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Infodemic Management Approaches Leading up to, During, and Following the COVID-19 Pandemic

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Introduction

When SARS-CoV-2 first began to sweep the globe, so too did information about the virus, including accurate, false, and misleading information. Almost immediately, this deluge of information was recognized as a significant threat to public health, with WHO Director-General Tedros Adhanom Ghebreyesus announcing in February 2020 that "we're not just fighting an epidemic, we're fighting an infodemic." Since then, the notion of an infodemic, which has been defined by WHO as "an over-abundance of information – some accurate and some not – that occurs during an epidemic" (WHO, 2020), has gained traction as a serious and ongoing public health concern, interfering with individuals' ability to obtain and/or trust accurate information when they need it most (WHO, 2020).

In response to the threat posed by infodemics, numerous organizations have dedicated time and resources to infodemic research and management. The National Academies of Sciences, Engineering, and Medicine (NASEM) have taken an active role in these efforts. In April 2023, NASEM will hold a 2-day public workshop on the history and impact of infodemics as well as existing infodemic management strategies. The NASEM workshop planning committee has defined an infodemic as "the rapid spread of large amounts of sometimes conflicting or inaccurate information that can impede the ability of individuals, communities, and authorities to protect health and effectively respond in a crisis." Implicit in this definition is an acknowledgement that false information represents only a small fraction of the problem facing public health crisis communication and response. Indeed, an infodemic is characterized by much more than misinformation/disinformation, including contradictory information, information voids, and information overload. As such, infodemic response efforts must consist of approaches that target the information environment broadly.

The aim of this paper, commissioned by NASEM, is to inform the workshop by providing an overview of infodemic management tools and approaches that have been developed at the international, national, state, and local levels. In addition, this paper will summarize existing evidence and scholarly commentary regarding the effectiveness of different approaches, providing workshop organizers with an understanding of the potential strengths and limitations of each approach as well as gaps in research and practice.

While the tools and approaches discussed in this paper do not pertain to policy or legislation, it is nevertheless important to note that there have been several attempts, some of them ongoing, to use regulatory and legal mechanisms to combat infodemics. Most of these efforts have been aimed at reducing or eliminating false information online. In the US, for example, Section 230 of the Communications Decency Act, which

grants online platforms legal immunity from the content shared by third parties, is currently being challenged (see Gonzalez v. Google LLC and Klobuchar's proposed Health Misinformation Act). Outside of the US, some governments have criminalized sharing false information online and/or given authorities permission to censor online content (see Singapore's Protection from Online Falsehoods and Manipulation Act and Egypt's Law Regulating the Press, Media, and the Supreme Council for Media Regulation). Such attempts to combat infodemics through policy and legislation are controversial and challenging given the inherent tension between protecting public health and preserving civil liberties. However, they provide important context in which to situate the tools and approaches described below.

Methods

The tools and approaches described in this paper were drawn from a database of infodemic and mis/disinformation management strategies developed by our team. This database was compiled October 2022 – January 2023 using a multi-pronged search strategy outlined below:

i. **Academic literature:** we conducted a scoping review of review papers indexed in PubMed, Scopus, or Web of Science using keywords and database-specific search terms related to infodemics (including mis- and disinformation) and infodemic management. These papers (and the papers referenced by their authors) were also used to summarize existing evidence and commentary on the effectiveness of different approaches.

ii. **Gray literature:** we conducted a scoping review of publications, reports, and products developed by organizations involved in infodemic management, including international and intergovernmental organizations, federal agencies, non-governmental organizations (NGOs), technology and media companies, local and national non-profits, think tanks, and research centers.

iii. **State and local health department websites:** we conducted a search of all US state health department websites for infodemic management practices, policies, and tools. We also reviewed infodemic management tools and policies from the following large local health departments: the New York City Department of Health and Mental Hygiene, the San Diego County Health Department, Public Health – Seattle and King County, and the Philadelphia Department of Public Health.

iv. **Key informants:** as part of a separate project, our team interviewed public health practitioners and researchers working in the field of public health communication or infodemiology/infodemic management about their experiences communicating during public health emergencies and responding to mis- and

disinformation or lack of trust. Any tools or approaches related to infodemic management that were mentioned by key informants were added to the database.

