Misinformation, Crisis, and Public Health—Reviewing the Literature – Version V1.0

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Introduction

- The Covid-19 pandemic comes at a time when we were already grappling with information overload and pervasive misinformation.
- In a crisis, humans communicate in a process called collective sensemaking in order to understand uncertain and dynamic circumstances.
- Collective sensemaking is a vital process, but we can make mistakes—or the process can be manipulated and exploited.

The Covid-19 pandemic has been accompanied by a parallel "infodemic" (Rothkopf 2003; WHO 2020a), a term used by the World Health Organization (WHO) to describe the widespread sharing of false and misleading information about the novel coronavirus. Misleading information about the disease has been a problem in diverse societies around the globe. It has been blamed for fatal poisonings in Iran (Forrest 2020), racial hatred and violence against people of Asian descent (Kozlowska 2020), and the use of unproven and potentially dangerous drugs (Rogers et al. 2020). A video promoting a range of false claims and conspiracy theories about the disease, including an antivaccine message, spread widely (Alba 2020) across social media platforms and around the world. Those spreading misinformation include friends and relatives with the best intentions, opportunists with books and nutritional supplements to sell, and world leaders trying to consolidate political power.

This public health crisis hits us at a particularly challenging time, as we are already grappling with issues of information overload and pervasive misinformation due, in part, to increasing use of online information systems. This perfect storm of a global pandemic hitting a world with global connectivity may be unprecedented, but scientists have a long tradition of trying to understand how we—as individuals, groups, and societies—respond to collective-stress situations (Barton 1970).

What do we do when a crisis strikes? We communicate. We utilize our social networks to exchange information as we try to make sense of what is going on around us (Danzig et al. 1958; Erickson et al. 1978; Richardson et al. 1979; Pendleton 1998). We search for,

disseminate, and synthesize the content we see into narratives that fit with our current understanding of the situation and within our larger worldviews. For example, during a hurricane watch, people in potentially affected areas may try to piece together information from local radio and television, combine and contrast that with their own experiences of the incoming storm as well as previous storms, and convene with their neighbors to share perspectives as they decide whether or not to evacuate. This process, called collective sensemaking, is critical for our decision-making, and in many cases allows us to relieve some of the anxiety and uncertainty we face in order to take action (Comfort et al. 2004; Shklovski et al. 2008).

But our information processing system isn't perfect; we make mistakes. Sometimes our informal explanations get things wrong—rumors may turn out to be false and become misinformation. And at other times the collective-sensemaking process can be exploited by those who wish to purposefully mislead—for example, by seeding and spreading disinformation.

There is ongoing work to identify, distinguish, and define the different information toxicities contributing to the infodemic—and the broader "information disorder" (Wardle and Derakhshan 2017). Following Jack (2017), we define misinformation as information that is false, but not necessarily intentionally false, and disinformation as false or misleading information that is intentionally created and/or spread for a particular—e.g., financial or political—objective. (For more on the definitions of mis- and disinformation, please see the MediaWell research review Defining "Disinformation.")

While the current public health crisis highlights the pressing problems of mis- and disinformation in our society, the tradition of studying these phenomena dates much earlier. In this review, we highlight and discuss existing research, both new and old, on the spread of misinformation during crisis events—and specifically public health crises. We trace the history and evolution of early work in this domain, foregrounding a behavioral perspective that focuses on the processes that generate and spread misinformation. Connecting that perspective to current challenges, we describe several distinct types of mis- and disinformation in the public health context and explain why, together, they represent a complex and critical problem. We end by situating these issues within understandings of the broader social and technical systems that shape how information spreads in our society.

Studies of rumoring behavior

- The field of mis- and disinformation studies traces back to earlier traditions of studying rumor.
- This use of the term "rumor" refers to information that is unverified, but not necessarily false.

- Information about major events can spread extremely quickly through informal sharing, or "rumoring."
- A combination of factors makes societies susceptible to false information during crises.

