigate individuals' behaviors related to health misinformation on social media. Table 2 depicts the publication time separated by discipline.

Table 1. The Overview of Research Trends

Discipline	2013	2015	2016	2017	2018	2019	2020	Total (%)
Communication		1		1		3	5	10 (9.9%)
Computer science					1	1		2 (2.0%)
Information science				1	1	1		3 (3.0%)
Information systems							1	1 (1.0%)
Interdisciplinary					1	1	6	8 (7.9%)
Medicine and healthcare	1		1	2	8	15	48	75 (74.3%)
Psychology			1				1	2 (2.0%)
Total (%)	1 (1.0%)	1 (1.0%)	2 (2.0%)	4 (4.0%)	11 (10.9%)	21 (20.8%)	61 (60.4%)	101 (100%)

4.2 Health Misinformation Research Features

Table 3 shows that health misinformation appears most frequently during a pandemic or epidemic period (e.g., COVID-19, Ebola, and Zika) as uncertainty and anxiety breed great opportunities for misinformation to spread. The papers that addressed pandemic misinformation accounted for 27.7 percent of the identified studies. The papers addressed vaccination accounted for 23.8 percent of identified studies. We also found that 21 studies (20.8%) focused on misinformation of certain diseases, such as autoimmune diseases, urology, cancer, and anorexia. Moreover, only 21 studies (i.e., 20.8%) took the human subject as the unit of analysis and examined human emotional, cognitive, and behavioral issues related to health misinformation's spread. In contrast, the remaining studies (i.e., 79.2%) focused on health misinformation itself and identifying health misinformation features.

Table 3. Health Misinformation Types and Units of Analysis

Health misinformation type	Human subject	Nonhuman subject	Total (%)
Certain disease	0	21	21 (20.8%)
Pandemic	6	22	28 (27.7%)
Vaccine	8	16	24 (23.8%)
Others	7	21	28 (27.7%)
Total (%)	21 (20.8%)	80 (79.2%)	101 (100%)

4.3 Theoretical Foundations

Among the 101 identified papers, only 18 adopted theories to examine health misinformation on social media. As Table 4 shows, the studies adopted various theories. Specifically, most theories involve explaining which health misinformation features can influence health misinformation's spread on social media, such as rumor theory (Chua & Banerjee, 2018; Zhou et al., 2018), cultural attraction theory (Berriche & Altay, 2020), the theory of negativity bias (Chua & Banerjee, 2018), social network theory (Mututwa & Matsilele, 2020; Moukarzel et al., 2020), social cognitive theory (SCT) (Dedrick et al., 2020), exemplification theory (Guidry et al., 2020), and data-frame theory (Madathil & Greenstein, 2018). Some research used the theory of planned behavior to identify salient beliefs that can motivate individuals to share rumor denials to correct misinformation on social media, which includes behavioral beliefs, normative beliefs, and control beliefs (Pal et al., 2019). However, some theories, such as motivated reasoning (Bode & Vraga, 2015, 2018; Vraga & Bode, 2017, 2018) and the theory of boomerang effect (Chua & Banerjee, 2018), indicate that it is difficult to correct health misinformation on social media because people tend to accept confirmatory information to protect their preexisting attitudes (Bode & Vraga, 2015, 2018) and rumor denials sometimes have the potential to backfire by reinforcing the refuted rumors (Chua & Banerjee, 2018). Furthermore, some research used inoculation theory to highlight the important role that preventative health perceptions and behaviors play in preventing health misinformation from spreading on social media (Vraga et al., 2019). Some theories explain why individuals intend to share health misinformation on social media, such as protection motivation theory, cognitive load theory, and health belief model (Laato et al., 2020; Guidry et al., 2020). Research also used the theory of epistemic trust (Sharon et al., 2020) and the credibility, accuracy, reasonableness, and support checklist (i.e., CARS checklist) framework (Li et al., 2017) to determine which health information features would predict health misinformation on social media. This overview of theoretical foundations indicates that theory drove only a small number of studies, which makes it difficult to obtain meaningful conclusions from them to guide HCI designs. Considering HCI researchers in the IS discipline highly value theory-driven empirical research (Rogers, 2004; Scialdone, 2010), HCI researchers can play a significant role in exploring this important research topic.

Table 4. An Overview of Theoretical Foundations

Theoretical foundation	Description	Application
CARS checklist framework	This framework evaluates online information quality. Credibility, accuracy, reasonableness, and support constitute the framework's constructs (Harris, 1997).	Li et al. (2017) used this framework to identify the salient features of health misinformation on social media.
Cognitive load theory	This theory indicates that human brains possess limited processing capabilities, which may lead to overloaded states. It is based on the division of human memory into long and short-term memory (Sweller, 2011).	Laato et al. (2020) used this theory to explain in which case people are likely to share unverified health information (e.g., information load).
Cultural attraction theory	This theory "provides conceptual tools and a theoretical framework for explaining why and how ideas, practices, artifacts, and other cultural items spread and persist in a community and its habitat. It states that cultural phenomena result from psychological or ecological factors of attraction" (Heintz, 2018, p. 1).	Berriche and Altay (2020) used this theory to explain whether the presence of cognitive factors of attraction (e.g., information related to sexuality, social relations, threat, disgust, or negative emotions) involved in misinformation could influence the spread of health misinformation on social media.
Data-frame theory	This theory suggests that the initial frame, which is important to the sensemaking process, is anchored by initial data elements (Klein et al., 2006).	Madathil and Greenstein (2018) used this theory to explain why people weighed health misinformation more heavily when it was presented before the accurate information than when it is presented after that information.
Health belief model	This model establishes a link between psychological and demographic variables to affective and cognitive states, such as health motivation or perceived benefits. These are, in turn, connected to behavioral responses (Sheeran & Abraham, 1996).	Laato et al. (2020) and Guidry et al. (2020) used this theory to explain why people share unverified health information (e.g., perceived severity and perceived susceptibility).