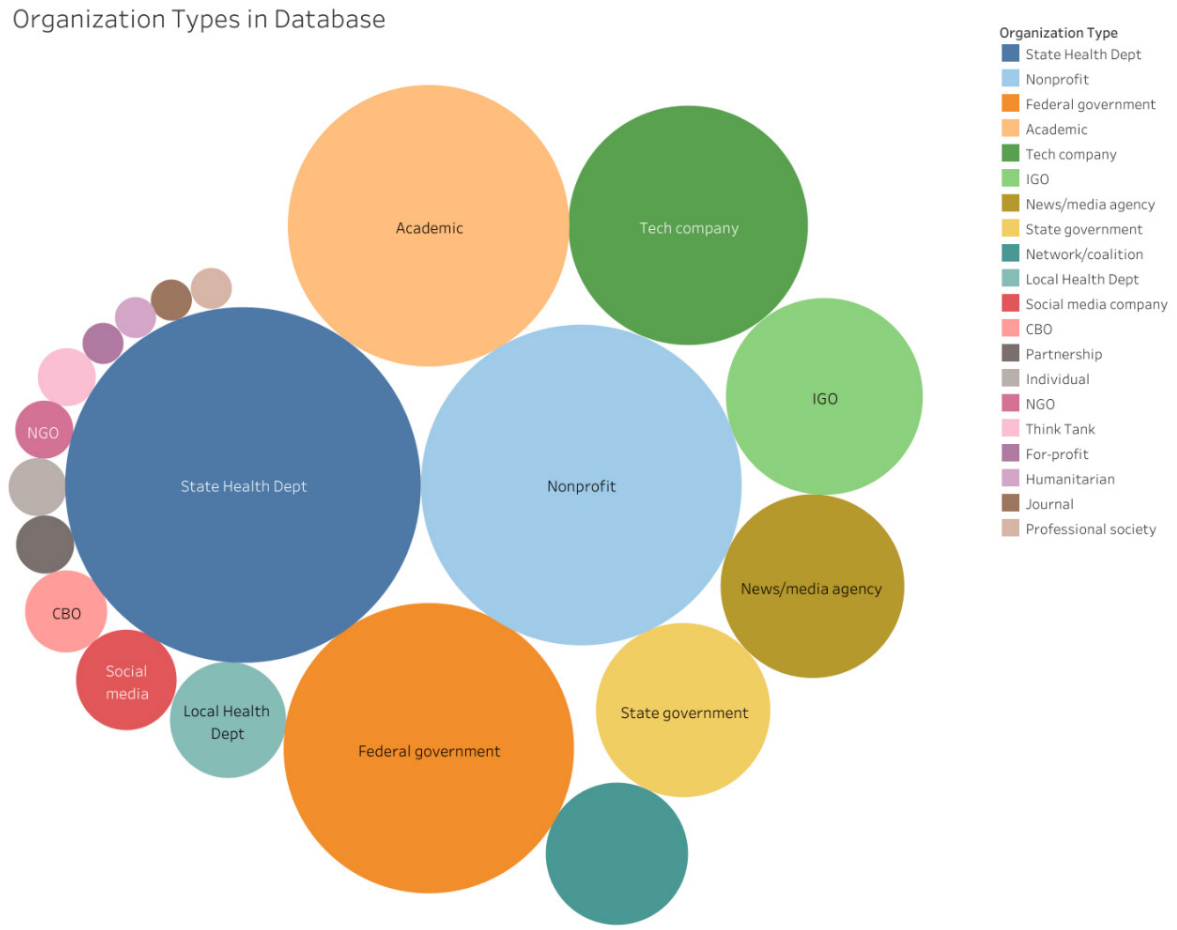
The research team developed a list of tags to identify the main features of each tool or approach. This list was refined iteratively as new tools and approaches were added to the database. The tags were not designed to be mutually exclusive, allowing for each tool to be tagged multiple times. Tools and approaches that were related to policy or legislation were excluded from this analysis because they were largely contextual and many had not yet been enacted into law.

Findings

Organizations and Intended Audiences

The organizations responsible for the infodemic management tools and approaches included: international/intergovernmental organizations (WHO, UNICEF, UNICRI, UNESCO, UNAOC, PAHO, EU, ESCTF, and the European Commission); US federal government agencies and programs (HRSA, FBI, Office of the US Surgeon General, CISA, CDC, FEMA, DHS, AARP, FDA, HHS, DOJ, the White House, USAID, US Marine Corps, and the Global Engagement Center); non-US federal government agencies; academic institutions and research centers; national and local non-profits; NGOs; think tanks; community-based organizations (CBOs); news, media, and marketing agencies; social media companies; technology companies; public-private partnerships; for-profit companies; and state and local health departments. The different organizations and agencies responsible for the tools in the database are depicted in Figure 1.

