EXPLORING THE COVID-19 INFODEMIC IN ALASKA

by

Emily Maxwell

B.A. Dartmouth College, 2014

M.P.H. University of Alaska Anchorage, 2021

A Dissertation submitted in Partial Fulfillment of the Requirements
for the Degree of

Doctor of Philosophy
in
Epidemiology: Interdisciplinary Studies

University of Alaska Fairbanks
August 2024

APPROVED:

Arleigh Reynolds, Committee Chair
David Parker, Committee Co-Chair
Jennifer Meyer, Committee Member
Tuula Hollmen, Committee Member
Cristina M. Hansen, Chair
Department of Veterinary Medicine
Karsten Hueffer, Dean
College of Natural Science and Mathematics
Richard Collins, Director
Graduate School

Abstract

The onset of the COVID-19 global health crisis coincided with an unprecedented rise in health misinformation and false narratives related to the disease. This simultaneous spread of accurate and inaccurate information, referred to as an infodemic, has had observable impacts on the trajectory of the pandemic and the future of public health. While health misinformation has been a factor in previous outbreaks, the increased prominence of social media as an information platform allowed misinformation to spread more widely and rapidly than ever before. This investigation aims to assess the impacts of COVID-19 misinformation in Alaska using a mixed methods approach. The first study uses a machine learning model to describe themes from popular public-facing Alaska-based Facebook pages in which posts or comments containing misinformation proliferated. The second study aims to evaluate the effectiveness of a brief educational intervention in lowering vaccine hesitancy using an online, randomized controlled trial survey. The final study uses a One Health framework to explore how the circulation of false, incomplete, and excessive information affected professionals responding to the COVID-19 pandemic. Findings from these studies offer insight into infodemic dynamics in Alaska, including trends in online misinformation, the need for highly targeted, coordinated communication strategies, and the challenges posed by misinformation across response sectors. First-hand knowledge of the effects of the infodemic revealed a direct impact on the community, professional practice, mental and physical health. The erosion of trust in science and public health along with the unprecedented politicization experienced during the pandemic not only impaired the immediate response but appears to have lasting repercussions on the field of public health. By leveraging these findings, we can enhance emergency preparedness for future public health threats with an informed, proactive, and nimble response.

Acknowledgements

This dissertation would not have been possible without the support, time and effort of many kind people. It is impossible to name every individual who helped me along the way, but I will do my best to name them here.

First and foremost, I would like to thank my committee members: my committee chair, Dr. Arleigh Reynolds, my co-chair, Dr. David Parker, Dr. Jennifer Meyer, and Dr. Tuula Hollmen. From the very early days of answering endless questions about entering a doctoral program to editing the final version of this 38,000-word document, these individuals served as supportive mentors who were always there when I ran into a roadblock throughout this process. With their guidance, I have grown immensely both personally and academically. Access to the data used in this dissertation was gained only with the help of members of my committee. Many crucial connections were also made with the help of my committee, including introductions to Dr. Taylor van Doren, who gave me valuable advice on navigating the application process for my first NSF award (thank you also to Dr. Erica Hill), and Lydia Stark, who was essential to the successful preprocessing of my data.

Thank you to the many institutions who provided financial support for this degree including the Graduate School at the University of Alaska Fairbanks (Travel Award and Degree Completion Award), University of Alaska Fairbanks Office of the Vice Chancellor for Research Graduate Student Support Fund, Alaska EPSCoR Travel Award, National Science Foundation Arctic Section Doctoral Dissertation Research Improvement Grant, Mat-Su Health Foundation scholarship, Knik Tribe scholarship, the American Indian Science and Engineering Society, and lastly, the Choctaw Nation of Oklahoma. From the beginning of my graduate studies, the Choctaw Nation has been an unwavering source of support and an essential part of my academic success.

I also want to thank the many fellow students I emailed out of the blue with questions about various aspects of the program/funding/etc. Without exception, I was met with warmth and an eagerness to help guide me in the right direction. I must also thank the various employers I have had throughout the past several years, who supported my academic journey. I want to give a special thank you to Dr. Micah Hahn, who has served me not only as the best boss a person could ask for, but also as a mentor and friend.

Last but not least, I want to thank my family, especially my parents. I would not be here without you (literally), and it is your guidance and love that make me who I am today.

Table of Contents

List of Figures

List of Tables

Chapter 1: General Introduction

1.1 Background

On March 11, 2020, the World Health Organization (WHO) declared the novel coronavirus (SARS-CoV-2) outbreak a global pandemic (World Health Organization, 2020a). In the months following, governmental agencies around the world struggled to overcome complex issues associated with the prevention and control of this novel virus. The emerging threat of inaccurate or misleading information became evident when various mitigation efforts were unsuccessful, and public health measures were insufficient to stop the spread of the virus (Pei et al., 2020). Persistent misinformation and the ubiquity of social media contributed to widespread confusion about COVID-19 amongst the public (World Health Organization, 2020b).

Addressing health security issues during a global pandemic is a complex and dynamic undertaking, requiring expertise from many typically divergent domains (Bourbeau et al., 2022). Veterinary scientists, physicians, epidemiologists, social scientists, and virologists each play a critical role in understanding risk factors, surveillance, medical countermeasures, and origins of a pathogen (Bourbeau et al., 2022). Effective risk communication during a public health emergency requires a multidisciplinary approach to ensure transparent and clear communication, comprehensive and action-oriented emergency plans, and responsive policymakers (Bourbeau et al., 2022; Heydari et al., 2021). Health misinformation can undermine the efforts and recommendations made by these sectors (Reis, 2022). For example, despite the widespread availability of safe and effective vaccines, as of October 2022, only 67% of Americans were fully vaccinated (two doses) (Centers for Disease Control and Prevention, 2022c). This number is even lower in Alaska alone (63%) (Centers for Disease Control and Prevention, 2022c).

The proliferation of misinformation, fear, and uncertainty inhibited the uptake and efficacy of control measures implemented to protect the public and health workforce throughout multiple waves of the pandemic (Reis, 2022). Though a growing amount of scientific research on health misinformation exists, there is a pressing need to better understand how to identify, monitor, and understand misinformation and its impact on individual, community, and population health during emergencies (WHO, 2021).

1.2 COVID-19 Disease

The causative agent of the disease COVID-19 is SARS-CoV-2 (severe acute respiratory syndrome coronavirus 2). SARS-CoV-2 is a positive-sense, single-stranded RNA virus of the family *Coronaviridae* (Rabaan et al., 2020). Coronaviruses can infect humans and animals, causing mild to severe respiratory symptoms. Coronaviruses caused two previous human outbreaks, SARS-CoV (severe acute respiratory syndrome) in 2002 and MERS-CoV (Middle East respiratory syndrome) in 2012, both of zoonotic origin and causing serious illness in humans (Rabaan et al., 2020).

In late 2019, idiopathic viral pneumonia appeared in Wuhan, China, swiftly overtaking SARS and MERS in terms of transmissibility and geographic spread (Hu et al., 2021). Symptoms of this illness were similar to SARS and MERS and included fever, cough, sore throat, dyspnea, and bilateral lung infiltration (Hu et al., 2021). The first cohort of hospitalized patients were nearly all linked to the Huanan Seafood Wholesale Market in Wuhan, which sold seafood, poultry, wildlife, and live animals (see Figure 1.1). Subsequent studies have dated the first case back to December 8, 2019, and on December 31 (more than three weeks later), the Wuhan Municipal Health Commission alerted the WHO.

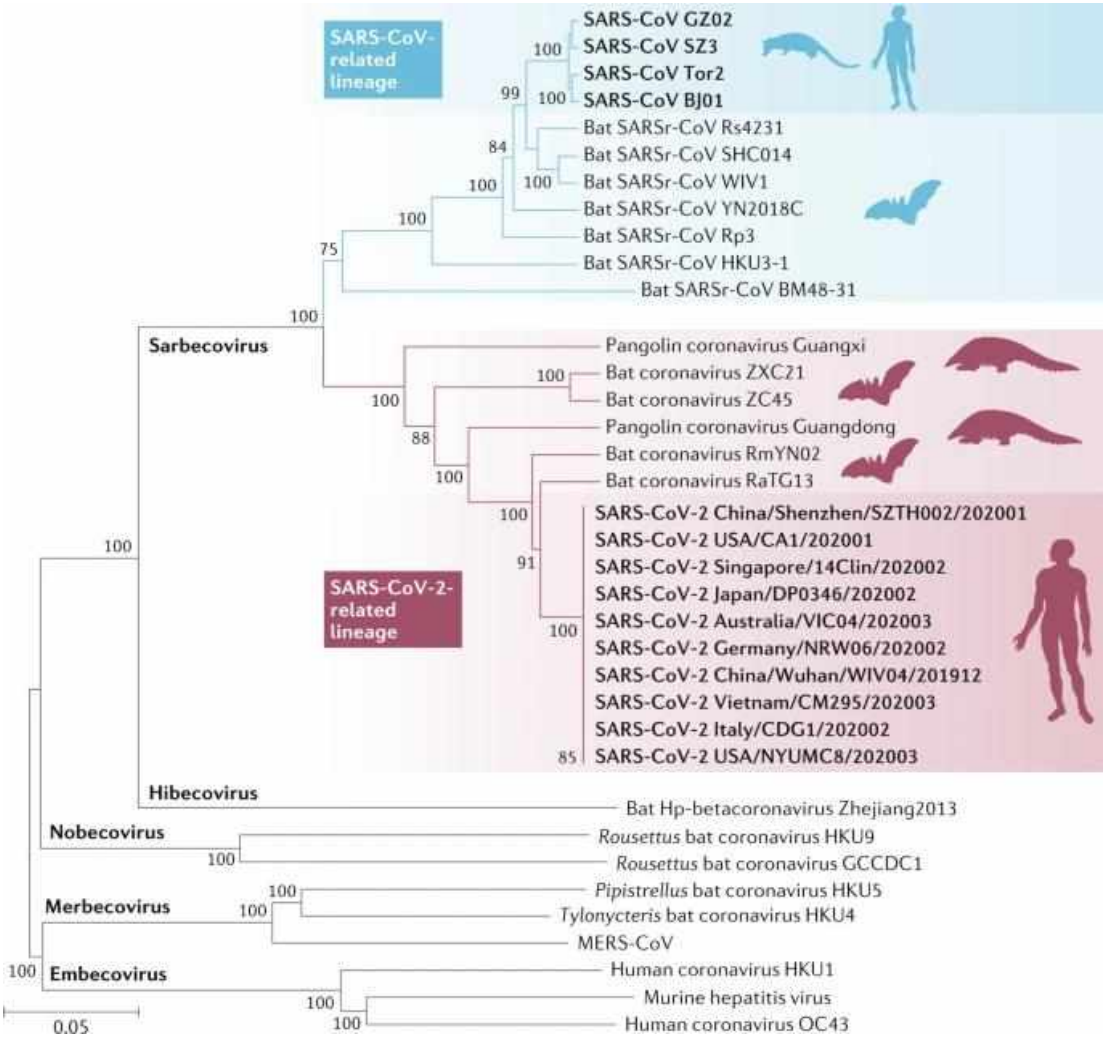
Figure 1.1: COVID-19 disease emergence timeline.