The emerging field of mis- and disinformation studies draws from a variety of traditions, but perhaps the most influential has been the study of rumors—or rumoring, the underlying processes that generate them. Scientific inquiry into rumoring has spanned numerous fields and is often inherently interdisciplinary in nature (Pendleton 1998). In this review, we build from a tradition anchored in sociology and social psychology. This body of work has focused on the societal and collective-action aspects of rumoring rather than the individual factors that may contribute (Rosnow 1988). Indeed, key contributors to this field viewed rumor as "part and parcel of the efforts of men [and people] to come to terms with the exigencies of life" (Shibutani 1966, 62). In this view, rumor is a byproduct of the group problem-solving process—or collective sensemaking. To be clear, we use the term rumor to refer to information that is unverified at the time it is being discussed. This definition implies that rumors can turn out to be false—or they can turn out to be true.

Crisis events provide a research setting ripe for studying rumoring, as they bring together a number of contextual factors associated with an increased prevalence of rumors. Historically, scientific exploration of rumoring received notable attention within wartime contexts, where world leaders and scholars were concerned about the potential for manipulation and coercion (Knapp 1944; Caplow 1947). In the years since, this work has expanded to include a broad array of crisis events, such as natural disasters, pandemics, and acts of terrorism. Crisis events are accompanied by high levels of uncertainty and anxiety. Officials and authoritative sources may offer limited or untimely information. Traditional communication channels such as broadcast media may break down (Danzig et al. 1958). To fill these gaps, rumoring becomes a collective problem-solving technique—a way to "improvise news" in order to make sense of the unfolding situation and cope with accompanying uncertainties (Shibutani 1966).

In early work, researchers took two distinct methodological approaches. One was studying rumors already in circulation, focusing on the conditions that made their existence more likely (Festinger et al. 1948; Schachter and Burdick 1955; Kapferer 1989). Another was studying rumors experimentally by planting them in controlled situations (Anthony 1973; Walker and Beckerle 1987). In both cases, much early research focused on the overall prevalence of rumors as well as the social process that underlay them—e.g., how information was distorted through the transmission process. Taken together, this body of work points to a set of factors associated with rumor circulation, including the importance of the subject to the individuals concerned, the ambiguity of the evidence pertaining to the topic, and the relevance of the information for taking actions or changing behaviors (Allport

and Postman 1947). Scholars also explored the role of an authoritative figure or opinion leader who lends credence to a rumor, as well as individual (such as gender and age) and group characteristics (like network homophily) that may shape common pathways of rumor transmission in a population (Koenig 1985).

One thing is evident in these studies: significant news events can diffuse extremely rapidly within an attentive public through this process of informal information sharing, or rumoring. Long before the internet became ubiquitous, researchers were already remarking upon the speed of information propagation through social networks (Richardson et al. 1979). For example, it is estimated that 68 percent of adults in the United States heard about the assassination of President John F. Kennedy within 30 minutes of its incidence (Pendleton 1998).

Exacerbating this issue of rapid transmission, crisis contexts pair uncertainty with challenges in verifying information; this often results in limited ability to clarify facts or check sources. There is also a perceived—and often real—risk that not sharing information during crisis events could have consequences. This combination of factors makes societies and individuals vulnerable to false or misleading information. In the case of public health crises, misinformation can have life-or-death effects.

Conspiracy theories and disinformation

- Conspiracy theories add perceptions that a crisis is being intentionally caused or manipulated by powerful entities.
- Many conspiracy theories appear to arise organically from corrupted sensemaking processes.
- Conspiracy theories can be both the products and beneficiaries of disinformation campaigns.
- Conspiracy theories and disinformation campaigns can undermine trust in providers of information.

Rumors that turn out to be false are one contributor to misinformation during crisis events. But misinformation takes on other forms—including fake medical advice, elaborate conspiracy theories about underlying causes, and intentional disinformation campaigns that attempt to leverage the crisis for political gain. The latter two are exceptionally vexing during a crisis because they feed off and contribute to uncertainty and distrust of governments, journalists, and scientists (Sunstein and Vermeule 2009; Pomerantsev and Weiss 2014).

Conspiracy theories are salient in discourse surrounding many public health issues, from fluoridation of water to vaccines. Building upon alternative narratives about likely causes

and effective treatments, conspiracy theories add a dimension of perceived intentionality, suggesting that the crisis is being manipulated or that information about it is being purposefully hidden by powerful entities for political or financial gain. A recent example claims that the symptoms associated with Covid-19 are actually caused by 5G technologies (rather than the SARS-CoV-2 coronavirus) and that powerful people are conspiring to hide this "fact" (Andrews 2020; Sorkin 2020). Research suggests that these unfounded theories can play a role in shaping health behaviors—for example, in decisions of whether or not to vaccinate (Jolley and Douglas 2014; Falade and Coultas 2017).