Figure 1: organizations and agencies involved in the development of the tools/approaches in the database. The size of each circle is proportional to the number of tools/approaches developed by each organization type.



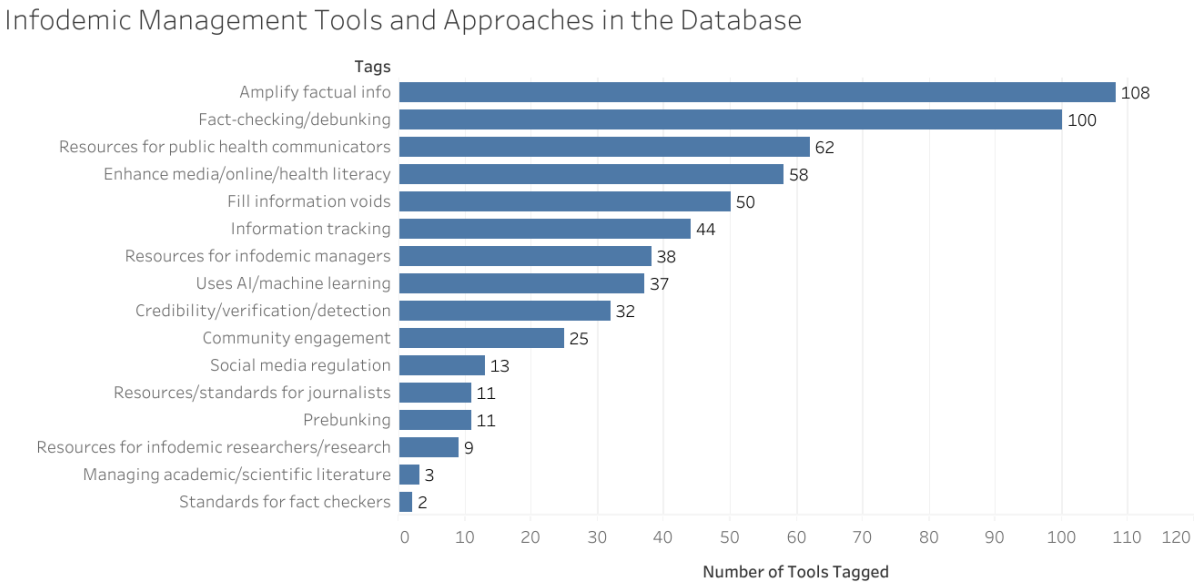
The tools and approaches targeted a large range of audiences, including infodemic managers, infodemiologists, and public health communicators at the federal, state, and local levels; healthcare professionals; journalists; specific communities (including marginalized or hard-to-reach communities) and community leaders (including faith leaders); parents and their children; social media users; state and local health departments; and businesses.

Tools and Approaches

The search strategy described above yielded over 300 infodemic management tools and approaches. Because the tags were not designed to be mutually exclusive, most of the tools and approaches have multiple associated tags. The final list of tags and the number of tools and approaches in the database that were labeled with each tag are presented in Figure 2. As can been seen from the figure, a large number of tools and approaches had fact-checking features or were designed to amplify factual information.

Many tools were also designed to fill information voids, assist public health communicators, or enhance digital, media, and/or health literacy.

Figure 2: tools and approaches included in the database by tag.



Though most tools and approaches had multiple associated tags, they can be loosely organized into the following categories based on their main purpose or feature:

- High-level resources for infodemic managers
- Tools and approaches for information tracking
- Tools and approaches for amplifying factual information, debunking false information, and filling information voids
- Efforts to enhance digital, media and/or health literacy
- Prebunking tools and approaches
- Communication and community engagement approaches and resources
- Verification, credibility, and detection tools.

The tools and approaches in each category are described below, along with a discussion of existing evidence for their effectiveness and any potential limitations or gaps in research or practice.