(Hu et al., 2021)

Through genomic sequencing and viral isolation from patient samples, scientists in China identified the causative agent as a novel beta coronavirus, and the complete genome sequence was published just days later, on the GISAID database (Hu et al., 2021). Evidenced by the almost immediate identification of healthcare facilities, it became apparent that human-to-human

transmission was occurring; within one month, every province of China had confirmed cases (Hu et al. 2021). In response, China implemented unparalleled public health restrictions, curbing all gatherings and outdoor activities, and shutting down transportation (Hu et al., 2021), but the international spread of the virus had already begun, with cases confirmed in Europe, North America, the United Arab Emirates, and Australia by the end of January (World Health Organization, 2020a). On March 11, 2020, the soaring number of cases and geographic reach of the virus led the WHO to declare the outbreak a global pandemic.

Figure 1.2: SARS-CoV-2 lineage.



(Hu et al., 2021)

Phylogenetic analysis reveals that SARS-CoV-2 is most closely clustered with coronaviruses from horseshoe bats and pangolins, though it is genetically distinct from both (see

Figure 1.2). The closest known relative to SARS-CoV-2, known as 'RATG13', is found in the bat species *Rhinolophus affinis*, which shares 96.2% of its genome with SARS-CoV-2 (Zhou et al., 2020). Despite the abundance of research on the origins of SARS-CoV-2, much remains to be determined. It is likely that, like previous human coronaviruses, SARS-CoV-2 emerged as a result of a spillover event, where an animal virus evolves to become capable of infecting humans. Typically, spillovers involve a reservoir animal, as was the case with both SARS and MERS (palm civets and dromedary camels, respectively); in these cases, the virus harbored by the intermediate hosts was more than 99% identical to the human form of the virus (Hu et al., 2021). As of November 2023, no virus has come close to matching that level of similarity to SARS-CoV-2. The two closest candidates, viruses from bats and pangolins, register at 96.2% and 92% similarity, a difference likely resulting from more than 20 years of genetic sequence evolution (Hu et al., 2021).

The clinical pathogenesis of COVID-19 ranges from mild symptoms to respiratory failure, the latter more likely in those with advanced age or certain pre-existing conditions such as obesity, pregnancy, diabetes, or immunocompromising comorbidities (Centers for Disease Control and Prevention, 2022b). The virus is often transmissible before a person becomes symptomatic (the mean incubation period is 6.9 days, while the mean latency period is 5.5 days), further enabling its spread (Xin et al., 2022). Pharyngeal virus shedding is the principal mode of spread through respiratory droplets and aerosolized particles, though fomite transmission is possible (Centers for Disease Control and Prevention, 2021). Therapeutics for COVID-19 infection include antivirals (Nirmatrelvir with Ritonavir, Molnupiravir, and Remdesivir) and convalescent plasma, and Pfizer developed the first vaccination for COVID-19 in December of 2020 (Centers for Disease Control and Prevention, 2021).

1.3 The Challenges of Misinformation

1.3.1 Disputed Definitions

Despite the recent upswing in research centered on COVID-19 misinformation, consensus around a case definition for the term continues to be defined (Southwell et al., 2022). The word misinformation carries with it confusion and political weight, and as a result, numerous studies work towards standardizing a case definition (Southwell et al., 2022; Vraga & Bode, 2020). Without a solid understanding of what is meant by misinformation, results from

studies investigating the topic can be conflicting, misconstrued, and produce reproducibility issues. According to the CDC, misinformation is defined as false information shared by people who do not intend to mislead others (Centers for Disease Control and Prevention, 2022a). There is a distinction between this definition of misinformation and two similar terms: disinformation, defined as false information deliberately created and disseminated with malicious intent (Centers for Disease Control and Prevention, 2022a), and malinformation, defined as genuine information shared to cause harm (Santos-D'Amorim & Miranda, 2021). Colloquialisms for misinformation, such as fake news and rumor, are often used synonymously with misinformation. The definitions of all three of these terms are debated and can differ slightly depending on the setting. Importantly, these distinctions are based upon the author's intent, making definition determination challenging and rendering this classification system problematic, as the author's intent is not always knowable. Therefore, as in other studies (Bahl et al., 2022; Wu et al., 2019), misinformation will be defined more broadly in a definition derived from Vraga and Bode; information considered incorrect based on the best available evidence from relevant experts at the time. (Vraga & Bode, 2020). This definition avoids the imprecise language often used in alternative definitions (such as that found in the CDC definition above), which invites discord around what "false information" is. Though this case definition also has notable limitations and can provoke additional inquiry (such as who is doing the considering or who the relevant experts are), it adheres to the scientific norm of favoring simplicity while maintaining accuracy and being relatively easy to operationalize (Southwell et al., 2022).

Mis-, dis-, and malinformation can be seen in many contexts, going back to antiquity. When the Roman Republic faced a civil war, Octavian launched a misinformation campaign against Mark Antony and later became the first Emperor of Rome (BBC, 2023). The introduction of the printing press facilitated large-scale misinformation campaigns, which could alter the course of history. Misinformation in the form of propaganda led to the outbreak of war in the 19th and 20th centuries (Spanish-American War and World War I, respectively) (BBC, 2023). Political strategists have also used misinformation; during the 2016 United States presidential election, Russia's Internet Research Agency created fake social media accounts, groups, and news articles targeting specific racial groups and political ideologies (Grossman & Diresta, 2019). This content discouraged electoral participation by certain groups and sowed further division within the United States. In Brazil, the office of the presidency has spread

disinformation against political opponents and, more recently, messages aimed at discrediting COVID-19 precautions and the officials promoting them (Ricard & Medeiros, 2020). Finally, in the past, India was burdened with torrents of misinformation concerning child abuse, public health issues, and cyclones, which led to the outbreak of violence in the state's religious and caste system context (Doshi, 2017).

The complexity of health misinformation is compounded by the wide variety of channels, topics, sources, and receivers in the system. Researchers have attempted to classify health misinformation, including exercise and nutrition, cancer information, epidemics/pandemics, medication adherence, vaccinations, and tobacco use (Krishna & Thompson, 2021). Misinformation can spread swiftly on social media platforms, but also through blogs, media outlets, and television. Emerging research suggests interpersonal interaction may also play a significant role in misinformation proliferation (Melki et al., 2021).

1.3.2 [Info]rmation Pan[demics]: The Introduction of the Infodemic

The CDC states that "misinformation often arises when there are information gaps or unsettled science, as human nature seeks to reason, better understand, and fill in the gaps" (Centers for Disease Control and Prevention, 2022a). Throughout the COVID-19 pandemic, uncertainty and imperfect data set the stage for misinformation to proliferate and create significant barriers to public health response. The WHO developed resources to combat the unparalleled abundance of information during the COVID-19 pandemic, including guidelines, training, and resolutions dedicated to tackling the "infodemic".

The WHO defines an infodemic as an overabundance of information—some accurate and some not—that occurs during an epidemic (Tangcharoensathien et al., 2020). The term was coined during the SARS outbreak in 2003 by national security analyst David Rothkopf. In a May 2003 issue of the Washington Post, Rothkopf wrote about two simultaneous pandemics: the SARS pandemic and the infodemic, which made the public health crisis harder to contain (Rothkopf, 2003). The term was then picked up and expanded upon by Gunther Eysenbach (a health researcher at the University of Toronto), who created the field of infodemiology (information epidemiology) (Eysenbach, 2002). To support this burgeoning field, the WHO developed research priorities in 2021 to include five major streams, shown in Table 1.1 below.

Table 1.1: Infodemiology research priorities defined in *Framework for Managing the COVID-19 Infodemic: Methods and Results of an Online, Crowdsourced WHO Technical Consultation.*

1	Measure and monitor the impact of infodemics during health emergencies.
2	Detect and understand the spread and impact of infodemics.
3	Respond and deploy interventions that protect and mitigate the infodemic and its harmful effects.
4	Evaluate infodemic interventions and strengthen the resilience of individuals and communities to infodemics.
5	Promote the development, adaptation, and application of tools for managing infodemics.

(Tangcharoensathien et al., 2020)

The field of infodemiology saw renewed interest during the COVID-19 pandemic, and as a result, the body of credible scientific research on the topic grew, an appreciable portion of which is dedicated to identifying significant causal factors of an infodemic. As the volume of information on a topic swells, the noise also increases, making it difficult to determine which information is factual. This confusion intensifies when the subject is technically challenging, such as medical treatment or the epidemiological characteristics of a disease. In these cases where reliance on technical experts is paramount, the influence of celebrity backing on non-credible theories, products, and treatments is particularly harmful. Furthermore, failure to disclose financial conflicts of interest (something alarmingly common according to one study (Niforatos et al., 2019)) and an increased number of pre-print articles further obfuscate the facts.

When a disease is caused by a novel pathogen (such as SARS-CoV-2), and there is sparse, imperfect data about the disease itself, it is human nature to seek concrete answers, even when none exist. This phenomenon, known as 'cognitive closure,' leads us to believe in alternative facts and trust unproven treatments (Webster & Kruglanski, 1994). In addition, as knowledge about a novel pathogen advances, it will inevitably change and evolve, which can lead to distrust in the scientific method and institutional authority. This is especially detrimental in a democratic society, as public health systems primarily depend on the public's trust in regulatory and recommending authorities.

The role of media (both social and traditional) in the making of an infodemic is apparent. As discussed, social media and other digital technologies enhance the speed of spread and volume of misinformation online. As web-based media has overtaken traditional print and television media, the pressure to publish salacious, provoking, and polarizing clickbait has risen, and twenty-four-hour cable news networks have grown increasingly ideologically biased (Kim et al., 2022). At the same time, only 4 in 10 U.S. adults learn to analyze science news stories for bias and credibility in high school (Lessenki, 2021). The result is a ripple effect, as countries with lower media literacy have higher levels of distrust in scientists and vice-versa (Lessenki, 2021). Studies have established that medical mistrust is associated with many adverse health outcomes, including underutilization of healthcare services (LaVeist et al., 2009), lower adherence to medication amongst patients with HIV (Dale et al., 2016), and lower quality of life for men with prostate cancer (Kinlock et al., 2017).