In the crisis context, many conspiracy theories appear to develop organically from a sort of corrupted sensemaking process (Sunstein and Vermeule 2009; Kou et al. 2017; Starbird et al. 2019). In this process, participants assemble evidence to fit previously held meta-theories—e.g., about a world where powerful people control global events, and where "mainstream" media, scientific experts, and government officials cannot be trusted. Conspiracy theories often build from compelling (and in some cases valid) criticisms of the intersections between power, politics, and the often competing interests of the public (Hofstadter 2008; Barkun 2003; Fenster 2008; Oliver and Wood 2014). For example, the US military operation that led to the assassination of Osama bin Laden utilized a fake vaccine program to identify where his family was living (Lenzer 2011). It is not difficult to see how operations like these can feed into conspiracy theorizing, for example, about the "true purpose" of vaccines.

Conspiracy theories can be both the products and beneficiaries of disinformation campaigns.

Unlike rumors and misinformation, which can be unintentional, disinformation is false or misleading information that is produced and/or spread intentionally for a strategic objective (Jack 2017; Starbird et al. 2019). It can be productive to think of disinformation not as a single piece of content, but as a campaign (Starbird et al. 2019). History provides examples of conspiracy theories about public health crises being seeded or amplified by disinformation campaigns. For example, in the 1980s, Soviet intelligence operatives carried out an international campaign claiming that HIV/AIDS was a US bioweapon (Boghardt 2009). Similarly, in the Covid-19 crisis, we are witnessing efforts to frame the disease as a Chinese or US bioweapon, based on the motivations of those spreading that disinformation narrative.

By spreading false information and fostering doubt and confusion, conspiracy theories and disinformation campaigns can undermine trust in information providers—a problem with potentially severe consequences in a public health crisis like the Covid-19 pandemic.

Public health crises and misinformation

- Pandemics often require major changes in behavior—like social distancing—and this can make the positive and negative aspects of collective sensemaking more obvious.
- Having information—even misinformation—can help soothe feelings of anxiety, fear, and uncertainty.
- Misinformation can delay or prevent implementation of effective public health measures.

One need only look at the outbreaks of Zika fever (Miller et al. 2017; Bode and Vraga 2018; Dredze et al. 2016), Ebola (Allgaier and Svalastog 2015; Jin et al. 2014; Fung et al. 2016), and measles (Kata 2010, 2012; Dubé et al. 2015) over the past decade to see the troubling role of misinformation, disinformation, and conspiracy theories in public health crises. Infectious disease pandemics bring collective sensemaking processes to the fore, in part because large-scale behavioral changes—such as adjusted cultural practices around death and mourning during Ebola or massive social distancing measures for Covid-19—are often necessary to address them.

During a public health crisis, people seek information to help them understand risks and make decisions on how to respond. It can be difficult to determine what information to trust or not trust, and emotions such as fear, anxiety, and uncertainty can mobilize people and shape their actions (van der Meer and Jin 2020), including how they search for information (Gui et al. 2017). Having information can help to soothe these feelings (Jin et al. 2016; Tan et al. 2015). Similarly, misinformation can be powerful during a crisis because it can reduce feelings of uncertainty and provide a (false) sense of safety and control (Crabtree and Masuda 2019). For example, misleading claims downplaying the risks of Covid-19 can provide people with a sense of security, encouraging them to return as quickly as possible to their normal routines. Misinformation can be particularly persuasive when it supports already-held beliefs (Dredze et al. 2016).

Unfortunately, misinformation during a public health crisis can prevent the adoption and use of evidence-based preventative measures and treatments and consequently worsen an epidemic (Tan et al. 2015). For example, misinformation spread during the 2014–2016 Ebola outbreak may have contributed to negative health outcomes by motivating attacks on health workers and blocking them from providing treatment (Allgaier and Svalastog 2015). We are already seeing the health effects of misinformation during the Covid-19 pandemic, such as incidences of people self-medicating by taking chloroquine, an unproven treatment (Mackey 2020), or drinking bleach (Bernard 2020).