High-Level Resources for Infodemic Managers

Several organizations and agencies, mostly at the federal or international/intergovernmental level, developed high-level guides, frameworks, or toolkits outlining how to manage infodemics. For example, in 2020, WHO released its Framework for Managing the COVID-19 Infodemic, which was based on the results of a crowdsourced

technical consultation (Tangcharoensathien et al., 2020). WHO's framework outlines five broad "action areas" for member states to focus their infodemic management efforts on. Other guides in this category were focused on specific aspects of infodemic management, such as combatting mis- and disinformation. In 2022, for example, the office of the US Surgeon General released Confronting Health Misinformation: The US Surgeon General's Advisory on Building a Healthy Information Environment, which provides guidance to a wide variety of stakeholders on understanding, identifying, and combatting health-related misinformation.

In addition to developing high-level frameworks, several organizations have also spearheaded efforts to train infodemic managers and establish infodemic management communities of practice. Brown University's Information Futures Lab, for example, runs the Information Futures Fellowship program, which brings together public health practitioners working to improve the information environment and provides them training, resources, and professional connections. In addition, WHO operates a global infodemic management training program, which equips trainees with the tools, resources, and knowledge necessary to become effective infodemic managers. It is important to note that very few public health practitioners identify as "infodemic managers," and that for many, infodemic management is one part of a larger scope of work. The tools and approaches in this category, in other words, can be used and adapted by a variety of professionals who may or may not consider infodemic management their primary responsibility.

While research has been undertaken to evaluate the effectiveness of individual infodemic management strategies (see below), there have been few efforts to evaluate whether the high-level infodemic management guides or resources described above are effective or even utilized by target audiences. State and local health departments often referred to the US Surgeon General's Advisory when describing their own infodemic management efforts, suggesting that these guides can be helpful tools. However, more work needs to be done to assess the utility and effectiveness of these resources both systematically and empirically, including those designed to train infodemic managers or provide a community of practice.

Information (Including Misinformation and Disinformation) Tracking

Several organizations developed tools that enable infodemic managers and public health practitioners to identify what information about a particular topic exists and is being shared, how that information is being discussed, and any information gaps that may exist in a community. Understanding the information environment within a community can help public health communicators tailor messages to a particular

audience and their information needs, and information about circulating rumors can be used to guide debunking efforts. Moreover, information tracking can identify issues related to service delivery and access to medical care, testing, and vaccines. Finally, summaries and reports on emerging scientific information from peer-reviewed publications and pre-prints (including those that have been retracted) can help inform medical and public health decision-making and risk communication.

Most of the tools in this category were social listening tools. These tools often rely on advanced software or artificial intelligence (AI) such as natural language processing (NLP) to track communication trends on popular social media and communication channels (eg, WhatsApp, Facebook, Instagram, Twitter). For example, the WHO launched the Early AI-Supported Response with Social Listening (EARS) platform in January 2021. The social listening platform summarizes real-time information about how individuals are talking about COVID-19 in public online forums, allowing public health practitioners, decision-makers, and infodemic managers to view up-to-date analyses of narratives across multiple countries, languages, and categories of COVID-19 questions and concerns.

Other information tracking tools were developed in partnership with non-profit and academic organizations. Many of these tools were vaccine specific. One example is the Vaccine Demand Observatory (VDO) Dashboard: a collaborative effort of UNICEF, the Public Good Projects, and the Yale Institute for Global Health. The VDO is a dashboard that shows trending vaccine misinformation at the global and national level. VDO analysts collect and monitor publicly available media data to understand vaccine-related knowledge, attitudes, and social behaviors in real time. Vaccine-related misinformation is assigned levels of risk based on its potential to spread and cause damage. Another example of an information tracking tool is Project VCTR: Vaccination Communication Tracking and Response, developed by The Public Good Projects in partnership with the New York State Health Foundation. Project VCTR (pronounced "Vector") was launched in June 2019 to monitor vaccine-related attitudes and behaviors in traditional and digital media sources. The tool identifies common themes in circulating misinformation, the source and level of spread of both verified facts and misinformation, and shifts in conversation following major events or significant updates to vaccine information.

Though social media platforms have been implicated in the spread of false information (Zarocostas, 2020; Törnberg, 2018), it is evident that they have also provided public health communicators with a wealth of real-time information that can be harnessed to gain rapid insights into community questions and concerns during a public health emergency. In fact, information tracking (both on and off social media) has now been recognized as a key "pillar" of infodemic management (Eysenbach, 2020), allowing

for enhanced public health communication that aligns with individuals' information needs, answers relevant questions, and refutes circulating false information (Purnat et al., 2021). However, as Purnat et al. (2021) noted, practical and evidence-based guidance regarding how practitioners should actually use information tracking tools to improve public response emergency response is still limited.