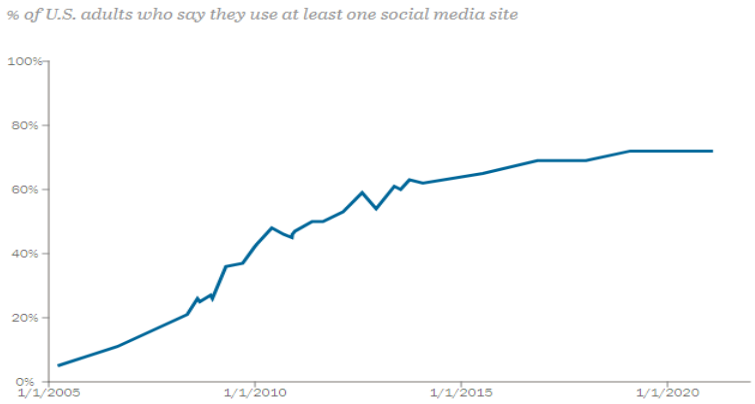
1.3.3 Technology-Enabled Misinformation

While mis-, dis-, and malinformation are age-old, novel methods of disseminating misinformation have arisen in recent decades. Current technologies allow information to flow at unprecedented speed and volume, enabling misinformation to flourish in the virtual world. In 2017, the term 'deepfake' gained popularity after developers used artificial intelligence to create synthetic, highly realistic videos. Researchers at the University of Washington generated a photorealistic video of Barack Obama speaking using audio alone, while other technologies, such as Face2Face, utilize different inputs to create similar videos (Suwajanakorn et al., 2017). The product is a video showing a person saying or acting out whatever the creator decides, sparking concern about its potential to be used maliciously and threaten political security (Pantserev, 2020). Social bots (automated accounts that use artificial intelligence to promote their influence) (Allem & Ferrara, 2018) have become increasingly common across platforms in recent years, amplifying misinformation by giving the impression of widespread interest or stoking partisan division (Akers et al., 2018). Social media algorithms allow bots to significantly influence online discourse, as they reward hasty emotional responses and encourage confirmation bias (Vosoughi et al., 2018). A 2022 study of over four billion tweets suggested that conservative-leaning bots promulgated the conspiracy theory that COVID-19 was developed as a bioweapon 200% more than conservative-leaning humans (Chang & Ferrara, 2022). A growing body of evidence also

shows that specific user characteristics are associated with trusting and disseminating false information and may be more prone to social bots' influence (Shu et al., 2018). Though social bots can effectively influence online discourse and support chosen agendas, their broader impact on health behavior is poorly understood (Shao et al., 2018). Finally, highly sophisticated tracking of users' web browsing habits has emerged to enhance the effectiveness of advertisement targeting. Typically, a company will embed content into websites to track a visiting user's history between sites (Roesner et al., 2012). Alternatively, browser fingerprinting allows some operating systems and browser features to identify users across web pages (Nikiforakis et al., 2013). Both tools target individuals based on private information stored on social media sites, such as health conditions, zip codes, and other sensitive data points (Cinelli et al., 2020). Gab, a newcomer to social networking, found that engagement for unreliable messages was 300% more than for reliable messages. The ubiquity of online misinformation during the COVID-19 pandemic was quickly recognized, and as a result, fact-checkers increased by over 900% in just three months (January-March) in 2020 (Brennen et al., 2020).

The impact of these technologies deepens as the role of social media as an information source escalates. In 2005, only 5% of American adults used any social media platform, a sharp contrast to the 72% who use social media today (see Figure 1.3) (Pew Research Center, 2021). Significant variation exists when breaking down users by age, gender, and education level. Social media use tends to decrease with age; females use social media more than men, and individuals who attended at least some college showed higher social media use than those with only a high school education or less. (Pew Research Center, 2021).

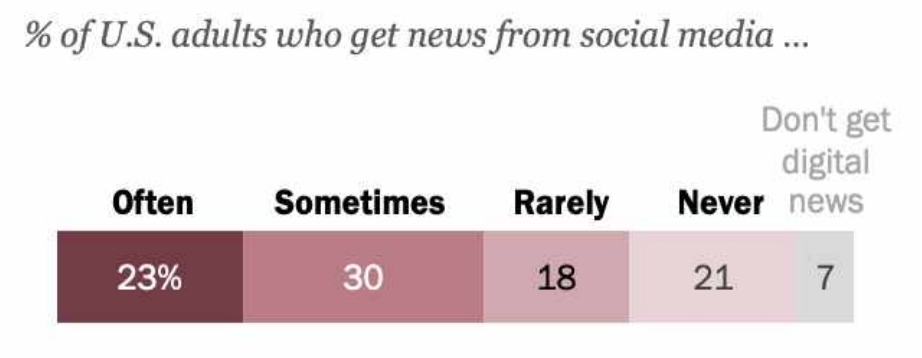
Figure 1.3: Percent of U.S. adults who say they use at least one social media site.



(Pew Research Center, 2021)

According to Pew Research Center, eight in ten Americans "often" or "sometimes" get news from a digital device such as a smartphone, tablet, or laptop (Mitchell & Shearer, 2021), an increase from the 23% who regularly went online for news in 2000 (Pew Research Center, 2000). See Figure 1.4 below. Further, over half of Americans get news on social media at least sometimes, with Facebook standing out as a dominant source (Mitchell & Shearer, 2021).

Figure 1.4: Percent of U.S. adults who get news from social media.



(Mitchell & Liedke, 2021)

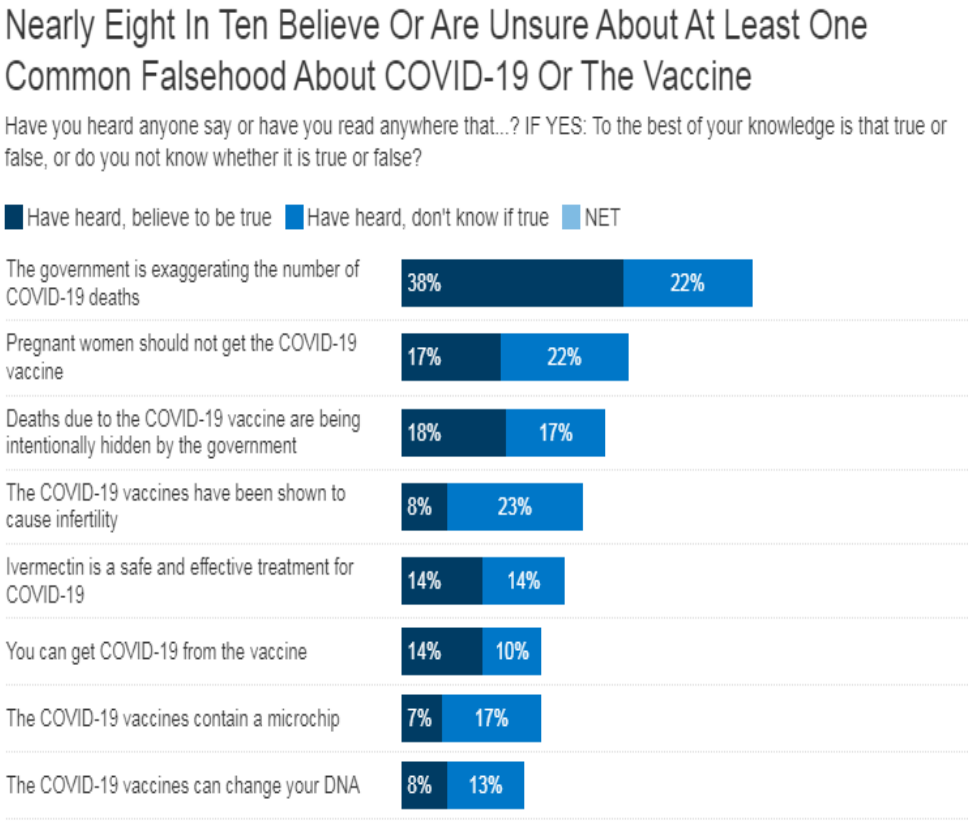
Interestingly, only 25% of Americans say social media has improved their understanding of current events (a number that continues to decline), and most (59%) expect social media news to be largely inaccurate (Mitchell & Shearer, 2021). Despite this, the situation regarding health information found online is essentially the same. During the COVID-19 pandemic, almost half of Americans claimed to be getting some (30%) or a lot (18%) of information about COVID-19 vaccines on social media (Mitchell & Liedke, 2021). This surge in information availability has complicated the filtering of false information, leading to the term 'infodemic.'

1.3.4 Susceptibility to Health Misinformation

Recent surveys by the Kaiser Family Foundation (KFF) have attempted to gauge belief in misinformation in the United States. One survey identified eight common misinformation statements about COVID-19 and surveyed over 1,500 people about their belief in those statements (see Figures 1.5 and 1.6 below). Of the individuals surveyed, 78% had heard of at least one of these statements and either believed them to be accurate or were unsure if they were true (Hamel et al., 2021). There were significant differences between partisanship and vaccination status and minor differences when broken down by community type and education

level. Of those surveyed, 46% of Republicans believed or were unsure about four or more of the statements, compared to 14% of Democrats.

Figure 1.5: Have you heard anyone say or have you read anywhere that...? IF YES: To the best of your knowledge, is that true or false, or do you not know whether it is true or false?.

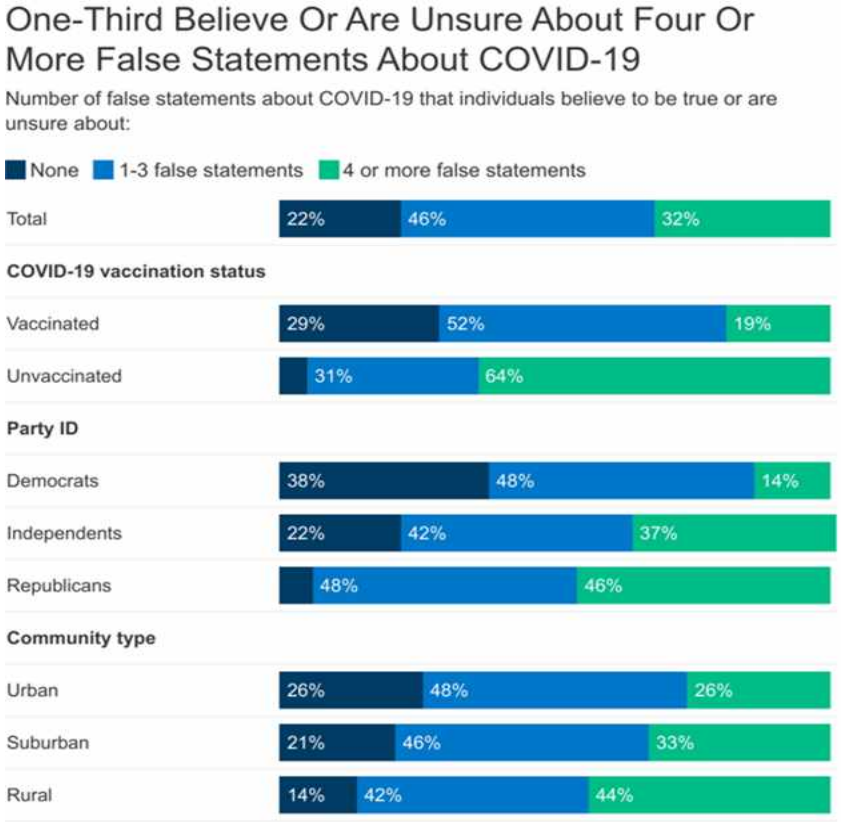


(Hamel et al., 2021)

Among unvaccinated adults, 64% believed or were unsure about four or more statements, while that number was only 19% for those who had received a vaccine. Additionally, respondents who lived in rural areas were more likely to believe or have doubts about four or more of the above statements than urban residents.