Larson (2018) warned that the biggest pandemic risk would be viral misinformation. She wrote that the next major outbreak would be exacerbated by efforts to sow distrust in the

vaccines developed for the pandemic. She described some of the most influential actors in the spread of misinformation about vaccines, including "people with medical credentials stoking overblown or unfounded fears," people seeking financial gain, and people seizing a political opportunity. We can already see these three types of actors spreading misinformation about future vaccines for Covid-19.

Larson's work reveals a larger underlying problem: a worldwide increase in vaccine hesitancy that can be tied to a growing "antivaccine" movement. This movement, which has largely taken shape within online communities, has been characterized by widespread misinformation about vaccinations, specifically the false link between the measles, mumps, and rubella (MMR) vaccine and autism, and the false belief that vaccines are ineffective in protecting against communicable diseases (Kata 2012; Poland and Jacobson 2001). Consequently, due to increasing resistance against childhood vaccinations, there has been an increased incidence of measles outbreaks across the world, including in the US, Samoa, and the Democratic Republic of the Congo (CDC 2020; Craig et al. 2020; WHO 2020b). The antivaccination movement is also salient in conversations about the development of a Covid-19 vaccine, especially among people who oppose social distancing measures (Bogel-Burroughs 2020).

The discourse promoting vaccine hesitancy is difficult to classify as simply rumor or disinformation or conspiracy theory—and indeed it has elements of all three. Communities of activists have coalesced around a set of antivaccine narratives and worked to gather evidence to support their beliefs, to recruit new members, and to spread their ideas (Kata 2010, 2012; Dubé et al. 2015). However, while some participants may be motivated by reputational or financial gain, much of this activity appears to be the work of sincere believers (Koltai and Fleischmann 2017; Wang et al. 2015; Gottlieb 2015).

Though the antivaccination movement has gone global, research on this phenomenon has lagged behind. For example, we can see that countries like South Africa and Brazil are experiencing growth in vaccine hesitancy due to fears of a link between autism and the MMR vaccine (Brown et al. 2018; Burnett et al. 2012; Fujita et al. 2018; Sato 2018). However, there have been very few studies dedicated to studying the antivaccination movement and related misinformation in specific cultural contexts (Cooper et al. 2018; de Menezes Succi 2018). As with other research in mis- and disinformation studies, the majority of work in this area has focused on the global North.

Misinformation, trust, and public health messaging

- Getting factual narratives out quickly is essential to prevent misinformation.
- Science moves more slowly than public demand for information.
- Experts recommend that officials acknowledge uncertainty, but officials may feel

pressure to appear as if the situation is under control.
- Trust in institutions has been declining for decades in many societies.

During a public health crisis, scientists, physicians, communications professionals, and public health officials can play a critical role in informing the public and preventing the spread of misinformation (Pribble et al. 2010; Tirkkonen and Luoma-aho 2011; Walker 2016; SAMHSA 2019). In particular, public health officials can provide the most up-to-date, accurate health information during public health crises, which can be especially important for vulnerable populations (Vaughan and Tinker 2009). Distributing factual narratives quickly from health officials is essential to help prevent misinformation (Bowen and Heath 2007; SAMHSA 2019).

Effectively communicating health information to the public, however, can be challenging—especially in the context of an emerging pandemic characterized by high levels of fear, anxiety, and uncertainty (Covello 2003). The persistent scientific uncertainty with a disease like Covid-19 can make this particularly challenging, as the best information (and the scientific consensus) changes from day to day. The pace of the science combined with the intensity of media coverage about that science is proving particularly challenging for public health communicators during the Covid-19 pandemic (Garrett 2020). Experts have recommended that public health officials acknowledge the uncertainty of the situation (SAMHSA 2019), but this can be difficult, as officials may feel pressure to appear as if the situation is under control. Another issue is the potential misalignment between the information that is being communicated and what the public is interested in knowing (Gui et al. 2017).