Amplifying Factual Information, Debunking False Information, and Filling Information Voids

A large proportion of the tools and approaches were aimed at amplifying factual information and/or debunking circulating false information. For example, during the height of the COVID-19 pandemic, the Baltimore City Health Department launched a series of social media campaigns outlining the benefits of vaccination while also refuting common rumors. Memes and humor were used to appeal to audiences on social media, with one post reading "there are microchips in your phone, Jesse! But not in any of the vaccines. It won't give you 5G. The vaccine will, however, help prevent the worst effects of COVID-19 and its variants." Some of the tools and approaches in this category utilized AI or machine learning (ML). WHO and UNICEF, for example, partnered in 2020 to create HealthBuddy+, a mobile app that uses AI/ML to deliver up-to-date information on COVID-19 and debunk circulating misinformation.

Many of the efforts in this category were also designed to fill information voids by providing credible answers to commonly asked questions or ensuring factual responses to search queries. For example, WHO has partnered with Google since the onset of the COVID-19 pandemic to ensure that Google users searching for information about COVID-19 are directed to reliable sources via an organized search results panel. In addition, several US states, including Georgia, New Hampshire, and Tennessee operated COVID-19 telephone hotlines that residents could use throughout the pandemic to ask questions about the disease or recommended mitigation measures.

According to the US Surgeon General's Advisory (*Confronting Health Misinformation*, 2021), misinformation "thrives in the absence of easily accessible, credible information" (p. 5). As such, providing individuals with a steady stream of factual and credible information could be an effective way to combat the spread of mis- and disinformation. However, it is important to note that individuals may not be willing to act on (or even listen to) information that is provided to them. In fact, evidence from the political and psychological literature suggests that individuals are more trusting of information that conforms with their pre-established beliefs and are generally skeptical of information that does not, even if such information is supported by evidence (Kraft et al., 2015; Kunda, 1990). In addition, in stressful situations or emergency conditions, individuals may have difficulty processing factual information or acting on it in the way that public

health communicators desire (Reynolds, 2011). It may not be enough, in other words, to simply communicate facts during an infodemic.

Fortunately, there is some evidence that debunking can be used to change individuals' beliefs or misperceptions about certain topics. A meta-analysis, for example, found that correcting health-related misinformation on social media was effective in terms of changing individuals' attitudes, behavioral intent, or behavior (Walter et al., 2021). The authors of another meta-analysis found that debunking had a moderate effect on belief in misinformation (Walter & Murphy, 2018). Despite these results, there has been concern for some time that debunking might be associated with a "backfire effect," causing individuals to believe false information more strongly following attempts to refute it (Nyhan and Reifler, 2010; Pluviano et al., 2017). However, the current scientific consensus is that the backfire effect is not "a robust empirical phenomenon" (Swire-Thompson et al., 2020, p. 286).

While the backfire effect may not be a legitimate concern, there are still challenges associated with debunking. It has been argued, for example, that psychological processes and biases make it inherently difficult to correct mis- and disinformation, especially when such information aligns with individuals' previously held beliefs (Helm & Nasu, 2021). In fact, there is substantial evidence that individuals' belief in false information is likely to persist and/or continue to impact their decision-making despite debunking efforts (Chan et al., 2017; Lewandowsky et al., 2012). As Lewandowsky et al. (2012) explained, "it is extremely difficult to return the beliefs of people who have been exposed to misinformation to a baseline similar to those of people who were never exposed to it" (p. 114). However, efforts to correct tobacco-related misinformation have revealed some promising strategies (eg, narrative correction) to improve debunking and mitigate the continued influence of misinformation (Ophir et al., 2020; Sangalang et al., 2019).

Efforts to Enhance Digital, Media, and/or Health Literacy

Many organizations, including academic institutions, research centers, non-profits, NGOs, and local health departments developed programs or resources to enhance individuals' digital, media, and/or health literacy (including science literacy). These resources were generally designed to help individuals become more conscientious consumers of health and/or online information, thereby improving their ability to navigate the information environment during an infodemic. Some of these resources targeted the general public and were focused on specific health topics. For example, during the pandemic, the San Diego County Health Department created a page on their main website with information about how to find, evaluate, and understand credible information about COVID-19. The page includes explanations of the peer

review and pre-print processes as well as a discussion of sample size considerations for epidemiological studies, providing users with the tools necessary to critically evaluate and better understand scientific information about COVID-19.