Table 4. An Overview of Theoretical Foundations

Inoculation theory	This theory draws parallels of individuals being inoculated against attitude attacks in the same way as individuals can be inoculated against viral attacks (Compton & Pfau, 2005).	Vraga et al. (2019) and Featherstone and Zhang (2020) used this theory to highlight the importance of preventative health perceptions and behaviors in combating the spread of health misinformation on social media.
Motivated reasoning	The theory indicates that individuals tend to accept confirmatory information to protect their pre-existing attitudes (Jerit & Barabas, 2012).	Bode and Vraga (2015, 2018) and Vraga and Bode (2017, 2018) used this theory to explain why it is difficult to correct health misinformation that matches individuals' existing beliefs.
Protection motivation theory	This theory evaluates the causes for an individual's protective health measure adoption (Prentice-Dunn & Rogers, 1986).	Laato et al. (2020) used this theory to explain why people share unverified health information (e.g., perceived severity and perceived susceptibility).
Rumor theory	This theory refers to "a collective and collaborative transaction in which community members offer, evaluate, and interpret information to reach a common understanding of uncertain situations, to alleviate social tension, and to solve collective crisis problems" (Oh et al., 2013, p. 409).	Chua and Banerjee (2018) and Zhou et al. (2018) used this theory to explain the factors that influence rumor propagation, such as anxiety, source and content ambiguity, personal involvement, and social ties.
Social network theory	"Social network theory focuses on the role of social relationships in transmitting information, channeling personal or media influence, and enabling attitudinal or behavioral change" (Liu et al., 2017, p. 1).	Mututwa and Matsilele (2020) and Moukarzel et al. (2020) used this theory to explain the accelerated rate at which (mis)information spreads on social media if it originates from an influential person or arouses public interest.
Theory of boomerang effect	This theory indicates that "messages designed to change a behavior can trigger a behavioral shift in a direction opposite to that of the intended outcome" (Chua & Banerjee, 2018, p. 3).	Chua & Banerjee (2018) used this theory to explain why the presence of counter-rumors might reinforce refuted rumors.
Theory of epistemic trust	This theory examines the evaluations of expert knowledge by individuals, highlighting the "depend[ence] on the knowledge of others who are more knowledgeable" while outlining "a vigilance toward the risk to be misinformed" (Hendriks et al., 2016, p. 143).	Sharon et al. (2020) used this theory to examine which (mis)information features predict perceived trustworthiness and information quality.
Theory of negativity bias	This theory indicates that negative information is likely to affect an individual's attitudes and behaviors stronger than neutral or positive information (Cacioppo & Berntson, 1994).	Chua and Banerjee (2018) used this theory to explain why dread rumors have a stronger influence than wish rumors.
Theory of planned behavior	This theory indicates that "intentions to perform behaviors of different kinds can be predicted with high accuracy from attitudes toward the behavior, subjective norms, and perceived behavioral control; and these intentions, together with perceptions of behavioral control, account for considerable variance in actual behavior" (Ajzen, 1991, p. 179).	Pal et al. (2019) used this theory to help identify salient beliefs that influence whether individuals share rumor denials, such as behavioral beliefs, normative beliefs, and control beliefs.
Social cognitive theory (SCT)	"Social cognitive theory provides an agentic conceptual framework within which to analyze the determinants and psychosocial mechanisms through which symbolic communication influences human thought, affect, and action" (Bandura, 2001, p. 265).	Dedrick et al. (2020) used this theory's constructs to guide their analysis on how health (mis)information drives receivers' engagement behavior.
Exemplification theory	This theory argues that single exemplars can have a stronger influence on shifting attitudes if they are portrayed in a more specific rather than generic manner (Zillmann, 2006).	Guidry et al. (2020) used this theory to examine the use of exemplars in (mis)information posts and their influence on receiver perceptions.

4.4 Research Methods

As Table 5 shows, prior literature has adopted many different research methods to examine health misinformation on social media. However, studies most commonly adopted content analysis (i.e., 73.3%) as they considered the health misinformation itself as the unit of analysis (see Table 3). Research mainly used content analysis to identify health misinformation features (e.g., Syed-Abdul et al., 2013; Gallotti et al., 2020; Zhou et al., 2018), analyze the spreading metrics of health misinformation (e.g., Rovetta & Bhagavathula, 2020; Mututwa & Matsilele, 2020), and evaluate the quality of health information on social media (e.g., Dedrick et al., 2020; Ataç et al., 2020; Arikanoglu et al., 2020). As a result, this research provided some thumb rules to judge health misinformation on social media. We identified experimental design as the second most common research method (i.e., 15.8%). Studies used this method to manipulate the types and presence of health misinformation and examine their impact on individuals' responses (e.g., Albarracin et al., 2018; Madathil & Greenstein, 2018; Chua & Banerjee, 2018). Other studies also used the experimental design to evaluate the effectiveness of different intervention strategies (Bode & Vraga, 2015, 2018; Vraga & Bode, 2017, 2018). We also found that some studies used interviews and surveys to explore and examine individuals' cognition and behaviors in relation to health misinformation. In particular, as major forms of HCI research methods, experiments, interviews, and surveys mainly regard human subjects as the unit of analysis to examine their opinions and responses to health misinformation on social media. Finally, three studies leveraged a mixed-methods approach to examine health misinformation on social media and its impact on propagation (Sommariva et al., 2018; DeDominicis et al., 2020; Moukarzel et al., 2020).

Table 5. An Overview of Research Methods

Research method	Applications	Studies	Total (%)
Content analysis	Studies used content analysis to identify the features of health misinformation, such as the informational features (e.g., sources, formats, lengths, and elements), spreading metrics (e.g., the number of likes, shares, and comments), and information quality (e.g., high, low, or ambiguity).	Syed-Abdul et al. (2013), Gallotti et al. (2020), Zhou et al. (2018), Rovetta & Bhagavathula (2020), Mututwa & Matsilele (2020), Dedrick et al. (2020), Ataç et al. (2020), Arikanoglu et al. (2020)	74 (73.3%)
Experiment	Studies used experiments to examine individual's responses to different scenarios involved in the spread of health misinformation, such as different intervention strategies and different types of health misinformation.	Albarracin et al. (2018), Bode & Vraga (2015, 2018), Vraga & Bode (2017, 2018), Chua & Banerjee (2018)	16 (15.8%)
Interviews	Studies used interviews to inductively explore individuals' cognition and behaviors in the spread of health misinformation.	Trembath et al. (2015), Steffens et al. (2019, 2020)	3 (3.0%)
Survey	Studies used surveys to collect individuals' subjective evaluations and responses to health misinformation.	Laato et al. (2020), Balami & Meleh (2019), Almomani & Al-Qur'an (2020)	5 (5.0%)
Mixed-methods approach	Studies used a mixed-methods approach that combines qualitative (e.g., interview) and quantitative (e.g., social network analysis) research methods to examine individuals' evaluation and responses to health misinformation.	Sommariva et al. (2018), DeDominicis et al. (2020), Moukarzel et al. (2020)	3 (3.0%)

5 A Stage-based Framework of Heath Misinformation on Social Media

To review and summarize key variables that prior research on health misinformation on social media examined, we build on the Shannon-Weaver model of communication (SWMC) (Shannon, 1948) to propose a stage-based framework of health misinformation on social media. The SWMC comprises a sender (i.e., information source), message, a transmission medium (i.e., channels and noise), a receiver, and the destination. As such, it yields a simple but powerful way to abstract human information communication (see Figure 2) (Shannon, 1948; Chalmers, 1996).

Based on the SWMC, we classify health misinformation's propagation on social media into four stages:

1) The originating stage, which involves the health misinformation's source (i.e., the actors who send/create health misinformation) and the resulting health misinformation
2) The transmitting stage, which involves social media platforms (i.e., the channels) and intervention strategies (i.e., the noise in the SWMC)
3) The consuming stage, which involves the receivers and their reactions to the spread of health misinformation, and
4) The impacting stage, which involves the impact that health misinformation has on individuals (also known as the individual reactions in the consuming stage) and societies, which will, in turn, influence health information's origination (i.e., the feedback in the SWMC).

For example, the panic that results from health misinformation will, in turn, fuel the further production and propagation of health misinformation on social media (Gallotti et al., 2020). Figure 3 illustrates our proposed stage-based framework of health misinformation on social media. We next discuss key variables that we identified from the literature and cluster them in each health misinformation stage. Table 6 overviews key variables that we identified from the literature review.