Perhaps the most critical challenge for communicating official information during public health crises is trust (Covello et al. 2001). In recent decades, many societies have experienced a loss of trust in the very institutions—such as government and media (Brenan 2019; Rainie et al. 2019)—that people rely on for information during these events. When public health officials are seen as less credible sources, people tend to turn to informal sources to find health information (Jan and Baek 2019). Increasingly, those information searchers are going online where new media and social media have disrupted how trust is formed and provided massive visibility to new kinds of influencers. In the context of Covid-19, this has given rise to a group of arm-chair epidemiologists who are difficult to distinguish from qualified scientists (Limaye et al. 2020). All of these factors can contribute to the spread of misinformation.

Online misinformation

- People turn to the internet to fill information gaps in crisis events.
- Building from early work, scholars argue that online rumors stem from collective

efforts to reduce uncertainty during disruptive events.
- Most people's behavior after a crisis is altruistic, but unscrupulous actors can exploit circumstances for financial or political gain; we see this online as well.

People are now going online during crisis events—including public health crises—to fill information gaps and resolve uncertainty (Sutton et al. 2008; Hughes et al. 2008; Jan and Baek 2019). Research on rumoring and misinformation is increasingly going online as well, perhaps following the action, as the internet affords rumor participation at a massive new scale, but also seizing the opportunity to study human behavior, including rumoring during crisis events, through a new sort of data—i.e., traces left behind on social media platforms (Palen and Anderson 2016).

In recent years, scholars have paid considerable attention to the study of online rumors and misinformation (e.g., Mendoza et al. 2010; Oh et al. 2013; Starbird et al. 2014; Andrews et al. 2016), conspiracy theorizing (e.g., Del Vicario et al. 2016; Starbird 2017; Samory and Mitra 2018), disinformation (e.g., Marwick and Lewis 2017; Ong and Cabañes 2018; Starbird et al. 2019), false news (Vosoughi et al. 2018; Lazer et al. 2018), and other related phenomena. A large portion of this research has focused on techniques for automatic detection (e.g., Castillo et al. 2011; Qazvinian et al. 2011; Derczynski et al. 2015; Zhao et al. 2015; Shao et al. 2016; Zubiaga et al. 2018). But a parallel track of research seeks to better understand how and why rumors and misinformation spread.

This empirical and conceptual work has demonstrated a range of findings. For example, in terms of pure size, the vast majority of rumor cascades are small—though a few are very big (Vosoughi et al. 2018; Goel et al. 2016). Looking at underlying mechanisms, network structure shapes how rumors spread (Arif et al. 2016; Del Vicario et al. 2016). And exploring differences due to veracity, researchers have found that false rumors spread further and faster than true information (Vosoughi et al. 2018) and corrections (Starbird et al. 2014). Extending that last point, there is active debate about whether and how corrections work. Researchers disagree about the existence of a so-called backfire effect that proponents argue causes people to double-down on false beliefs when corrected (Nyhan and Reifler 2010; Nyhan et al. 2014; Bode and Vraga 2015, 2018; Wood and Porter 2019; Ecker et al. 2020). Similarly, researchers continue to explore—and question—the role of "echo chambers" (Sunstein 2001; Jamieson and Cappella 2008) or "filter bubbles" (Pariser 2011) in the spread of misinformation online (e.g., Del Vicario et al. 2016; Bruns 2017; Guess et al. 2018). (For more on these concepts, see our research review on Contexts of Misinformation.)

Focusing specifically on the crisis context, researchers have examined the spread of rumors and misinformation during natural disasters (e.g., Mendoza et al. 2010; Oh et al. 2010;

Gupta et al. 2013; Acar and Muraki 2011), industrial accidents (Zeng et al. 2017), mass shootings and acts of terrorism (Oh et al. 2013; Starbird et al. 2014; Starbird 2017), ethnic violence (Banaji and Bhat 2019), and public health crises (Kou et al. 2017; Oyeyemi et al. 2014; Chen et al. 2015).

The earliest studies of online rumoring (e.g., Bordia and Rosnow 1998; Bordia and DiFonzo 2004; Bordia et al. 1999) built upon Shibutani's (1966) conceptualization of rumoring as a form of group problem-solving (described in the first sections of this paper). Oh et al. (2010, 2013) applied this lens to crises, theorizing that online rumors stem from collective work by online communities to resolve uncertainty during disruptive events. This phenomenon gained widespread attention after the 2013 Boston Marathon bombings, when an online effort to identify the perpetrators notoriously pointed fingers at the wrong suspects (Madrigal 2013; Starbird et al. 2014). Rumors about the National Guard being deployed to "lock down" parts of the United States in response to Covid-19 (Lamothe 2020) suggest similar origins in sensemaking processes.