Studies have also shown that those who believe conspiracies about COVID-19 are almost four times less likely to receive a vaccine than those who do not (Earnshaw et al., 2020). Researchers have conducted studies on racial differences in COVID-19 misinformation beliefs, but unfortunately, they did not include American Indian and Alaska Native (AI/AN) peoples (the largest minority group in Alaska) as a population group for analysis.

Figure 1.6: Number of false statements about COVID-19 that individuals believe to be true or are unsure about by community type, party identification, and COVID-19 vaccination status.



(Hamel et al., 2021)

1.3.5 Effects of Health Misinformation

In 2021, U.S. Surgeon General Vivek Murthy issued a statement urging Americans to help slow misinformation's spread, emphasizing the threat to public health. (U.S. Department of Health and Human Services, 2021). Past outbreaks have demonstrated the role of misinformation and distrust in public health institutions. During the Ebola virus outbreak in West Africa in 2014, fear and misinformation spread in online social media networks, leading many to believe inaccurate information about the virus's transmission mode (Oyeyemi et al., 2014). It also led to the distrust of foreign NGOs responding to the crisis and stigmatizing Ebola survivors and medical professionals (Allgaier & Svalastog, 2015). One researcher wrote of the widespread chaos in the region when rumors of false cures circulated, resulting in the death of two individuals who drank large quantities of saltwater to avoid contracting Ebola (Krishna & Thompson, 2019).

In recent decades, measles outbreaks have cropped up around the world, from the United States to Israel and Italy. In 2018, over 600 measles cases were reported in the United States, many of which were clustered in areas with suboptimal vaccination rates (Liu et al., 2015). Similarly, between September 2017 and August 2018, the European Surveillance System reported over 13,000 measles cases across 30 countries attributed to low vaccination rates (Gesser-Edelsburg et al., 2018). Despite measles being vaccine-preventable and the link between health misinformation and vaccine hesitancy being repeatedly demonstrated (Carrieri et al., 2019), the prevalence of parental concerns over childhood vaccines continues to rise (Kempe et al., 2011).

Belief in misinformation can cause many other harmful health effects, including delaying or denying medical treatment and using complementary and alternative medicine (CAM) (Stoneman et al., 2013). Homeopathic remedies have recently experienced an uptick in the social media information ecosystem, including claims that essential oils can cure various childhood illnesses (Armstrong & Naylor, 2019). Further, some have forgone cancer treatment, favoring herbal supplements, vitamins, or specific diets (Wilner & Holton, 2020). Finally, belief in health misinformation can negatively impact everyday lifestyle choices, including diet and exercise habits. In recent years, dieting by blood type has become a trend despite it having little to no scientific foundation (Cusack et al., 2013), and fad diets made famous by influencers are consistently linked to health risks and negative psychological impacts (Khawandanah & Tewfik, 2016). Additionally, in 2023, 78% of physicians said misinformation about weight loss was a problem, 77% said misinformation about dietary supplements was a problem, and 72% said misinformation about mental health was a problem (De Beaumont, 2023).

New challenges have arisen during the current COVID-19 pandemic, reflecting technological advancements and the changing political climate. A 2022 poll by de Beaumont found that 72% of physicians (primary care providers, acute care physicians, urgent care physicians, hospital physicians, and other types of physician specialists) said misinformation has made it harder to treat patients for COVID-19, and the same percentage said it has negatively impacted patient outcomes (De Beaumont, 2023). The same poll also found that 44% of physicians estimate that more than half of the COVID-19 information they see, read, and hear from patients is misinformation (De Beaumont, 2023). The sample included 806 U.S. physicians who spent at least half of their time in direct patient care.

1.4 Combating Health Misinformation

1.4.1 Theoretical Context

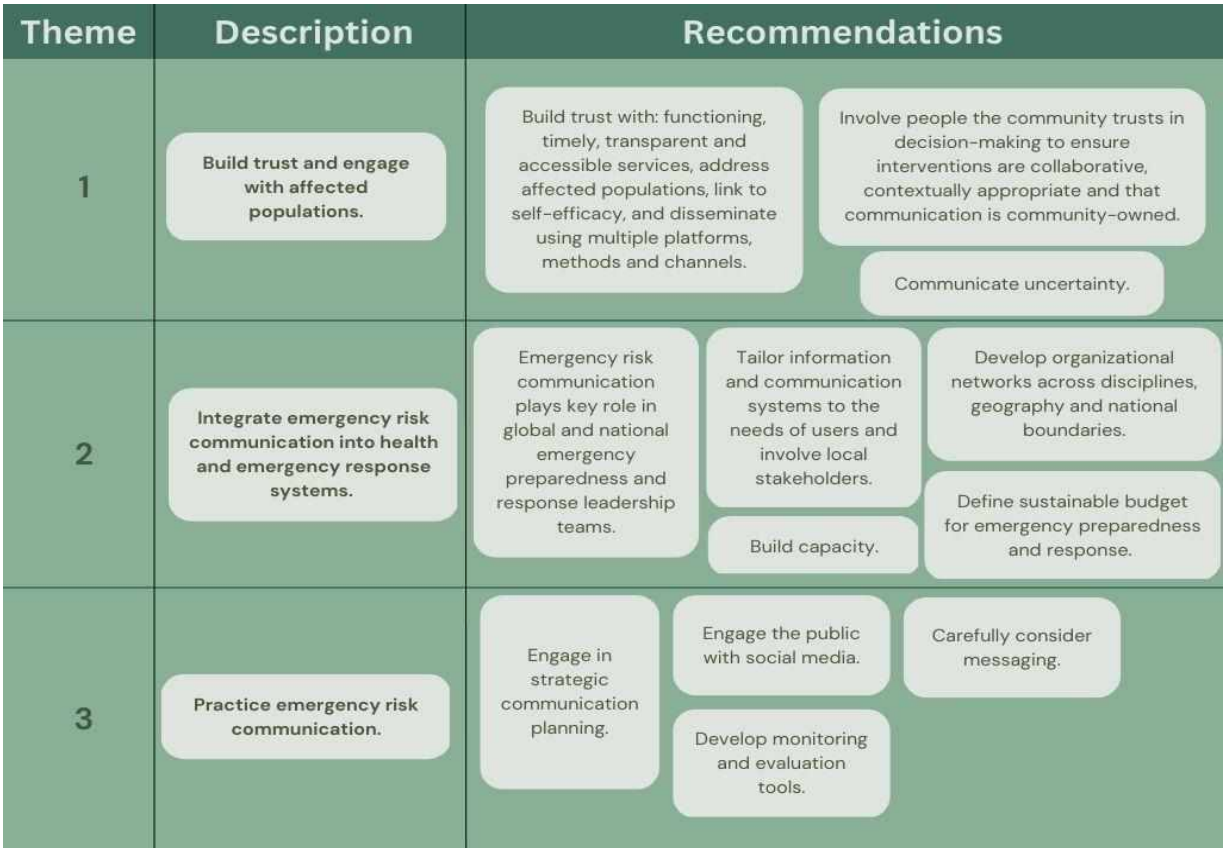
Communication Theory

Existing preparedness frameworks identify effective risk communication as a critical component of pandemic preparedness (Dar et al., 2014). Risk communication is the act of providing the audience with information about the expected type (good or bad) and magnitude (weak or strong) of an outcome from a behavior or exposure (Centers for Disease Control and Prevention, 2014). In 2017, the WHO developed a report on risk communication, *Communicating Risk in Public Health Emergencies: a WHO Guideline for Emergency Risk Communication (ERC) Policy and Practice*, which highlights the importance of building trust in communities, communicating uncertainty and engaging community members (World Health Organization, 2017). This 79-page report materialized in response to public health emergencies that highlighted challenges and gaps in current risk communication frameworks, such as the 2014 Ebola virus outbreak in West Africa, yellow fever outbreaks throughout Africa in 2016, and the Zika virus in 2015. The report provides three primary recommendation themes, each containing multiple specific recommendations, classified by strength of recommendation and quality of evidence.

Interestingly, the only one of these statements designated as a 'conditional recommendation' is 3.c (engage the public with social media). The rationale given for the rating was that though there is moderate evidence to support the use of social media to create situational awareness, address public concerns, facilitate local response, and monitor and respond to rumors, the resource requirements, feasibility, and potential harms (such as misuse, cultural concerns) delegate it as a recommendation only in certain contexts (World Health Organization, 2017).

The CDC produced its own emergency communications guidelines in 2014, the *Crisis and Emergency Risk Communication (CERC)* manual, which includes chapters on the communication lifecycle during a crisis, the psychology of a crisis, matching messages and audiences, and stakeholder and media engagement (see Figures 1.7 and 1.8). The report emphasizes the importance of communication at different stages of a crisis. Considering the appropriate communication at each interval ensures proper application of risk communication principles.

Figure 1.7: Recommendations from the 2017 WHO report, *Communicating Risk in Public Health Emergencies: a WHO Guideline for Emergency Risk Communication (ERC) Policy and Practice.*



(Maxwell, 2024)

The CERC draws upon risk communication principles outlined in documentation from another federal entity, the Environmental Protection Agency (EPA). The EPA's *Seven Cardinal Rules of Effective Risk Communication* identifies the guidelines seen in Table 1.2.

To specifically target misinformation during emergent public health threats, the Johns Hopkins Center for Health Security developed a report in 2021 titled, *National Priorities to Combat Misinformation and Disinformation for COVID-19 and Future Public Health Threats: A Call for a National Strategy.* This report provides a comprehensive guide to developing a national strategy aimed at preventing and correcting misinformation using four pillars:

1. Intervene against false and damaging content and the sources propagating it.
2. Promote and ensure the abundant presence and dissemination of factual information.
3. Increase the public's resilience to misinformation and disinformation.
4. Coordination of a national strategy includes input from social and news media, government, national security officials, public health officials, scientists, and the public.