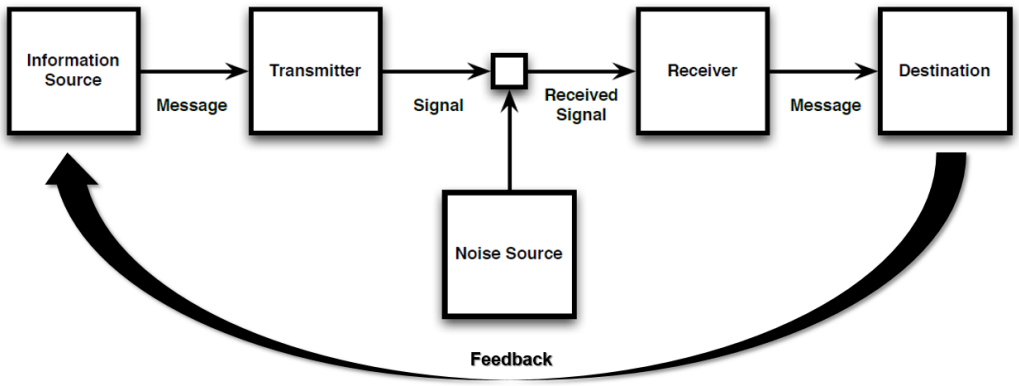

Figure 2. The Shannon-Weaver Model of Communication (Shannon, 1948)

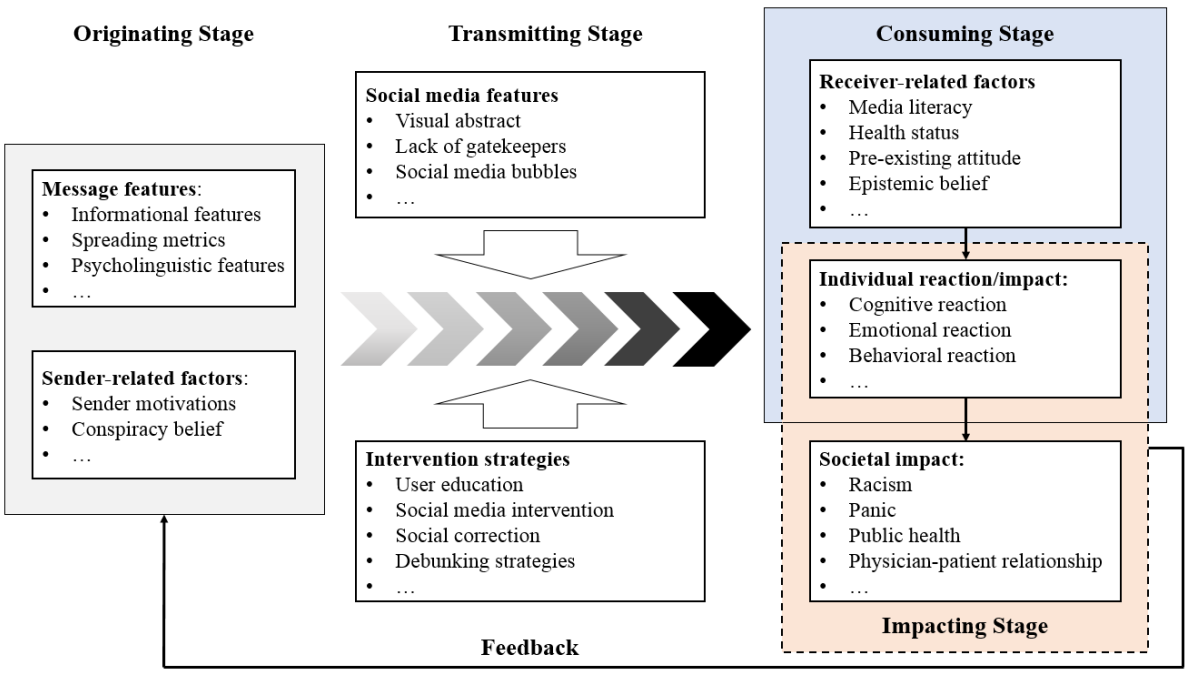

Figure 3. A Stage-based Framework of Heath Misinformation on Social Media

5.1 The Originating Stage of Health Misinformation on Social Media

The originating stage of health misinformation describes the process by which actors produce and create health misinformation on social media. We identified two clusters of key variables from the literature on health misinformation on social media in this stage: message and sender.

5.1.1 Message

The message cluster mainly involves identifying key health misinformation features and elements, which include:

1) Informational features, such as format (e.g., pictorial, auditory, or textual) (Syed-Abdul et al., 2013; Gallotti et al., 2020; Zhou et al., 2018; Bail, 2016), length (Zhou et al., 2018; Zhang et al., 2015; Smith & Seitz, 2019), and social ties (e.g., the external links, tags, or mentions) (Zhou et al., 2018)

2) Psycholinguistic features, such as ambiguity (Zhang et al., 2015), emotional valence (e.g., wish or dread rumor) (Chua & Banerjee, 2017; Zhou et al., 2018; Berriche & Altay, 2020), and emotional language (sensational or exaggerated content) (Chen et al., 2018; Waszak et al., 2018), and

3) Spreading metrics, such as the number of likes, shares, comments, or views (e.g., Rovetta & Bhagavathula, 2020; Mututwa & Matsilele, 2020). These studies mostly adopted a descriptive approach and reported the characteristics of misinformation on major social media platforms (e.g., Fode et al., 2020; Dutta et al., 2020).

5.1.2 Sender

The sender cluster mainly involves senders' motivation behind sharing health misinformation and their characteristics. The potential motivations include financial motivation (e.g., marketing motivation or monetary motivation) (Trembath et al., 2015; Ahmed et al., 2020a; Mourad et al., 2020), capturing social attention (Gallotti et al., 2020; Mututwa & Matsilele, 2020), self-promotion motivation (i.e., seeking prestige) (Trembath et al., 2015), helping others (Laato et al., 2020), and causing damage (Mourad et al., 2020; Steffens et al., 2019). Sender features include source credibility (Gallotti et al., 2020; Mututwa & Matsilele, 2020) and conspiracy belief (Waszak et al., 2018; Bode & Vraga, 2018).

5.2 The Transmitting Stage of Health Misinformation on Social Media

The transmitting stage of health misinformation mainly involves the process by which health misinformation diffuses and propagates on social media. We identified two clusters of key variables in this stage: social media (i.e., transmission medium in the SWMC) and intervention strategies (i.e., the noise in the SWMC).

5.2.1 Social Media

The social media cluster mainly covers social media features that explain how health misinformation propagates and continues to spread on social media, such as visual abstract (i.e., content limitation or oversimplification on social media) (Brady et al., 2017), social media bubbles (Mitchell, 2019; Brady et al., 2017; Smith & Seitz, 2019; Sullivan, 2019), information overload (Sommariva et al., 2018; Trembath et al., 2015), the presence of debunking information (Chua & Banerjee, 2018), and the lack of information gatekeepers (Smith & Seitz, 2019; Steffens et al., 2019).