Online rumors also take the form of viral internet memes such as fake or misattributed photos—for example, the photo of a young girl running who was falsely claimed to have been killed in the Boston Marathon bombings (Maddock et al. 2015a) and the often-used image of a shark that is falsely claimed to be swimming in hurricane waters (Gupta et al. 2013). In the context of a public health crisis like Covid-19, chain-letter-style messages around fake remedies (Doherty 2020) have a similar meme-like quality.

The spread of medical misinformation has become a particularly salient problem online—both within social media platforms themselves and on the diverse websites that feed social media discourse. Public health crises can catalyze and call attention to this phenomenon. For example, during the 2010 Deepwater Horizon oil spill, as people converged online to voice concerns about health impacts, they encountered a scientifically complex information space where false theories about hidden dangers (e.g., "It's raining dispersants") emerged and spread (Starbird et al. 2015; Dailey and Starbird 2015). So-called alternative health information—which included false and misleading claims about treatments—also spread online during the Ebola outbreak in 2014–2016 (Oyeyemi et al. 2014; Fung et al. 2016). And in predominantly English-language threads on Reddit during the Zika outbreak, online sensemaking efforts produced a range of false conspiracy theories about, among other things, the disease's origins (e.g., as a bioweapon in a lab), its severity (e.g., exaggerated by media), and its true cause (e.g., fertilizers from "big agriculture") (Kou et al. 2017). Similarly, during the Covid-19 pandemic, several conspiracy theories spread online—at times at a massive scale—claiming, for example, that the virus was a "planned" event (Neuman 2020) and that 5G technology is the "real" cause of symptoms (Andrews 2020).

Most human behavior after a disaster is prosocial and altruistic (Fritz and Mathewson 1957). But just as in-person exploiters have been known to converge upon a crisis-affected community, online exploiters are now converging onto the digital scene of the crisis to take advantage of the situation—for example, by spreading disinformation for financial or political gain. On the financial side, there have been numerous cases of fake fundraising efforts after natural disaster events (e.g., Strickler 2010; Lehr 2011) and, in the public health context, online campaigns that set the stage for the sale of unproven remedies (e.g., Caulfield 2020; Paul 2020). Public health crises are also leveraged for political gain. For example, though the 2014–2016 Ebola outbreak primarily affected African countries, the virus was mobilized as a political frame to discuss domestic politics—e.g., to argue for border control—in the United States and United Kingdom (Abeysinghe 2016). Roy et al. (2020) describe how people used social media to identify figures to blame, focusing over time on political leaders in their own countries (e.g., national governments and "Obama").

In recent years, we have seen more intentional and organized disinformation campaigns during crises. Between 2014 and 2017, "trolls" working inside Russia's Internet Research Agency (Ru-IRA) took advantage of the convergence of attention during real-world crises—and even manufactured fake crisis events—as part of their disinformation campaigns. Interestingly, Ru-IRA trolls were also active in online conversations about vaccines (Broniatowski et al. 2018), and though their activities reflect tactics of sowing and amplifying confusion and division, the objectives of their vaccine-related engagement are not yet fully understood.

Methodological and ethical considerations

- Most misinformation studies focus on Twitter because data is publicly available, but that creates gaps in knowledge about different demographics and global contexts.
- Similarly, most studies focus on text, leaving us with incomplete understandings of misinformation in videos and images.
- Misinformation studies raise troubling questions around privacy and consent which can be especially problematic in the context of digital content.

As research on the spread of misinformation during crisis events increasingly moves online, we are confronted by new methodological and ethical concerns.

In the crisis context, online platforms make activities that were previously very hard to capture newly legible for investigation (Palen and Anderson 2016). Researchers from diverse fields including computer science, sociology, psychology, media studies, social computing, and human-computer interaction have converged on this new crisis data. They have brought with them a wide range of methodologies, from quantitative analysis at scale (e.g., Del Vicario et al. 2016) to mixed-method studies that move back and forth from high-

level to close-up views of the data (e.g., Andrews et al. 2016; Wilson et al. 2018). Experimental studies measuring the actual spread of misinformation during crisis events have proven difficult. However, researchers have effectively used survey experiments—for example, to explore the efficacy of corrections (Bode and Vraga 2018).