Other resources were aimed at specific audiences. Arizona State Career Catalyst, for example, created an online course and certification program in media literacy for healthcare professionals. The course is designed to help healthcare professionals understand how false health-related claims are spread in the media and how to combat them. Many digital and media literacy resources were also created for use in classrooms. For example, during the beginning of the COVID-19 pandemic, teachers from 6 US states came together to develop a media and science literacy unit for high school students. The unit includes sections on the difference between correlation and causation and how to evaluate the credibility of media articles, with case studies and exercises focused on COVID-19 and climate change (Miller et al., 2021).

The relationship between various forms of digital, media, or health literacy and outcomes relevant to infodemic management has been examined in several observational studies (An et al., 2021; Patil et al., 2021; Pickles et al., 2021). Some of these studies have found a negative relationship between digital health literacy and belief in COVID-19-related conspiracy theories or misinformation (An et al., 2021; Pickles et al., 2021), suggesting that efforts to enhance digital and/or health literacy could help combat mis- and disinformation during a public health emergency. Two studies also demonstrated a positive relationship between digital health literacy and adherence to recommended COVID-19 prevention behaviors (An et al., 2021, Patil et al., 2021), indicating that those with higher levels of digital health literacy may be better equipped to follow expert guidance during infodemics. However, not all studies have yielded such promising results. The author of a study of Polish internet users, for example, found that respondents with higher eHealth literacy were actually more likely to believe COVID-19-related conspiracy theories (Duplaga, 2020).

The effectiveness of digital, media, and/or health literacy interventions has been tested in experimental studies, with some individual studies yielding encouraging results. For example, one study found that teaching students how to evaluate information online was effective: those in the intervention group showed better critical thinking about online information than those in the control group (McGrew et al., 2019). Another large study found that individuals exposed to a digital media literacy intervention were more skeptical about the accuracy of fake news headlines after the intervention (Guess et al., 2020). However, authors of systematic reviews have identified issues with the methodological rigor of digital and/or health literacy intervention studies as well as gaps in the existing body of evidence, making it difficult to assess what aspects of health literacy interventions might make them successful (Visscher et al., 2018), the impact

of digital literacy interventions on health outcomes among older adults (Watkins and Xie, 2014), and the long-term effects of school-based science literacy interventions (Nordheim et al., 2016).

Prebunking/Inoculation

Individuals and organizations involved in infodemic management, particularly academic research centers, non-profits, and technology companies, have grown increasingly interested in prebunking as a strategy to combat mis- and disinformation. Prebunking is a concept that grew out of inoculation theory, which posited that individuals could be "inoculated" against persuasion in the same way that they could be inoculated against a pathogen (McGuire, 1964). Current prebunking or inoculation strategies (used interchangeably in this paper) involve exposing individuals to warnings and "pre-emptive refutations" of anticipated misinformation (see van der Linden et al., 2017) or common tactics of deception (see Roozenbeek et al., 2020) in order to provide them with psychological resistance to future exposures. Many of the recent inoculation interventions have been developed in "gamified" formats. For example, in 2020, the University of Cambridge, UK Cabinet Office, and WHO released Go Viral!, a free online game in which players assume the role of manipulators and learn how to create viral false content. Another example is Bad News (developed by the University of Cambridge Social Decision-Making Lab), which is a free online game in which players publish their own fake news and learn techniques behind mis- and disinformation campaigns.

A growing body of empirical evidence suggests that prebunking/inoculation can help individuals better understand and identify misinformation (Basol et al., 2021; Saleh et al., 2021), make them less likely to spread or share misinformation (Basol et al., 2021; Iles et al., 2021), and reduce the likelihood that they will be persuaded by misinformation or find it credible when exposed (Van der Linden et al., 2017; Roozenbeek et al., 2020; Iles et al., 2021). In addition, there is some evidence that inoculation interventions can result in "post-inoculation talk," a phenomenon in which inoculated individuals share the information or skills they learned and in doing so inoculate others against misinformation (Ivanov et al., 2012). Finally, it is important to note that prebunking interventions overcome one of the primary shortcomings of debunking by tackling misinformation *before* individuals are exposed, thereby circumventing the challenge of correcting false information that has already been seen.