5.2.2 Intervention Strategies

The intervention strategies cluster involves strategies to prevent health misinformation from spreading on social media. Major intervention strategies include:

1) Educating or empowering users with high health or information literacy (Syed-Abdul et al., 2013; Sullivan, 2019; Pulido et al., 2020a)

2) Efforts from social media platforms, such as increasing the visibility of misinformation correction posts or articles (Bode & Vraga, 2015, 2018), automatically detecting and removing health misinformation (Ahmed et al., 2020a; Pulido et al., 2020a), flagging or warning (Featherstone & Zhang, 2020; Ahmed et al., 2020a), and banning misinformation spreaders (Mourad et al., 2020), and

3) Social correction, which involves highlighting the role of peers, influencers, and experts in rating and correcting health misinformation (Syed-Abdul et al., 2013; Bode & Vraga, 2018; Lavorgna et al., 2018; Sommariva et al., 2018; Vraga & Bode, 2018) and increasing the social media presence of health experts and organizations (Steffens et al., 2019; Ahmed et al., 2020a; Pulido et al., 2020b).

Some studies also examined strategies to debunk health misinformation on social media. Specifically, health organizations should communicate health information transparently and respond to the public's fears and concerns (Gesser-Edelsburg et al., 2018). Correcting health misinformation timely and using humor to deliver corrections are also helpful to address health misinformation on social media (Smith & Seitz, 2019; Tully et al., 2020; Featherstone & Zhang, 2020; Vraga et al., 2019).

5.3 The Consuming and Impacting Stage of Health Misinformation on Social Media

The consuming and impacting stage involves how receivers react to health misinformation (i.e., how they consume health misinformation) and the impact that health misinformation has on society. According to our literature review, we identified three key variable clusters in these two stages: receiver, individual reactions, and societal impact.

5.3.1 Receiver

The receiver cluster considers the receiver-related variables that influence how receivers evaluate and respond to health misinformation, such as media and information literacy (Chen et al., 2018; Smith & Seitz, 2019), epistemic beliefs (Chua & Banerjee, 2017; Gallotti et al., 2020), demographics (e.g., age, gender, and education level) (Li et al., 2017; Madathil & Greenstein, 2018), personal involvement (Chua & Banerjee, 2018; Gallotti et al., 2020), life quality or health status (Madathil & Greenstein, 2018), initial misperceptions (Vraga & Bode, 2018), sense of control (Gallotti et al., 2020), and emotions (Gallotti et al., 2020; Laato et al., 2020).

5.3.2 Individual Reactions

The individual reactions cluster considers how individuals consume and react to health misinformation and the impact that it has on individuals. Accordingly, it includes:

1) Cognitive reactions, such as forming health misperceptions (Chen et al., 2018; Zaidi & Flores-Romo, 2020), confusion and uncertainty in evaluating health information (Mourad et al., 2020), and fostering cynicism, apathy, or extremism (Pulido et al., 2020b)

2) Emotional reactions, such as creating anxiety, anger, fear, and long-term mental health issues (Chua & Banerjee, 2017; Dong et al., 2020; Featherstone & Zhang, 2020)

3) Behavioral reactions, such as refusing normal treatment (Chen et al., 2018; Pulido et al., 2020a) and seeking self-protection behaviors (e.g., building health and information literacy and checking and verifying the unverified health information encountered) (Vraga et al., 2019; Pulido et al., 2020a).

In particular, the impact that health misinformation has on individuals further influences whether they produce and propagate health misinformation in line with the feedback in the SWMC (Shannon, 1948). For example, individuals who receive health misinformation may also begin sending and forwarding it to others if they perceive it as helpful (Laato et al., 2020).

5.3.3 Societal Impact

The societal impact cluster involves the impact that health misinformation has on societies, such as hindering public prevention efforts against health issues (Pulido et al., 2020b), causing social panic (Mututwa & Matsilele, 2020; Pal et al., 2019), increasing racism activities and conspiracy theories (Pulido et al., 2020a; Ahmed et al., 2020a; Rovetta & Bhagavathula, 2020), and damaging trust and limiting

physician-patient relationships (Lavorgna et al., 2018; Madathil & Greenstein, 2018). In turn, these undesired consequences will likely provide fertile grounds for individuals to further produce and propagate health misinformation on social media (Laato et al., 2020).

Table 6. An Overview of Key Variables

Stage	Key cluster	Key variables	References
Originating stage	Message features	**Informational features**	
		Format	Syed-Abdul et al. (2013), Zhou et al. (2018), Bail (2016), Chua & Banerjee (2017, 2018), Mututwa & Matsilele (2020), Dutta et al. (2020), Guidry et al. (2020), Wilner & Holton (2020), Berriche & Altay (2020), Albalawi et al. (2019)
		Length	Zhou et al. (2018), Zhang et al. (2015), Smith & Seitz (2019), Moon & Lee (2020), Smith et al. (2019), Esen et al. (2019)
		Social ties	Zhou et al. (2018), Featherstone & Zhang (2020), Berriche & Altay (2020)
		Psycholinguistic features	
		Ambiguity	Zhang et al. (2015), Bonnevie et al. (2020)
		Attractiveness	Alsyouf et al. (2019), Arikanoglu et al. (2020), Berriche & Altay (2020), Albalawi et al. (2019), Wilner & Holton (2020), Murphy et al. (2020), Ng et al. (2020), Dedrick et al. (2020), Gallotti et al. (2020)
		Emotional valence	Zhang et al. (2015), Zhou et al. (2018), Chua & Banerjee (2017), Featherstone & Zhang (2020), Berriche & Altay (2020), Guidry et al. (2020), Dong et al. (2020)
		Emotional language	Bail (2016), Chen et al. (2018), Featherstone & Zhang (2020), Massey et al. (2020), Dong et al. (2020)
		Similarity with truth	Brady et al. (2017), Trembath et al. (2015)
		Compatibility	Trembath et al. (2015), Pulido et al. (2020a, 2020b), Zaidi & Flores-Romo (2020)
		Novelty	Chen et al. (2018), Pulido et al. (2020a)
		Procedural	Madathil & Greenstein (2018)
		Easy to understand	Alsyouf et al. (2019), Mututwa & Matsilele (2020), Berriche & Altay (2020), Mitchell (2019)
		Spreading metrics	
		The number of likes, comments, shares, views	Ahmed et al. (2020b), Alsyouf et al. (2019), Ataç et al. (2020), Bonnevie et al. (2020), Goobie et al. (2019), Guidry et al. (2020), Kawchuk et al. (2020), Kocyigit et al. (2020), Kouzy et al. (2020), Massarani et al. (2020b), Kaynak et al. (2020), Shi et al. (2019), Rodríguez et al. (2020), Hutchison et al. (2020), Stens et al. (2020), Rovetta & Bhagavathula (2020), Sharon et al. (2020), Selvi et al. (2020), Smith et al. (2019), Loeb et al. (2019), Gimenez-Perez et al. (2020), Zaila et al. (2020), Lahouati et al. (2020), Moukarzel et al. (2020), Mututwa & Matsilele (2020)
	Sender-related factors	**Sender motivations**	
		Marketing motivation	Trembath et al. (2015), Dedrick et al. (2020), Pulido et al. (2020a), Ahmed et al. (2020a), Mourad et al. (2020), Fode et al. (2020), Jamison et al. (2020)
		Self-promotion motivation	Trembath et al. (2015), Dedrick et al. (2020)
		Causing damage	Pulido et al. (2020a), Mourad et al. (2020), Steffens et al. (2019)
		Capturing social attention	Bonnevie et al. (2020), Gallotti et al. (2020), Mututwa & Matsilele (2020), Ahmed et al. (2020a)
		Helping others	Laato et al. (2020), Mueller et al. (2019), Jamison et al. (2020)
		Sender features	
		Conspiracy belief	Waszak et al. (2018), Bode & Vraga (2018), Jang et al. (2019)