But new data bring new challenges (boyd and Crawford 2011; Tufekci 2014; Crawford and Finn 2015; Olteanu et al. 2019). Though online misinformation takes shape and spreads across many and diverse platforms, the vast majority of research in this space focuses on one platform, Twitter, due to public availability of its data. Though Twitter is a relatively popular platform, other platforms with quite different types of affordances (e.g., Facebook) have far more users and interactions—which suggests that current research is missing large parts of the online misinformation phenomenon. This singular focus also means that we overlook whole demographics and sections of the global population where Twitter is not a primary means of communication. For example, there is evidence that WhatsApp facilitated the spread of misinformation that played a role in religious-based mob violence in India (Banaji and Bhat 2019). But, due to the private nature of communications on that platform, the data are not easily accessible, and there have been few (mostly interview-based) research studies. In addition, boyd and Crawford (2011) write of a "data divide," where access to most social media data is restricted—by cost and access—to a select group of researchers. That fact can be especially problematic when it comes to trying to understand the role of the platforms themselves in facilitating (or dampening) the spread of misinformation. There are related concerns about the representativeness of the data that are accessible to researchers (boyd and Crawford 2011; Tromble et al. 2017), an issue of particular concern in the crisis context (Crawford and Finn 2015). These data limitations render it difficult to make comparisons—across events, platforms, geographies, and time.

The methodologies brought to these data have limitations as well. Online misinformation takes a range of different forms, from textual to graphical memes to videos. With a few notable exceptions (e.g., Gupta et al. 2013), the vast majority of misinformation studies have focused on textual content. We may need new techniques and approaches to better understand how false information spreads via images and videos.

There are ethical concerns as well. Much of the data used for online misinformation studies were created by people who were not aware that their activities would become part of research studies—raising troubling questions around privacy and consent (boyd and Crawford 2011; Crawford and Finn 2015; Olteanu et al. 2019). This can be especially problematic in the context of digital misinformation, as studies that reveal the identities (intentionally or accidentally) of people who spread misinformation may put those people at risk of reputational damage. Misinformation researchers have often navigated these issues by anonymizing and attempting to protect the identities of specific users (Franzke et al.

2020), though exceptions are often made in cases of public individuals such as professional journalists, political figures, and government officials, as well as other highly visible accounts.

There are other dangers specific to conducting research in this context of online misinformation. For example, researchers may amplify hoaxes and extreme messages, even if that is not their intention (Phillips 2018). And researchers themselves face potential negative effects, such as harassment from extremist groups (Gewin 2018) and mental health concerns.

Looking forward

The historical perspective on rumors, and the growing body of work that leverages digital data to understand how and why misinformation spreads through sociotechnical systems, has much to add to the scholarly conversation surrounding the Covid-19 infodemic, but there are notable gaps and pressing questions for the scholarly community.

We live in an increasingly complex and networked global information environment. The consequences of this new ecosystem are visible in the wake of disinformation campaigns attributed to the Russian government and the rise of networked propaganda across the globe. This is the backdrop for the current infodemic. We are already seeing the ways that alternative narratives seeded and amplified by disinformation campaigns become entangled with current public health communications and recommendations.

Effective crisis communications will depend on our ability to disentangle this information; collective sensemaking will be put to the test. We need to know more about how problematic information is taken up, given value, and acted upon; we need to know how to identify explicitly coordinated campaigns from emergent or resonant effects; we need to know how false claims can best be corrected, both for the author and for their audience; we need to understand how authentic information is sustained, exchanged, and applied; and we need to understand the cognitive, social, and technical facets of vulnerability.

At the same time, we have seen a nascent field taking shape around questions at the intersection of technology, democracy, and misinformation studies. Emerging work in this domain will be immediately relevant to the current public health crisis. The Covid-19 pandemic will provide opportunities for researchers to study how information campaigns—both good and bad—get started, take shape, and spread across populations. Bringing perspectives from the social and behavioral sciences to these is vital.

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