Figure 1.8: Recommendations from the 2017 WHO report, *Communicating Risk in Public Health Emergencies: a WHO Guideline for Emergency Risk Communication (ERC) Policy and Practice.*

(Centers for Disease Control and Prevention, 2014)

Table 1.2: Seven cardinal rules of effective risk communication.

1	Accept and involve the public as a legitimate partner.
2	Listen to the audience.
3	Be honest, frank, and open.
4	Coordinate and collaborate with other credible sources.
5	Meet the needs of the media.
6	Speak clearly and with compassion.
7	Plan carefully and evaluate performance.

(Centers for Disease Control and Prevention, 2014)

This report recommends establishing a national strategy to combat misinformation during future health threats, allowing for increased capacity, expertise, and capability from federal security agencies. The report outlines key stakeholder partners in this national strategy, including social media platform owners, policymakers, scientists, members of the public, and national security agencies. Approaching health misinformation from a national security standpoint is gaining momentum, as the federal government already has standing agencies tasked with combatting similar influence operations (such as the Mis-, Dis-, and Malinformation Team

housed within the Cybersecurity and Infrastructure Security Agency). Similar reports from the Johns Hopkins Center for Health Security emphasize the cost of COVID-19 vaccine misinformation and disinformation, estimated to be from $50 to $300 million daily (Kirk Sell et al., 2021).

Despite the extensive existing toolkits, guidelines, and recommendations on risk communication for public health officials (the more recent one aimed directly at tackling COVID-19 misinformation), integrating this literature into public health practice in real-time remains a remarkable challenge.

Behavior Change Theory

Another approach to tackling the impacts of misinformation during public health emergencies is through behavior change models. Theories of behavior change guide the development of evidence-based strategies aimed at altering or preventing belief in misinformation (Gimpel et al., 2021; Houlden et al., 2021; Joseph et al., 2023; Kamran & Naeim, 2021) and recently, international organizations such as UNICEF have established behavior change observatories to inform COVID-19 misinformation interventions (United Nations International Children's Emergency Fund, 2021).

Theories of behavior change describe, explain, and predict behavior change. They should enable us to design an effective intervention that produces exactly those behavior changes predicted by the relevant theory (Lippke & Ziegelmann, 2008). These models are extensively utilized when designing health interventions such as nutrition and physical activity changes, smoking cessation, substance abuse treatment, injury prevention, and various other areas of public health. All behavior-change theories assume that social and psychological processes underlie health behavior and must be considered during the development of interventions for them to be successful. While it is outside of the scope of this research to review each of the numerous behavior-change theories relevant to public health; Table 1.3 shows a high-level overview of some of the most common.

In addition to informing behavior change-related interventions, these models have also been utilized to assess motivating factors for health beliefs. In 2021, (Mahmud et al., 2021) applied sociodemographic measures derived from the Health Belief Model (perceived susceptibility, perceived severity, perceived benefits, perceived barriers, cues to action, self-

efficacy) to examine the predictive factors of intent to receive a COVID-19 vaccine in Saudi Arabia. The findings of this study identified that perceived susceptibility and severity of COVID-19 and perceived benefit of the vaccine were positively associated with vaccination intent, but perceived barriers had a negative association with vaccination intent.

Table 1.3: Selected theories of behavior change.

Theory	**Stages**	**Key Components and Mechanisms of Change**	**Applications to Health Behavior**
Reasoned Action and Planned Behavior	None	Behavioral intentions are caused by attitudes toward behavior and subjective norms. Perceived behavior control also impacts behavioral intentions. Behavioral intentions are linked to actual behavior. Behavior explained by this theory must be under volitional control.	Smoking, condom use, weight loss, diet, giving blood, testicular self-exam, marijuana use, drinking low-fat milk, gambling, gang violence, breastfeeding, drinking and driving, sexual behavior, breast self-exam, Lamaze childbirth, physician and healthcare worker behavior, domestic violence.
Health Belief Model	None	A perceived threat consists of susceptibility and severity of consequences. Susceptibility and severity must be high in order for the threat to be high. The perceived benefit includes the efficacy of the health behavior. If the efficacy of the health behavior is seen as high, a person is more likely to do that behavior. Barriers can keep a person from taking health behavior action even when threat and behavior efficacy are both high. Emphasis is placed on perceived threat and perceived efficacy. Cues to action may initiate health behavior. Self-efficacy as an independent co ponent	Mammography screening, compliance with physician recommendation, HIV protective behavior.

Table 1.3 (cont.)

Protection Motivation Theory	None	Fear arousal (from fear of an outcome) results from threat appraisal (including perceived vulnerability and perceived severity). Coping appraisal includes response efficacy and self-efficacy. Personal mastery of a behavior may relate to increased behavior, too.	Safe sex, health compliance, exercise.
Transtheoret-ical Model	5	Five stages include 1) pre-contemplation, 2) contemplation, 3) preparation, 4) action, and 5) maintenance. The "Strong Principle" states that there is a one standard deviation increase in the "pros" of behavior change and a 0.5 standard deviation decrease in the "cons" of behavior change that defines the progress from pre-contemplation to action. Individuals can progress and relapse and circularly re-progress through stages. The maintenance stage is the only stage at which true change can be said to have occurred.	Smoking cessation, diet, skin cancer prevention, mammography screening, meat consumption during livestock epidemic.

(Jans et al., 2023)

In 2018, (Gagneur et al., 2018) used a modified Transtheoretical Model as a foundation for a postpartum vaccination promotion intervention, resulting in a 15% increase in mothers' intentions to vaccinate their children. These behavior-change theoretical frameworks can be used in partnership with behavior-change techniques, such as motivational interviewing, to enhance an intervention's efficacy, as was done in the previously mentioned study. Still, others have chosen to segment their audience into categories to take a more personalized approach. Through survey data, researchers at Surgo Ventures (a U.S.-based public health non-profit) developed 'The Five Vaccine Personas': the enthusiasts, the watchful, the cost-anxious, the system distrusters, and the COVID skeptics (Surgo Ventures, 2023). They argue that addressing these

subgroups is essential, as it involves acknowledging the specific perceptual and structural barriers that affect their vaccination intent.

1.4.2 Infodemic Management Approaches

Research devoted to health misinformation (specifically infodemic management) has been mainly within the digital realm since the onset of the COVID-19 pandemic. In 2020, the WHO developed guidelines for multilevel, evidence-based interventions to change people's behaviors (World Health Organization, 2021). The infodemic management ecosystem model (Figure 1.9 below) outlines four pillars of intervention: listen to concerns, communicate risk, and distill science, promote resilience to misinformation, and engage and empower communities. Within these pillars lie multiple techniques and strategies, many of which are becoming increasingly popular across industry and academia.

Figure 1.9: Recommendations from the WHO's *Infodemic Management: An Overview of Infodemic Management During COVID-19*.

(World Health Organization, 2021)

Listen to Concerns

To enable public health practitioners' ability to listen to the concerns of the public, methods of tracking information have advanced since the beginning of the pandemic. Communicators can yield valuable results by understanding what information is shared, how that

information is discussed, and identifying information gaps. They can use this information to develop custom messages and inform efforts to combat particularly virulent misinformation. While this pillar applies to online and offline forums, novel methods of listening to online concerns have arisen. One technique, social listening, uses new open-sourced tools across social media platforms to gauge specific metrics around a chosen topic. Social listening involves tracking and analyzing public conversations on social media, blogs, and news commentaries and disaggregating data by categories, such as the complaints people are making, or questions people are asking. It must also discern the population's sentiments, perspectives, practices, and attitudes (World Health Organization, 2021). Social listening often utilizes natural language processing and machine learning technology to provide policymakers and public health authorities with timely data, such as topics of concern and evaluation of messages, and the opportunity to get ahead of emerging misinformation. Social listening has been widely used on digital platforms during the COVID-19 pandemic as a form of information surveillance, particularly in the context of vaccine sentiment and hesitance (Hou et al., 2021), but also as a method to inform the design of qualitative and interdisciplinary research methodologies (Myneni et al., 2023). There were several high-level social listening platforms launched during the pandemic, including the WHO's Early AI-Supported Response with Social Listening (EARS) tool, the Vaccine Demand Observatory (VDO) Dashboard (a partnership between the Public Good Projects, UNICEF, and the Yale Institute for Global Health) and Project VCTR: Vaccination communication Tracking and Response (a collaboration between the Public Good Projects and New York State Health Foundation) (Sundelson et al., 2023).

Communicate Risk and Distil Science

Building upon the behavior change theories and emergency risk communication principles discussed above, the prevalence of other techniques used to communicate critical health information has grown. Though fact-checking websites like Snopes.com and FactCheck.org have existed for years, efforts to debunk inaccurate information have ballooned since 2020. Scientific institutions and federal agencies have published web pages dedicated solely to fact-checking rumors and myths. Both the CDC and the WHO established pages urging the public to better understand the facts about COVID-19 (Krause et al., 2020) and English-language fact-checkers multiplied by 900% from January to March 2020 (Brennen et al., 2020).

Though this strategy can be of some utility, there is significant evidence from prior research in the social psychology and political science fields that its impact is limited and can, in some cases, encourage motivated reasoning on behalf of the viewer (Krause et al., 2020). Even when a piece of information is proven false, a phenomenon known as the continued influence effect leads individuals' reasoning to remain impacted by the misinformation (Lewandowsky et al., 2012). Additionally, fact-checking may contradict the risk communication principle of conveying uncertainty, further eroding trust between the audience and the fact-checking entity.

Many social media companies have taken on similar challenges to combat misinformation. Historically, many of these platforms have forgone intervention to remain a neutral channel for public discourse (Baker et al., 2020). However, mounting pressure has led many social media giants to implement some form of content moderation mechanism to minimize harm (Twitter, Facebook, Spotify, and YouTube each have their own approach to addressing information deemed harmful) (Baker et al., 2020). These approaches differ significantly across platforms, ranging from placing interstitials (or 'flags') on potentially harmful content to removing it entirely, and each involves varying levels of automated versus human determination. Concerns around free speech limitations have arisen due to perceived censorship of information deemed false by fact-checkers at many social media companies. This is especially prevalent in the United States, where the first amendment protects freedom of speech, though not all speech is protected. If speech incites violence, illegal activity, or otherwise threatens the liberty of others, the government may place regulations on it (The Conversation, 2023). If, and how, this applies to health misinformation is unclear; some medical professionals have faced repercussions for spreading misinformation, but many have not (Sun & Weber, 2023).

Promote Resilience to Misinformation

The incomplete solutions offered by content moderation and debunking have led communications researchers to investigate methods of developing resilience to misinformation in populations. One popular approach called inoculation theory, developed by McGuire in the 1960s, builds resistance to persuasion.