Table 6. An Overview of Key Variables

		Source credibility	Zhang et al. (2015), Bode & Vraga (2015, 2018), Vraga & Bode (2018), Gallotti et al. (2020), Lahouati et al. (2020), Laato et al. (2020)
	Social media features	Visual abstract	Brady et al. (2017)
		Social media bubbles	Basch et al. (2019), Mitchell (2019), Brady et al. (2017), Smith & Seitz (2019), Sullivan (2019), Vraga et al. (2019), Jenkins & Moreno (2020), Zaidi & Flores-Romo (2020)
		Information overload	Sommariva et al. (2018), Trembath et al. (2015), Chen et al. (2018), Laato et al. (2020)
		The presence of debunking	Chua & Banerjee (2018)
		The lack of gatekeepers	Ataç et al. (2020), Culha et al. (2020), Esen et al. (2019), Fode et al. (2020), Smith & Seitz (2019), Steffens et al. (2019), Sullivan (2019)
Transmitting stage	Intervention strategies	**User education**	
		Health (media) literacy	Syed-Abdul et al. (2013), Trembath et al. (2015), Pulido et al. (2020a, 2020b), Oh & Lee (2019), Tully et al. (2020), Sullivan (2019), Vraga et al. (2019), Zaidi & Flores-Romo (2020), Hauer & Sood (2020)
		Social media intervention	
		Social media correction curation	Bode & Vraga (2015, 2018), Vraga & Bode (2018), Pulido et al. (2020b), Sullivan (2019)
		Algorithm intervention (automated removal, detection)	Pulido et al. (2020a), Ahmed et al. (2020a), Pulido et al. (2020b), Mourad et al. (2020)
		Platform-based warnings	Ahmed et al. (2020a), Featherstone & Zhang (2020)
		Banning of misinformation spreaders	Ahmed et al. (2020a), Albarracin et al. (2018), Mourad et al. (2020)
		Social correction	
		Peers, influencers, and experts (e.g., source rating)	Syed-Abdul et al. (2013), Bode & Vraga (2018), Lavorgna et al. (2018), Sommariva et al. (2018), Vraga & Bode (2018), Ahmed et al. (2020a), Mututwa & Matsilele (2020), Pulido et al. (2020b), Pal et al. (2019), Mourad et al. (2020), Rovetta & Bhagavathula (2020), Pulido et al. (2020a)
		Social presence of health organizations	Alsyouf et al. (2019), Alataş et al. (2019), Brady et al. (2017), Ahmed et al. (2020a), Pan et al. (2020), Fode et al. (2020), Ramos et al. (2020), Tripathi et al. (2020), Pulido et al. (2020b), Steffens et al. (2019), Steffens et al. (2020), Hauer & Sood (2020)
		Debunking strategies	
		Transparency and emotional consideration	Gesser-Edelsburg et al. (2018), Smith & Seitz (2019), Pal et al. (2019), Rovetta & Bhagavathula (2020), Steffens et al. (2019), Steffens et al. (2020), Gandhi et al. (2020), Martin et al. (2020), Vraga et al. (2019)
		Framing/timing of correction	Smith & Seitz (2019), Tully et al. (2020), Featherstone & Zhang (2020), Porat et al. (2019), Jenkins & Moreno (2020), Vraga et al. (2019)
Consuming and impacting stage	Receiver-related factors	Epistemic belief	Chua & Banerjee (2017), Gallotti et al. (2020), Smith & Seitz (2019), Pulido et al. (2020b)
		Demographics	Balami & Meleh (2019), Li et al. (2017), Jang et al., (2019), Madathil & Greenstein (2018), Pulido et al. (2020a), Laato et al. (2020), Rodríguez et al. (2020), Sabbagh et al. (2020), Wilner & Holton (2020), Lahouati et al. (2020), Kawchuk et al. (2020)
		Media literacy	Chen et al. (2018), Smith & Seitz (2019), Sullivan (2019), Laato et al. (2020)
		Health status	Madathil & Greenstein (2018), Mueller et al. (2019)
		Quality of life	Madathil & Greenstein (2018)

Table 6. An Overview of Key Variables

		Pre-existing attitude	Vraga & Bode (2018), Pons-Fuster et al. (2020), Pulido et al. (2020a), Pulido et al. (2020b)
		Personal involvement	Chua & Banerjee (2018), Gallotti et al. (2020), Smith & Seitz (2019), Rovetta & Bhagavathula (2020), Laato et al. (2020), Dong et al. (2020)
		Emotion (i.e., anxiety)	Balami & Meleh (2019), Gallotti et al. (2020), Laato et al. (2020), Sell et al. (2020), Massarani et al. (2020a), Oh & Lee (2019), Dong et al. (2020)
		Sense of control	Gallotti et al. (2020)
		Trust in authorities	Almomani & Al-Qur'an (2020), DeDominicis et al. (2020), Zaidi & Flores-Romo (2020), Martin et al. (2020)
	Individual reactions / impact	**Cognitive reactions**	
		Health-misperceptions	Chen et al. (2018), Zaidi & Flores-Romo (2020)
		Confusion and uncertainty	Mourad et al. (2020)
		Cynicism, apathy, or extremism	Pulido et al. (2020b)
		Distrust in physicians	Lavorgna et al. (2018), Islam et al. (2020)
		Emotional reactions	
		Anxiety, anger, fear	Chua & Banerjee (2017), Dong et al. (2020), Featherstone & Zhang (2020)
		Behavioral reactions	
		Refusal of normal treatment	Chen et al. (2018), Pulido et al. (2020a), Islam et al. (2020)
		Building health and information literacy	Pulido et al. (2020a)
		Verification	Vraga et al. (2019)
	Societal impact	Public health	Almomani & Al-Qur'an (2020), Alsyouf et al. (2019), Basch et al. (2019), Cárdenas-Robledo et al. (2020), Carrieri et al. (2019), Pulido et al. (2020b), Islam et al. (2020), Rodríguez et al. (2020), Porreca et al. (2020), Gallotti et al. (2020)
		Racism	Pulido et al. (2020a, 2020b), Rovetta & Bhagavathula (2020), Li et al. (2020)
		Conspiracy theories	Pulido et al. (2020a), Pulido et al. (2020b), Ahmed et al. (2020a), Rovetta & Bhagavathula (2020), Mourad et al. (2020)
		Panic	Ahmad & Murad (2020), Mututwa & Matsilele (2020), Pal et al. (2019), Hauer & Sood (2020), Mourad et al. (2020), Steffens et al. (2019), Islam et al. (2020)
		Physician-patient interaction	Lavorgna et al. (2018), Madathil & Greenstein (2018), Islam et al. (2020)