It is also important to acknowledge some potential limitations and challenges associated with prebunking. From a practical standpoint, individuals must agree to be inoculated in order for prebunking to have its intended effects (Kozyreva et al., 2020). Like individuals who are vaccine hesitant, many may be inoculation hesitant, and persuasion or confidence building efforts will likely be difficult and resource intensive.

In addition, the protective effect of inoculation may diminish over time or languish "in the face of unexpected or novel deceptive techniques" (Kozyreva et al., 2020, pg. 141), potentially necessitating "boosters" (Maertens et al., 2021).

Verification, Credibility, and Detection Tools

Verification, credibility, and detection tools are designed to detect false information or evaluate the credibility of online or media content. Technology companies, academic institutions, and non-profits were key players in the development of these tools, which included browser extensions, websites, and specialized media accounts to detect false information, evaluate content or source credibility, and identify potential biases and political leanings of information sources. Many of the tools in this category were automated and relied on AI/ML. BotSentinel, for example, is an online tool that uses a ML model to categorize Twitter accounts based on their trustworthiness and credibility. Using its model, BotSentinel rates accounts from 0% to 100%, with higher scoring accounts being more likely to engage in targeted harassment or deceptive tactics to perpetuate misinformation.

Another example, The Factual, uses a similar grading scale to conduct news media content verification: with its browser extension, news articles receive a grade from 1-100% to determine source credibility. The score is based on 4 key metrics: site quality, author's expertise, quality and diversity of sources, and article tone. The Factual also assesses the political orientation of news outlets using data from the nonpartisan news bias-checking websites AllSides and Media Bias Fact Check. In addition to helping individuals better evaluate the information they consume, news media content verification tools can be helpful in choosing what information to share secondarily online, including retweeting or quoting articles circulating on social media. Additionally, news agencies, broadcasters, newspapers, and journalists may use similar tools to validate and select videos to share. InvID, for example, is a verification platform designed to assess the reliability of video files spread via social media.

There is some evidence that providing individuals with an indication of the credibility of information sources can impact the extent to which they believe information from that source to be true. Kim et al. (2019), for example, found that when sources of information were accompanied by low credibility ratings, individuals were less likely to believe information from that source. However, Kim et al. (2019) also found evidence of confirmation bias (individuals were more likely to believe information that was consistent with their pre-existing beliefs), potentially limiting the utility of such ratings in the fight against false information. Nevertheless, as Kim et al. (2019) noted, credibility ratings may be preferable to debunking given their potential to prevent belief in misinformation in the first place. There is also evidence that attaching warning

labels to false information may reduce its influence (Ecker et al., 2010). Using detection tools to generate warnings on false information, in other words, could be an effective strategy to combat mis- and disinformation. However, it is important to note that warnings do not eliminate the continued influence of false information (Ecker et al., 2010), suggesting that they may only offer a partial solution. In addition, automated detection tools can have varying accuracy and may not perform well across different contexts or languages (Xarhoulacos et al., 2021).

Communication and Community Engagement

Organizations also tried to enhance infodemic management through improved communication and community engagement approaches. Many of these approaches and resources aimed to improve public health communication by producing (or providing guidance on how to produce) effective and trustworthy messages that could cut through the noise of an infodemic, resonate with target audiences, and promote protective health behavior. For example, Public Health Communication Collaborative has developed a collection of toolkits, talking points, messaging, and graphics to help public health communicators convey information about COVID-19 (and other health topics) in a way that seeks to be "timely, clear, credible, and effective" (Public Health Communications Collaborative - About).

A large number of the approaches and resources in this category targeted traditionally hard-to-reach, vulnerable, and/or marginalized communities. For example, the Rural Institute at the University of Montana developed a hub of resources and information for how best to conduct COVID-19 vaccination outreach to rural communities, particularly those with disabilities. The hub includes guidance for public health messaging as well as exercises and instructions for deep canvassing. To overcome barriers to communication with hard-to-reach or marginalized communities (such as lack of trust in public health institutions or messengers), several organizations have developed community engagement programs to identify and train trusted messengers, gain insight into community needs and communication preferences, and establish and maintain trust. Live Chair Health, for example, is a public health communication and outreach program that trains US barbers to have conversations about health with their African American clients. As Live Chair Health founder Andrew Suggs explained, the program aims to close the life expectancy gap for African American men "by leveraging the trusted social space of the barbershop" (Suggs, 2019).