Inoculation theory is a metaphor for the biological immunization process against a disease. The theory proposes that, much like how an individual can be vaccinated against a

pathogen, they can be preventatively inoculated against misinformation through exposure to a weaker or smaller dose of the contrary argument (McGuire, 1964). In this theory, the exercise of misinformation inoculation contains two messages: threat and refutational preemption. The threat component involves individuals being made aware that a persuasive attack is imminent, such as by forewarning them that political actors may want to mislead audiences' attitudes on issues, while refutational preemption (also called pre-bunking) refers to providing individuals with tools or arguments to refute future persuasion attempts (Traberg et al., 2022). Recent studies have shown the effectiveness of interventions based on inoculation theory in enhancing individuals' ability to recognize misinformation, identifying one of the underlying mechanisms as the promotion of persuasion knowledge (Ma et al., 2023). The University of Cambridge Social Decision-Making Lab and a joint effort between the University of Cambridge, the U.K. Cabinet Office, and the WHO have produced gamified versions of the inoculation theory, allowing players to create their own false rumors and manipulate their spread (Sundelson et al., 2023). The promise of this method is growing, backed by an increasing number of empirical studies showing that it leads individuals to identify misinformation better and makes them less likely to share it or be persuaded when they encounter it (Basol et al., 2021; Roozenbeek et al., 2020; van der Linden et al., 2017). However, there are potential drawbacks to this method as well, as it would require individuals to agree to be inoculated prior to being exposed to misinformation, and any inoculation effect may wane over time, eventually making 'booster' doses necessary (Kozyreva et al., 2020).

The infodemic management model developed by the WHO also outlines various social inoculation strategies, such as improving health, media, and digital literacy to promote resilience to misinformation. Several observational studies have shown a negative relationship between digital health literacy and belief in COVID-19 misinformation and a positive relationship between digital health literacy and adoption of COVID-19 prevention practices (An et al., 2021; Patil et al., 2021; Pickles et al., 2021). However, a lack of research in this field leaves several questions about the future of health and media literacy improvement as an approach to combatting misinformation, including its efficacy on older adults and the long-term impacts of school-based interventions (Nordheim et al., 2016; Watkins & Xie, 2014).

Engage and Empower Communities

The fourth and final pillar of the WHO infodemic management model centers around communities. The model identifies community engagement ("involving, consulting, informing, as well as engaging and collaborating with diverse communities across different cultures and geographies") and community empowerment ("enabling communities to develop and implement their own solutions") as best practices in any communications designed to increase health behavior uptake (World Health Organization, 2021). To work with communities, it is necessary to build partnerships with key decision-makers and influential actors within communities, such as employers, faith-based organizations, youth, healthcare providers, and local leadership (World Health Organization, 2021). In one case study, the Rumour Tracker Programme in Puerto Rico was implemented to address information gaps during the COVID-19 crisis. The program took a community-based approach, using well-established networks to circulate verified information tailored to the community's specific needs (as determined through online and offline social listening and social media monitoring techniques) (Mercy Corps, 2021). The health information intervention reached over 118,000 people through training, educational materials, local newspaper articles, and community sensitizations led by health promotors (Mercy Corps, 2021). Community engagement approaches can be a valuable tool to promote accurate health information and clarify points of confusion during an infodemic (Gonah, 2020; Korin et al., 2022; Sommariva et al., 2021), but these efforts must not be short-lived or activated only during a crisis as this can lead to further distrust (Ojikutu et al., 2021).

1.5 COVID-19 and Misinformation in Alaska

The epidemiology of COVID-19 in Alaska is similar to trends across the United States. As of March 2023, there have been approximately 103 million cases of COVID-19 in the United States, 294,000 of which occurred in residents of the state of Alaska; this case count calculates to 31% of the U.S. population and 40% of the state of Alaska population (New York Times, 2022; State of Alaska Department of Health and Social Services, 2022). As shown in the visual below, cases are disproportionate in Hispanic/Latino and American Indian/Alaska Native populations in the U.S. and Alaska alone and in those who identify as two or more races or whose race is not represented (see Table 1.4 below).

Table 1.4: Race and Percent of COVID-19 cases compared to race as percent population.

	United States		Alaska	
Race/Ethnicity	% of population	% of Cases	% of population	% of Cases
Black or African American alone	12	12	3	3
Hispanic or Latino	19	25	7	10
Asian alone	5	4	6	5
Native Hawaiian and Pacific Islander alone	.2	.2	1	3
American Indian or Alaska Native alone	.7	.9	15	26
White alone	54	60	65	38
Two or more races and unrepresented races alone	3	4	10	24

(Satcher Health Leadership Institute, 2023; The Atlantic Monthly Group, 2023)

This is consistent with a plethora of other data exemplifying the social vulnerability of many minority groups in the United States, who are often more exposed to factors contributing to a weakened ability to combat the impacts of the pandemic, such as poverty, lack of transportation, ruralness, and inadequate housing. In addition to the incidence of COVID-19 cases being disproportionately higher in AI/AN populations, the severity of the disease is also higher. The age-adjusted COVID-19-associated hospitalization rate among AI/AN individuals was nearly three times the rate among White persons, while the mortality rate among AI/AN persons was also approximately three times that among White persons (Ward et al., 2022). This is due, in part, to the unique health challenges many Alaskans face, including access to care due to its remote geography; 86% of the state's communities are located off the road system (State of Alaska Department of Commerce & United States Department of Homeland Security Federal Emergency Management Agency, 2022). Many remote communities (here, approximately 20% of the population lives and 42% of which is AI/AN) also lack water and adequate sanitation facilities, limiting the effectiveness of non-pharmaceutical countermeasures (Eichelberger et al., 2021). One recent study of over 18,000 adults hospitalized with COVID-19 showed that despite having a lower comorbidity risk score, AI/AN patients were more likely than patients of all other races to die in the hospital (Musshafen et al., 2022). This is especially vexing considering that, according to data from the U.S. Centers for Disease Control and Prevention, AI/AN populations have consistently had the best vaccination records since COVID-19 vaccination began in early

2021 (Silberner, 2021). The early successes of the COVID-19 vaccine rollout in Alaska likely contributed significantly to the high COVID-19 vaccine rates in rural communities. Many of these successes were due to a partnership between the state of Alaska and the tribal health system. Tribal leadership decided to allocate vaccines through the state rather than the Indian Health Service and tribes in Alaska were able to make their own decisions about vaccine allocation, priority populations, and outreach strategies (Chhean et al., 2021).

Historically, infectious diseases have been a topic of particular significance in the Arctic region and particularly within Indigenous populations during past and present pandemics. The 1918 Spanish Flu devastated Indigenous populations so much that some small village communities were destroyed (Mamelund, 2011). Generational trauma from the pandemic still exists today in American Indian and Alaska Native (AI/AN) populations, and some may be experiencing renewed trauma due to the present pandemic (Connolly et al., 2021). In a 2009 study, Native Americans had higher levels of medical mistrust (often rooted in historical context (Freimuth & Quinn, 2004)) and lower levels of satisfaction with their healthcare (Guadagnolo et al., 2008). Misunderstanding within the health system (often communication-related), perceived discrimination, and awareness of adverse health statistics may contribute to this mistrust, exacerbating health disparities among minority populations (Bazargan & Bazargan-Hejazi, 2021).

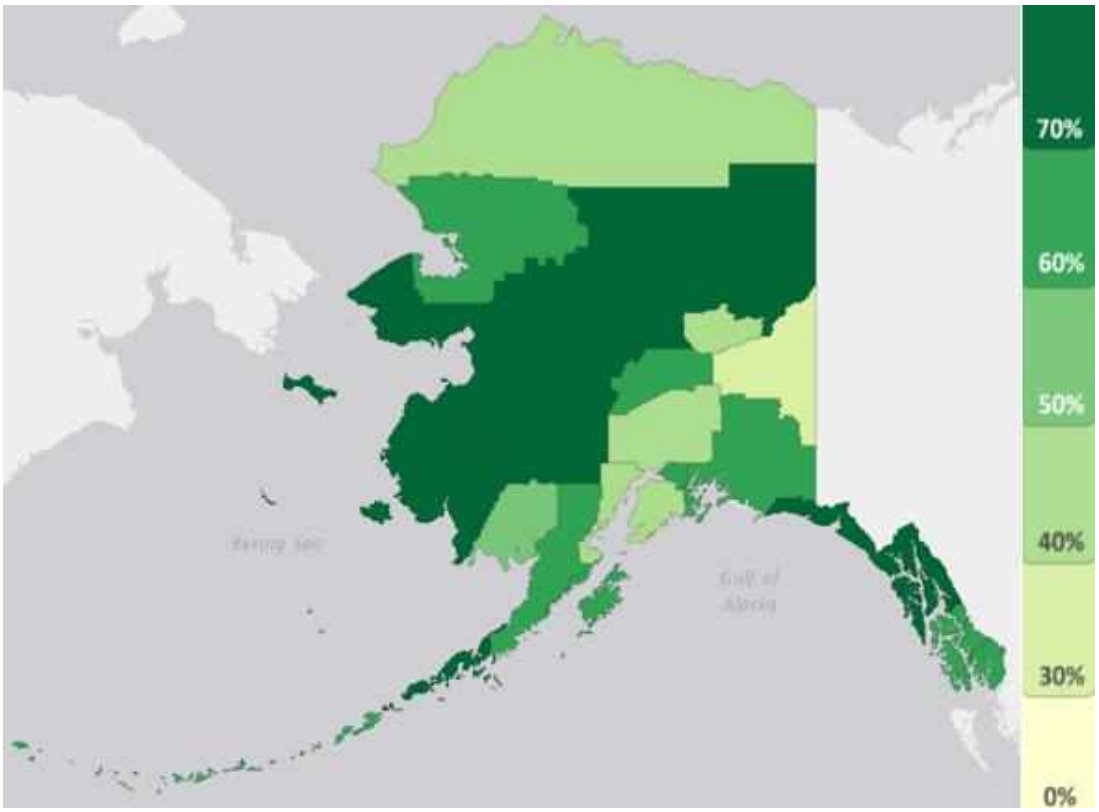
Recent studies have illuminated the epidemiology of COVID-19 in Alaska, but we know much less about the impact of COVID-19 misinformation across the state. The demographic makeup of Alaska includes significant populations of those identified as most at risk during infodemics. Alaska leans conservative (approximately 24% of the registered voters are Republican compared to 13% Democrat, though most, 57%, are unaffiliated), and political leaders elected by the state tend to be Republican (Alaska has voted Republican for the last six presidential elections (Pew Research Center, 2022). According to U.S. Census data, as of 2010, Alaska was the second most rural state, with approximately 34% of the population living in rural areas (though this number has been steadily decreasing for decades) (Iowa State University, 2022).