6 Discussion and Conclusion

As an emerging public concern, health misinformation has attracted increasing attention from researchers, policymakers, and practitioners, especially after the COVID-19 outbreak, which resulted in a social media infodemic. However, we have lacked an integrative framework that synthesizes existing and fragmented health misinformation findings. Following systematic guidelines for conducting a literature review, we collected and reviewed 101 published papers related to health misinformation on social media. Accordingly, we 1) clarify how research has conceptualized misinformation; 2) reveal current state of research on health misinformation on social media in terms of research trends, features (i.e., health misinformation types and unit of analysis), theoretical foundations, and research methods; and 3) summarize key variables that the literature has examined by proposing a stage-based framework of health misinformation on social media. Based on the literature analysis results, we discuss several research opportunities for future research on health misinformation on social media in this section. We also discuss the study's limitations and contributions and conclude the paper.

6.1 Future Research Directions

Based on the literature analysis, we can suggest several directions for future research on health misinformation on social media. Table 7 lists future research directions and associated research questions.

Table 7. Future Research Directions and Research Questions

Avenue for future research	Corresponding research question
Conceptualizing and defining misinformation	RQ1: How does misinformation differ or resemble other similar terms that describe false or inaccurate information?
The originating, transmitting, consuming, and impacting health misinformation stages	RQ2: What health misinformation features influence the extent to which health misinformation spreads on social media? RQ3: What sender-related factors influence the extent to which health misinformation spreads on social media? RQ4: What social media features influence the extent to which health misinformation spreads on social media? RQ5: What possible intervention strategies can different stakeholders adopt to prevent health misinformation from spreading on social media? RQ6: What receiver-related influencing factors affect how individuals evaluate and react to the spread of health misinformation on social media? RQ7: How do key stakeholders (e.g., general users, patients, physicians, and platforms) react to the spread of health misinformation on social media? RQ8: What possible impact could the spread of health misinformation on social media have on society?
Theoretical foundations and research methodologies	RQ9: How can researchers adapt existing theories and frameworks to explain health misinformation on social media? RQ10: How can researchers use the sociotechnical perspective to explain and address how health misinformation spreads on social media? RQ11: How can researchers collect rich, relevant, and unbiased data for research on health misinformation on social media?

6.1.1 The Conceptualization of Misinformation

Misinformation does not constitute a new phenomenon, though it has attracted increasing public attention in recent years due to its prevalence on social media. We observed that the literature has used many different similar terms (e.g., misinformation, disinformation, misleading information, fake news, rumors, hoax, and biased information) to describe false or inaccurate information. However, some studies used these terms interchangeably without proper discretion (e.g., Islam et al., 2020; Rodriguez et al., 2020). Furthermore, the terms varied in scope and meaning across different studies, which has caused conceptual uncertainty and inconsistency (see Table 1). In the literature, some studies have tried to classify the different types of false information (e.g., Fallis, 2014; Wardle & Derakhshan, 2017; Tandoc et al., 2018; Zannettou et al., 2019; Waszak et al., 2018; Molina et al., 2018). Researchers need to ensure they clearly define misinformation to clarify their studies' scope and focus. Future research should pay more attention to clearly defining these similar terms and providing suggestions on how to use them correctly. As such, we propose our first research question (RQ):

RQ1: How does misinformation differ or resemble other similar terms that describe false or inaccurate information?

6.1.2 The Originating, Transmitting, Consuming, and Impacting Stage of Health Misinformation

The health misinformation originating stage describes how actors create and produce health misinformation. Prior studies have identified health misinformation features, such as informational features, psycholinguistic features, and spreading metrics (see Table 6). Most of these features resemble features of misinformation on other topics (e.g., political and academic misinformation). Health misinformation may have some contextual features, such as emotional valence (e.g., wish or dread rumor) (Chua & Banerjee, 2017; Zhou et al., 2018). Researchers could further consider the uniqueness of health topics and explore new health misinformation features. As such, we propose our second research question:

RQ2: What health misinformation message features influence the extent to which health misinformation spreads on social media?

Health misinformation appears prevalently on social media and has had a profound impact on individuals, platforms, and societies. Therefore, we need to explore why actors generate health misinformation on social media. If we recognize the antecedents or determinants that cause actors to produce health misinformation on social media, we will be in a better position to prevent and combat its proliferation. While prior studies have identified several motivations and features that determine why senders produce health misinformation, future research can follow this work to identify the sender-related influencing factors unique to health misinformation. As such, we propose our third research question:

RQ3: What sender-related factors influence the extent to which health misinformation spreads on social media?

Social media has been a major channel for people to obtain health-related information, and, as a result, the spread of health misinformation on social media will hinder people's access to trustworthy and reliable information and cause some problems. Prior studies have identified several social media features that influence the extent to which health misinformation spreads on social media, such as visual abstract (i.e., content limitation or oversimplification on social media), social media bubbles, information overload, the presence of debunking information, and the lack of information gatekeepers. Identifying social media features and testing their effects on deviant behaviors on social media has been a main HCI research stream (Brooks et al., 2017; Chan et al., 2019; Li et al., 2022). Considering social media has been widely considered responsible for the prevalence of health misinformation, future research can explore the features of the social media environment and examine their impact on the spread of health misinformation. As such, we propose our fourth research question:

RQ4: What social media features influence the extent to which health misinformation spreads on social media?

Considering the devastating impact of health misinformation on individuals and societies, intervention strategies are required to influence individuals' evaluation and consumption of health misinformation and further minimize the devastating impact of health misinformation on social media. As discussed in Section 5.2.2, prior studies have proposed several intervention strategies, including educating social media users, social media intervention, social correction, and debunking strategies. These intervention strategies will provide clear and practical guidance to the practitioners. Therefore, researchers can further identify different intervention strategies against health misinformation on social media, considering efforts from different key stakeholders. As such, we propose our fifth research question:

RQ5: What possible intervention strategies can different stakeholders adopt to prevent health misinformation from spreading on social media?

Prior studies examined the receiver-related variables that influence how receivers evaluate and respond to health misinformation, such as media and health literacy, demographics, pre-existing attitudes, health status, and life quality, and epistemic beliefs (see Table 6). These features will inherently determine their reactions to health misinformation on social media. As such, we propose our sixth research question:

RQ6: What receiver-related influencing factors affect how individuals evaluate and react to health the spread of misinformation on social media?

Some negative consequences resulting from health misinformation on social media include unnecessary fear and anxiety (Chua & Banerjee, 2017), misperceptions about diseases (Chen et al., 2018), and impeded physician-patient interactions (Lavorgna et al., 2018). Although the negative consequences of health misinformation on social media have been widely recognized by both research and practice (Chou et al., 2018; World Health Organization, 2020) (see Table 6), relatively little research effort has been dedicated to empirically evaluate the influence of health misinformation on social media on individuals, platforms, and societies. Future research can follow this research line to empirically demonstrate the devastating impact of health misinformation on different stakeholders (i.e., general users, patients, physicians, and platforms). By doing this, public awareness will be greatly raised to prevent and combat the spread of health misinformation on social media. As such, we propose our seventh and eighth research questions:

RQ7: How do key stakeholders (e.g., general users, patients, physicians, and platforms) react to the spread of health misinformation on social media?