Numerous studies have documented the important role of community engagement in building trust and communicating effectively about health, particularly with communities that are marginalized or have historical mistrust of science/government. Much of this work has been in the context of vaccine acceptance or uptake (Burnett

et al., 2005; Gilmore et al., 2022; Rani et al., 2022; Jegede, 2007). However, there has also been work emphasizing the importance of community engagement for effective communication during public health emergencies such as COVID-19 (Sommariva et al., 2021; Gonah, 2020) and the Ebola outbreak (Gillespie et al., 2016; Carter et al., 2017). Community engagement has also been recognized as an important tool to combat misinformation as well as confusion resulting from information overload or changing information/guidance (Dada et al., 2022; Butler et al., 2022; Zhang et al., 2022; Pringle et al., 2022; Schoch-Spana et al., 2021; Korin et al., 2022), making it a promising strategy for infodemic management.

There is some evidence that individuals in marginalized groups, including racial/ethnic and religious minorities, may be more susceptible to false information (ie, more likely to believe false information is true) than their non-marginalized counterparts (Goertzel, 1994; van Prooijen et al., 2018; Freeman and Bentall, 2017). This relationship may be due to high levels of mistrust among individuals who are (or perceive themselves to be) marginalized (Freeman et al., 2020). Such findings and commentary highlight the need for infodemic resources (like the community engagement approaches noted above) that are targeted towards marginalized or minority groups and are focused on trust building.

However, community engagement cannot be a last-minute or short-term approach to infodemic management. In fact, community engagement and communication efforts that occur only in times of crisis may be counter-productive and further erode trust in public health institutions or researchers (Ojikutu et al., 2021). Instead, community and stakeholder relationships should be established and maintained prior to a crisis so that these relationships can be utilized for effective communication during the crisis (Schoch-Spana et al., 2018; Myers, 2021). Establishing and maintaining these relationships may be time and resource intensive, but such efforts will be worthwhile in the long run.

Summary

Based on the findings described above, it is evident that numerous organizations and agencies are invested and involved in infodemic management. As result of these organizations' efforts, a wealth of tools and approaches to managing infodemics now exists, including high-level frameworks and guides; information tracking tools; approaches and resources for amplifying factual information, refuting false information, and filling information voids; tools to enhance digital, media, and/or health literacy; prebunking tools and approaches; communication and community engagement approaches and resources; and verification, credibility, and detection tools. All of the tools and approaches outlined in this paper are promising but have associated gaps and limitations that require further work. One major unresolved question that

appeared across multiple categories of tools was how to overcome the psychological and cognitive processes (eg, confirmation bias) that dictate how individuals consume and respond to information. Another unanswered question is how to facilitate the uptake of infodemic interventions (such as prebunking or digital/health literacy exercises) among individuals that need them most. These issues (and the others outlined in the sections above) will need to be resolved before the tools in each category are truly effective.

As scholars have noted, the complex nature of infodemics warrants an equally complex and multi-faceted approach to infodemic management (Naeem and Boulos, 2021). The tools and approaches described in this paper, in other words, should not be considered in isolation, but should be combined into one comprehensive strategy. However, guidance or resources for how to combine different approaches remains limited. The high-level infodemic management frameworks developed by WHO and others offer a useful jumping-off point but require further development and detail regarding how to integrate approaches. In addition, while some of the tools described in this paper were developed by groups of organizations, many were developed in silos, resulting in redundant tools that often offered only partial solutions to infodemic management. A comprehensive infodemic management strategy will require better coordination across organizations and agencies at the international, national, state, and local levels.

Lastly, artificial intelligence and machine learning can enhance infodemic management approaches such as information tracking, fact checking, filling information voids, and verification/detection. However, there are issues associated with AI/ML applications that should not be ignored, including varying accuracy and limited applications across different contexts and languages. These tools also require significant in-house knowledge and human resources to operate and maintain. As such, health departments and other organizations involved in infodemic response and management may not be equipped to take full advantage of AI/ML tools or use them appropriately. Public health practitioners may also lack interest or sufficient time to integrate these tools into their regular duties. This may be particularly true for tools developed by academics or social media/marketing companies, as such tools may not be designed for use in public health practice.

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