With 63% of its population fully vaccinated, Alaska is in the middle of the pack at number 29 of 50 states (Centers for Disease Control and Prevention, 2022c). As seen in Figure 1.10, within Alaska, geographic vaccination rates in Alaska range from 36% (Southeast

Fairbanks) to more than double that in Aleutian East (86%) (State of Alaska Department of Health and Social Services, 2022). Vaccination rate also varied along racial lines, from over 68% of the AI/AN population being fully vaccinated to 34% of the Latino population (State of Alaska Department of Health and Social Services, 2022).

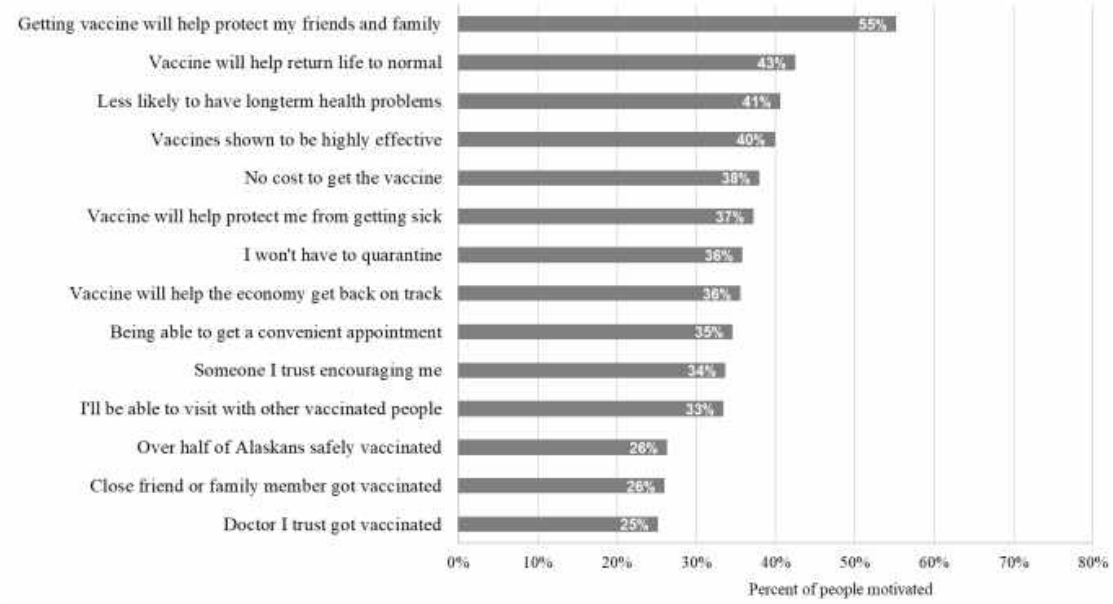
Vaccine attitudes and trusted media sources amongst Alaskans were evaluated by the Alaska Department of Health and Social Services (now Department of Health) in the summer of 2021 (Aho et al., 2022). The state conducted an online survey in two waves during June and July of 2021. The first wave sampled both vaccinated and unvaccinated individuals, while the second wave sampled primarily unvaccinated individuals (≥75%) (Aho et al., 2022). In these surveys, 42% of unvaccinated individuals definitely did not plan to get vaccinated (classified as more hesitant) and while 58% either planned to get vaccinated, were unsure, or probably did not plan to (classified as less hesitant) (Aho et al., 2022).

Figure 1.10: COVID-19 vaccination rates in Alaska as of April 2023.



(State of Alaska Department of Health and Social Services, 2022)

Figure 1.11: Survey responses when asked about motivating factors to get vaccinated.



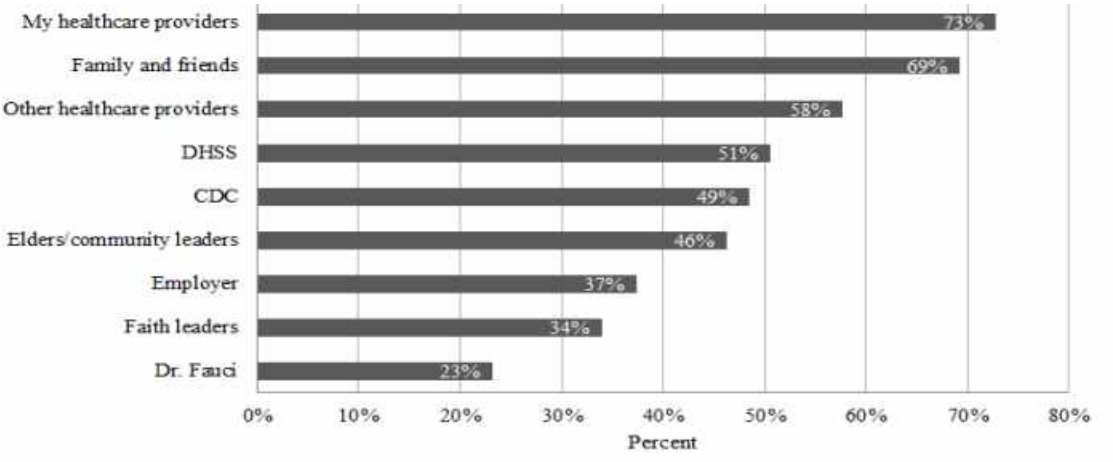
(Aho et al., 2022)

More than 80% of respondents classified as more hesitant believed they were at low or no risk for contracting severe COVID-19, compared to two-thirds of those classified as less hesitant (Aho et al., 2022). When asked about why they chose to not vaccinate, the most cited reasons were concerns about side effects and safety (18%), rushed development (17%), having already had COVID or feeling at low risk from COVID (14%), personal choice of disliking shots (13%), and other reasons (37%) (see Figure 1.11) (Aho et al., 2022). When researchers asked about motivating reasons to get vaccinated amongst the less hesitant group, the majority (55%) felt that getting the vaccine would help their family and friends (Aho et al., 2022).

The same surveys asked respondents classified as less hesitant to rate how much they trusted various media sources to provide accurate information about vaccines. Healthcare providers and friends and family were identified as the most trusted sources, while health officials such as the state's health department, the CDC and Dr. Fauci were not as trusted (see Figure 1.12) (Aho et al., 2022). This audience-specific information may inform educational interventions aimed at reaching the "movable middle", especially considering that only (51%) unvaccinated respondents who had seen a health care provider had had a conversation with them about vaccination (Aho et al., 2022).

Other recent survey studies centered around vaccine hesitancy in Alaska have focused on trusted sources in a local context and potential pathways to behavior change (Cameron et al., 2024), factors associated with receiving an initial dose of COVID-19 vaccine (Garcia et al., 2023), vaccine safety beliefs (Parker & Meyer, 2024), factors associated with vaccine hesitancy (Parker & Meyer, 2023), and COVID-19 vaccine perceptions in remote communities (Hahn et al., 2022).

Figure 1.12: Survey responses when asked about trusted sources



(Aho et al., 2022)

Other recent survey studies centered around vaccine hesitancy in Alaska have focused on trusted sources in a local context and potential pathways to behavior change (Cameron et al., 2024), factors associated with receiving an initial dose of COVID-19 vaccine (Garcia et al., 2023), vaccine safety beliefs (Parker & Meyer, 2024), factors associated with vaccine hesitancy (Parker & Meyer, 2023), and COVID-19 vaccine perceptions in remote communities (Hahn et al., 2022).

1.6 Closing Introductory Statement

In an editorial for The Washington Post, the Chief Medical Officer of Alaska stated, “Hesitancy and misinformation made many people underestimate the risk of COVID-19 infections and overestimate the risk from the coronavirus vaccines” (Zink, 2021). This statement echoes the experience of many medical providers and public health practitioners from around the

United States and the world. This research utilizes a mixed methods approach to gain insight into the composition and impact of misinformation on the effectiveness of response efforts in Alaska during the COVID-19 pandemic.

1.7 References

Aho, S., Barker, S., Garcia, G., Kuhn, S., & van Wyck, R. (2022). *Alaska Statewide COVID-19 Vaccine Survey, June–July 2021*. https://health.alaska.gov/dph/epi/id/siteassets/pages/HumanCoV/COVID_VaccineSurvey.pdf

Akers, J., Bansal, G., Cadamuro, G., Chen, C., Chen, Q., Lin, L., Mulcaire, P., Nandakumar, R., Rockett, M., Simko, L., Toman, J., Wu, T., Zeng, E., Zorn, B., & Roesner, F. (2018). *Technology-Enabled Disinformation: Summary, Lessons, and Recommendations*.

Allem, J.-P., & Ferrara, E. (2018). Could Social Bots Pose a Threat to Public Health? *American Journal of Public Health*, *108*(8), 1005–1006. https://doi.org/10.2105%2FAJPH.2018.304512

Allgaier, J., & Svalastog, A. L. (2015). The communication aspects of the Ebola virus disease outbreak in Western Africa–do we need to counter one, two, or many epidemics? *Croatian Medical Journal*, *56*(5), 4 6–499. https://doi.org/10.3325%2Fcmj.2015.56.496

An, L., Bacon, E., Hawley, S., Yang, P., Russell, D., Huffman, S., & Resnicow, K. (2021). Relationship Between Coronavirus-Related eHealth Literacy and COVID-19 Knowledge, Attitudes, and Practices among U.S. Adults: Web-Based Survey Study. *Journal of Medical Internet Research*, *23*(3), e25042. https://doi.org/10.2196/25042

Armstrong, P. W., & Naylor, C. D. (2019). Counteracting Health Misinformation. *JAMA*, *321*(19), 1863. https://doi.org/10.1001/jama.2019.5168

Bahl, R., Chang, S., McKay, D., & Buchanan, G. (2022). Health Misinformation Across Multi le Digital Ecologies: Qualitative Study of Data From Interviews With International Students. *Journal of Medical Internet Research*, *24*(7), e38523. https://doi.org/10.2196/38523

Baker, S. A., Wade, M., & Walsh, M. J. (2020). The challenges of responding to misinformation during a pandemic: content moderation and the limitations of the concept of harm. *Media International Australia*, *177* 1), 103–107. https://doi.org/10.1177%2F1329878X20951301

Basol, M., Roozenbeek, J., Berriche, M., Uenal, F., McClanahan, W. P., & Linden, S. van der. (2021). Towards psychological herd immunity: Cross-cultural evidence for two prebunking interventions against COVID-19 misinformation. *Big Data & Society*, *8*(1), 20539517 110138. https://doi.org/10.1177/20539517211013868

Bazargan, M., & Bazargan-Hejazi, S. (2021). Disparities in Palliative and Hospice Care and Completion of Advance Care Planning and Directives Among Non-Hispanic Blacks: A Scoping Review of Recent Literature. *American Journal of Hospice and Palliative Medicine®*, *38*(6), 688–718. https://doi.org/10.1177/1049909120966585

BBC. (2023). *A Brief History of Fake News*. BBC Bitesize.