RQ8: What possible impact could the spread of health misinformation on social media have on society?

6.1.3 Theoretical Foundations and Research Methodologies

According to the literature analysis results, we also propose several potential research directions related to theoretical foundations and research methodologies. In order to collect relevant data, researchers should rely on theories to ensure they collect data effectively and analyze it meaningfully. However, according to our literature analysis, most existing research on health misinformation on social media has no theoretical foundations. We also found that researchers from different disciplines have examined this phenomenon, which paves the way for interdisciplinary research that can holistically explain the factors that determine health misinformation on social media. Future research should borrow some classic theories from different disciplines (e.g., medicine and healthcare, information science and IS, communication, and psychology) and test the extent to which they apply in the health misinformation on social media context. In particular, researchers should also consider contextual factors (e.g., patient-physician interaction and health belief model) to address the unique manner in which health misinformation spreads on social media (Collier, 2018; Chou et al., 2018). As such, we propose our ninth research question:

RQ9: How can researchers adapt existing theories and frameworks to explain health misinformation on social media?

Given the key role that social media plays in health misinformation, we can understand health misinformation's spread on social media as a sociotechnical phenomenon because it results from both technical components (i.e., social media features) (Fernández-Luque & Bau, 2015; Brady et al., 2017) and social components (i.e., social, individual, or environmental factors) (Chua & Banerjee, 2017; 2018; Vraga & Bode, 2018; Wardle & Derakhshan, 2017). However, while health misinformation has attracted increasing academic attention, IS researchers have yet to join the conversation with only one paper published in IS journals. The IS discipline, with its inherent focus on the sociotechnical view (Sarker et al., 2019), explores the role that information technologies play in addressing business and societal issues. Therefore, IS scholars can build on the sociotechnical perspective to explore how the interplay between social components and technical components jointly influence how health misinformation spreads on social media. By doing so, IS researchers can not only engage with reference disciplines comprehensively and address emerging societal issues but also inform practitioners about the ways that technical design and social elements can combat health misinformation on social media. As such, we propose our tenth research question:

RQ10: How can researchers use the sociotechnical perspective to explain and address how health misinformation spreads on social media?

Existing research on health misinformation on social media has largely used content analysis to identify the textual health misinformation features. However, millions of users contribute to spreading health misinformation in different formats on social media. Only focusing on textual analysis may not sufficiently capture the features of health misinformation on social media. Future research could deploy innovative methods (e.g., natural language processing, multiple media data mining and analytics, and social network analysis) on a broader scale to track and identify features of different forms of health misinformation on social media (e.g., photos, videos, audios, texts, or a mixture). Moreover, future research could develop solutions to the ethical and methodological challenges that health misinformation behavioral research faces. For example, the social desirability bias poses an issue if researchers collect respondents' data about whether they intend to share false information on social media. Future research should employ alternative research methods to collect behavioral data rather than subjective response data to avoid response bias in health misinformation behavioral research. As such, we propose our eleventh research question:

RQ11: How can researchers collect rich, relevant, and unbiased data for research on health misinformation on social media?

6.2 Contributions

This study makes several contributions to research and practice. First, a systematic literature review can help researchers understand the current state of research on a certain topic. We followed systematic guidelines to conduct a literature review (Webster & Watson, 2002). Specifically, we discuss the frequently used terminologies in the literature and clarify conceptual misinformation ambiguities. We further discuss the research trends, research nature (i.e., health misinformation types and unit of analysis), theoretical foundations, and research methods in prior studies to define the current state of research on health misinformation on social media. As such, our study builds a benchmark for future HCI research on health

misinformation on social media by tracking the state of current research and consolidating existing knowledge on health misinformation on social media.

Second, drawing on the SWMC, we identify and integrate key variables that the literature has examined by proposing a stage-based framework of health misinformation on social media. The stage-based framework abstracts how different key stakeholders communicate misinformation and their associated features in a solid and powerful way; in this way, it can help future HCI research to build and test a nomological framework about how health misinformation spreads on social media. In particular, the identified key variables from the literature also draw a holistic picture for HCI researchers to quickly understand what factors prior studies have or have not been examined. With findings generated from the literature analysis, we finally outline several research opportunities and provide potential directions, guidelines, and research questions for future HCI research. As such, this study can serve as the starting point and pave the way for future HCI research on health misinformation on social media—a developing topic with significant societal implications.

Third, this systematic literature review on health misinformation also informs future research on other misinformation types (e.g., political and business misinformation). For example, some identified theoretical foundations in research on health misinformation do not pertain only to health misinformation, such as the CARS checklist framework, cognitive load theory, motivated reasoning, protection motivation theory, and rumor theory. Thus, researchers can use these theories to contribute to future research on other misinformation types via summarizing relevant theories in prior studies. The framework we propose along with the key variables that we identify in Table 6 also provide relevant information for future research on other types of misinformation. The stage-based framework does not pertain only to health misinformation but rather generalizes to research on other types of misinformation since one can generalize most of the key variables that we identify in Table 6 (e.g., informational features, psycholinguistic features, motivations, social media features, and interventions strategies) to other contexts. In particular, we identified some factors unique to health misinformation on social media (e.g., health belief model, inoculation theory, and physician-patient relationship). Therefore, our work can stimulate more academic research on misinformation until researchers reach scientific consensus on certain factors or relationships involved in misinformation's spread on social media.

Finally, our study also contributes to policymakers and practitioners attempting to address health misinformation on social media. As Benbasat and Zmud (1999, p. 9) have noted:

> *It is possible for some academic research to contribute to practice in a direct, implementable mode. Once a sizable body of literature exists regarding a phenomenon, it does become possible to synthesize this literature, e.g., as a state of the art review, to develop usable prescriptions.*

A timely and systematic literature review on health misinformation can provide a fairly "painless" way for practitioners to acquaint themselves with the "stage of knowledge" reading health misinformation and, thus, become more knowledgeable and efficient in the fight against health misinformation. In particular, the identified intervention strategies directly provide actionable suggestions to combat the spread of health misinformation on social media. Therefore, our study has great relevance to practice.

6.3 Limitations

Considering the results and insights that we gathered in this study, readers should consider some limitations. First, literature review limitations also affect our results. Our results depend on the inclusion and exclusion criteria that we applied to the database search results, and, thus, our study has a confined scope. We may have possibly omitted important and relevant papers due to not meeting the relevant criteria. Furthermore, by only considering peer-reviewed papers, we have not included potentially relevant information from books, conferences, practitioner articles, or magazines. Moreover, although we note that health misinformation on social media appears prevalently and can pose serious harm to individuals and the public, the number of studies with novel and valuable insights on the topic remains limited, which narrowed the literature analysis we could have performed. As the domain further develops, future research could address this limitation. Future research can also move beyond health misinformation to consider other misinformation types to develop new frameworks.

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Appendix A: A Summary of Reviewed Studies

Study	Discipline	Method	Theoretical background
Ahmad & Murad (2020)	Medicine	Survey	Null
Ahmed et al. (2020a)	Medicine	Content analysis	Null
Ahmed et al. (2020b)	Medicine	Content analysis	Null
Alataş et al. (2019)	Medicine	Content analysis	Null
Albalawi et al. (2019)	Medicine	Content analysis	Null
Albarracin et al. (2018)	Medicine	Experiment	Null
Almomani & Al-Qur'an (2020)	Medicine	Survey	Null
Alsyouf et al. (2019)	Medicine	Content analysis	Null
Arikanoglu et al. (2020)	Medicine	Content analysis	Null
Ataç et al. (2020)	Medicine	Content analysis	Null
Bail (2016)	Medicine	Content analysis	Null
Balami & Meleh (2019)	Medicine	Survey	Null
Basch et al. (2019)	Interdisciplinary	Content analysis	Null
Berriche & Altay (2020)	Interdisciplinary	Content analysis	Cultural attraction theory
Bode & Vraga (2015)	Communication	Experiment	Motivated reasoning
Bode & Vraga (2018)	Medicine	Experiment	Motivated reasoning
Bonnevie et al. (2020)	Medicine	Content analysis	Null
Brady et al. (2017)	Medicine	Content analysis	Null
Cárdenas-Robledo et al. (2020)	Medicine	Content analysis	Null
Carrieri et al. (2019)	Medicine	Content analysis	Null
Chen et al. (2018)	Medicine	Content analysis	Null
Chua & Banerjee (2017)	Medicine	Experiment	Null
Chua & Banerjee (2018)	Computer Science	Experiment	Rumor theory, theory of negativity bias, theory of boomerang effect
Culha et al. (2020)	Medicine	Content analysis	Null
DeDominicis et al. (2020)	Interdisciplinary	Mixed-methods approach	Null
Dedrick et al. (2020)	Medicine	Content analysis	Social cognitive theory (SCT)
Dong et al. (2020)	Medicine	Content analysis	Null
Dutta et al. (2020)	Medicine	Content analysis	Null
Esen et al. (2019)	Medicine	Content analysis	Null
Featherstone & Zhang (2020)	Medicine	Experiment	Inoculation theory
Fode et al. (2020)	Medicine	Content analysis	Null
Gallotti et al. (2020)	Interdisciplinary	Content analysis	Null
Gandhi et al. (2020)	Medicine	Content analysis	Null
Gesser-Edelsburg et al. (2018)	Interdisciplinary	Experiment	Null
Gimenez-Perez et al. (2020)	Medicine	Content analysis	Null
Goobie et al. (2019)	Medicine	Content analysis	Null

Guidry et al. (2020)	Medicine	Content analysis	Health belief model, exemplification theory
Hauer & Sood (2020)	Psychology	Content analysis	Null
Hutchison et al. (2020)	Medicine	Content analysis	Null
Islam et al. (2020)	Medicine	Content analysis	Null
Jamison et al. (2020)	Medicine	Content analysis	Null
Jang et al. (2019)	Medicine	Content analysis	Null
Jenkins & Moreno (2020)	Medicine	Content analysis	Null
Kawchuk et al. (2020)	Medicine	Content analysis	Null
Kaynak et al. (2020)	Medicine	Content analysis	Null
Kocyigit et al. (2020)	Medicine	Content analysis	Null
Kouzy et al. (2020)	Medicine	Content analysis	Null
Laato et al. (2020)	Information Systems	Survey	Health belief model, cognitive load theory, protection motivation theory
Lahouati et al. (2020)	Medicine	Content analysis	Null
Lavorgna et al. (2018)	Medicine	Survey	Null
Li et al. (2017)	Information Science	Content analysis	CARS checklist framework
Li et al. (2020)	Medicine	Content analysis	Null
Loeb et al. (2019)	Medicine	Content analysis	Null
Madathil & Greenstein (2018)	Medicine	Experiment	Data-frame theory
Martin et al. (2020)	Medicine	Content analysis	Null
Massarani et al. (2020a)	Medicine	Content analysis	Null
Massarani et al. (2020b)	Communication	Content analysis	Null
Massey et al. (2020)	Medicine	Content analysis	Null
Mitchell (2019)	Communication	Content analysis	Null
Moon & Lee (2020)	Medicine	Content analysis	Null
Moukarzel et al. (2020)	Interdisciplinary	Mixed-methods approach	Social network theory
Mourad et al. (2020)	Interdisciplinary	Content analysis	Null
Mueller et al. (2019)	Medicine	Content analysis	Null
Murphy et al. (2020)	Medicine	Content analysis	Null
Mututwa (2020)	Communication	Content analysis	Social network theory
Ng et al. (2020)	Medicine	Content analysis	Null
Oh & Lee (2019)	Medicine	Experiment	Null
Pal et al. (2019)	Computer Science	Experiment	Theory of planned behavior
Pan et al. (2020)	Medicine	Content analysis	Null
Pons-Fuster et al. (2020)	Medicine	Content analysis	Null
Porat et al. (2019)	Medicine	Content analysis	Null
Porreca et al. (2020)	Medicine	Content analysis	Null
Pulido et al. (2020a)	Medicine	Content analysis	Null
Pulido et al. (2020b)	Communication	Content analysis	Null
Ramos et al. (2020)	Communication	Content analysis	Null

Rodríguez et al. (2020)	Interdisciplinary	Content analysis	Null
Rovetta & Bhagavathula (2020)	Medicine	Content analysis	Null
Sabbagh et al. (2020)	Medicine	Content analysis	Null
Sell et al. (2020)	Medicine	Content analysis	Null
Selvi et al. (2020)	Medicine	Content analysis	Null
Sharon et al. (2020)	Medicine	Content analysis	Theory of epistemic trust
Shi et al. (2019)	Medicine	Content analysis	Null
Smith & Seitz (2019)	Communication	Experiment	Null
Smith et al. (2019)	Medicine	Content analysis	Null
Sommariva et al. (2018)	Medicine	Mixed-methods approach	Null
Steffens et al. (2019)	Medicine	Interviews	Null
Steffens et al. (2020)	Medicine	Interviews	Null
Stens et al. (2020)	Medicine	Content analysis	Null
Sullivan (2019)	Information Science	Experiment	Null
Syed-Abdul et al. (2013)	Medicine	Content analysis	Null
Trembath et al. (2015)	Psychology	Interviews	Null
Tripathi et al. (2020)	Medicine	Content analysis	Null
Tully et al. (2020)	Communication	Experiment	Null
Vraga & Bode (2017)	Communication	Experiment	Motivated reasoning
Vraga & Bode (2018)	Information Science	Experiment	Motivated reasoning
Vraga et al. (2019)	Communication	Experiment	Inoculation theory
Waszak et al. (2018)	Medicine	Content analysis	Null
Wilner & Holton (2020)	Medicine	Content analysis	Null
Zaidi & Flores-Romo (2020)	Medicine	Content analysis	Null
Zaila et al. (2020)	Medicine	Content analysis	Null
Zhou et al. (2018)	Medicine	Content analysis	Rumor theory

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