Bourbeau, P., Marcoux, J.-M., & Ackerly, B. A. (2022). *A Multidisciplinary Approach to Pandemics COVID-19 and Beyond*. OUP Oxford

Brennen, J. S., Simon, F. M., Howard, P. N., & Nielsen, R. K. (2020). *Types, sources, and claims of COVID-19 misinformation*. Reuters Institute for the Study of Journalism. https://reutersinstitute.politics.ox.ac.uk/types-sources-and-claims-covid-19-misinformation

Cameron, D. B., Grage, L., Van Wyck, R., Edwards, A., Chavez Mapaye, J., Cheng, A., & Garcia, G. (2024). Identifying trusted local sources and predicting behavior change pathways according to COVID-19 vaccination status: Results of a 2022 statewide survey of Alaskan adults. *Vaccine*, *42*(10), 2592–2607. https://doi.org/10.1016/j.vaccine.2024.03.027

Carrieri, V., Madio, L., & Principe, F. (2019). Vaccine hesitancy and (fake) news: Quasi-experimental evidence from Italy. *Health Economics*, *28*(11), 1377–138 . https://doi.org/10.1002/hec.3937

Centers for Disease Control and Prevention. (2014). *Crisis and Emergency Risk Communication Manual*.

Centers for Disease Control and Prevention. (2021, April 5). *Science Brief: SA S-CoV-2 and Surface (Fomite) Transmission for Indoor Community Environments*. https://stacks.cdc.gov/view/cdc/104762

Centers for Disease Control and Prevention. (2022a). *How to Address COVID-19 Vaccine Mi information*. https://www.cdc.gov/vaccines/covid-19/health-departments/addressing-vaccine-misinformation.html

Centers for Disease Control and Prevention. (2022b, August 11). *Understanding Risk*. https://archive.cdc.gov/www_cdc_gov/coronavirus/2019-ncov/your-health/understanding-risk.html

Centers for Disease Control and Prevention. (2022c, October 1). *CDC COVID Data Tracker*. https://covid.cdc.gov/covid-data-tracker/#datatracker-home

Chang, H.-C. H., & Ferrara, E. (2022). Comparative analysis of social bots and humans during the COVID-19 pandemic. *Journal of Computational Social Science*, *5*(2), 1409–1425. https://doi.org/10.1007/s42001-022-00173-9

Chhean, E. F. H., Tewarson, H., DelFavero, M., Thoumi, A., Haldar, S., & Hockenberry, S. (2021). *Partnering with Tribal Nations for COVID-19 Vaccinations: A Case Study of Alaska*. https://www.nga.org/publications/partnering-with-tribal-nations-for-covid-19-vaccinations-a-case-study-of-alaska/

Cinelli, M., Quattrociocchi, W., Galeazzi, A., Valensise, C. M., Brugnoli, E., Schmidt, A. L., Zola, P., Zollo, F., & Scala, A. (2020). The COVID-19 social media infodemic. *Scientific Reports*, *10*(1), 16598. https://doi.org/10.1038/s41598-020-73510-5

Connolly, M., Jacobs, B., & Notzon, F. C. (2021). COVID-19 among American Indians and Alaska Natives in the United States: An early look. *Statistical Journal of the IAOS*, *3* (1), 25–36. https://doi.org/10.3233/SJI-210790

Cusack, L., de Buck, E., Compernolle, V., & Vandekerckhove, P. (2013). Blood type diets lack supporting evidence: a systematic review. *The American Journal of Clinical Nutrition*, *98*(1), 99–104. https://doi.org/10.3945/ajcn.113.058693

Dale, S. K., Bogart, L. M., Wagner, G. J., Galvan, F. H., & Klein, D. J. (2016). Medical mistrust is related to lower longitudinal medication adherence among African-American males with HIV. *Journal of Health Psychology*, *21*(7 , 1311–1321. https://doi.org/10.1177/1359105314551950

Dar, O., Buckley, E. J., Rokadiya, S., Huda, Q., & Abrahams, J. (2014). Integrating Health Into Disaster Risk Reduction Strategies: Key Considerations for Success. *American Journal of Public Health*, *104*(10), 1811–1816. https://doi.org/10.2105%2FAJPH.2014.302134

De Beaumont. (2023, March 29). *Physician Poll: Medical Misinformation is Harming Patients*. https://debeaumont.org/news/2023/physician-poll-medical-misinformation-is-harming-patients/

Department of Labor and Workforce Development, R. and A. S. (2012). *Alaska Population Overview: 2010 Census and 2011 Estimates*. https://live.laborstats.alaska.gov/pop/estimates/pub/1011popover.pdf

Doshi, V. (2017, October 1). India's Millions of New Internet Users are Falling for Fake News – Sometimes with Deadly Consequences. *The Washington Post*. https://www.washingtonpost.com/world/asia_pacific/indias-millions-of-new-internet-users-are-falling-for-fake-news--sometimes-with-deadly-consequences/2017/10/01/f078eaee-9f7f-11e7-8ed4-a750b67c552b_story.html

Earnshaw, V., Eaton, L. A., Kalichman, S. C., Brousseau, N. M., Hill, E. C., & Fox, A. B. (2020). COVID-19 conspiracy beliefs, health behaviors, and policy support. *Translational Behavioral Medicine*, *10*(4), 850–856. https://doi.org/10.1093%2Ftbm%2Fibaa090

Eichelberger, L., Dev, S., Howe, T., Barnes, D. L., Bortz, E., Briggs, B. R., Cochran, P., Dotson, A. D., Drown, D. M., Hahn, M. B., Mattos, K., & Aggarwal, S. (2021). Implications of inadequate water and sanitation infrastructure for community spread of COVID-19 in remote Alaskan communities. *Science of The Total Environment*, *76*, 145842. https://doi.org/10.1016/j.scitotenv.2021.145842

Eysenbach, G. (2002). Infodemiology: the epidemiology of (mis)information. *The American Journal of Medicine*, *13*(9), 763–765. https://doi.org/10.1016/S0002-9343(02)01473-0

Freimuth, V. S., & Quinn, S. C. (2004). The Contributions of Health Communication to Eliminating Health Disparities. *American Journal of Public Health*, *94*(12), 2053–2055. https://doi.org/10.2105%2Fajph.94.12.2053

Gagneur, A., Lemaître, T., Gosselin, V., Farrands, A., Carrier, N., Petit, G., Valiquette, L., & de Wals, P. (2018). A postpartum vaccination promotion intervention using motivational interviewing techniques improves short-term vaccine coverage: PromoVac study. *BMC Public Health*, *18*(1), 811. https://doi.org/10.1186/s12889-018-5724-y

Garcia, G., Meyer, J., Edwards, A., & Cameron, D. (2023). Factors associated with receiving an initial COVID-19 vaccine among Alaskan residents: results from an online cross-sectional survey. *International Journal of Circumpolar Health*, *82*(1). https://doi.org/10.1080/22423982.2023.2252604

Gesser-Edelsburg, A., Diamant, A., Hijazi, R., & Mesch, G. S. (2018). Correcting misinformation by health organizations during measles outbreaks: A controlled experiment. *PLOS ONE*, *13*(12), e0209505. https://doi.org/10.1371/journal.pone.0209505

Gimpel, H., Heger, S., Olenberger, C., & Utz, L. (2021). The Effectiveness of Social Norms in Fighting Fake News on Social Media. *Journal of Management Information Systems*, *38*(1), 196–221. https://doi.org/10.1080/07421222.2021.1870389

Gonah, L. (2020). Key Considerations for Successful Risk Communication and Community Engagement (RCCE) Programmes During COVID-19 Pandemic and Other Public Health Emergencies. *Annals of Global Health*, *86*(1). https://doi.org/10.5334/aogh.3119

Grossman, S., & Diresta, R. (2019). *Potemkin Pages & Personas: Assessing GRU Online Operations, 2014-2019*. https://fsi.stanford.edu/publication/potemkin-think-tanks

Guadagnolo, A. B., Cina, K., Helbig, P., Molloy, K., Reiner, M., Cook, E. F., &, Petereit, D.G. (2008). Medical Mistrust and Less Satisfaction With Health Care Among Native Americans Presenting for Cancer Treatment. *Journal of Health Care for the Poor and Underserved*, *20*(1), 210–226. https://doi.org/10.1353/hpu.0.0108

Hahn, M. B., Fried, R. L., Cochran, P., & Eichelberger, L. P. (2022). Evolving perceptions of COVID-19 vaccines among remote Alaskan communities. *International Journal of Circumpolar Health*, *81*(1). https://doi.org/10.1080/22423982.2021.2021684

Hamel, L., Lopes, L., Kirzinger, A., Sparks, G., Stokes, M., & Brodie, M. (2021, November 8). *KFF COVID-19 Vaccine Monitor: Media and Misinformation*. Kaiser Family Foundation. https://www.kff.org/coronavirus-covid-19/poll-finding/kff-covid-19-vaccine-monitor-media-and-misinformation/

Hou, Z., Tong, Y., Du, F., Lu, L., Zhao, S., Yu, K., Piatek, S. J., Larson, H. J., & Lin, L. (2021). Assessing COVID-19 Vaccine Hesitancy, Confidence, and Public Engagement: A Global Social Listening Study. *J Med Internet Res*, *23*(6), e27632. https://doi.org/10.2196/27632

Houlden, S., Hodson, J., Veletsianos, G., Reid, D., & Thompson-Wagner, C. (2021). The health belief model: How public health can address the misinformation crisis beyond COVID-19. *Public Health in Practice*, *2*, 1001 1. https://doi.org/10.1016%2Fj.puhip.2021.100151

Hu, B., Guo, H., Zhou, P., & Shi, Z.-L. (2021). Characteristics of SARS-Co -2 and COVID-19. *Nature Reviews Microbiology*, *19*(3) 141–154. https://doi.org/10.1038/s41579-020 00459-7

Iowa State University. (2022). *Urban Percentage of the Population for States, Historical*. Iowa Community Indicators Program. https://www.icip.iastate.edu/tables/population/urban-pct-states

Jans, M., Aremia, M., Killmer, B., & Alattar, L. (2023). *Potential Mechanisms Underlying the Decision to Use a Safety Belt: A Literature Review*. https://deepblue.lib.umich.edu/handle/2027.42/110521

Joseph, L., Rahman, A., & Varghese, R. (2023). Medical Misinformation and Healthy Information Environment: A Call to Action. *The Journal for Nurse Practitioner* , *19*(4), 104502. https://doi.org/10.1016/j.nurpra.2022.11.012

Kamran, A., & Naeim, M. (2021). Behavioural change theories: a necessity for managing COVID-19. *Public Health*, *197*, e4–e5. https://doi.org/10.1016%2Fj.puhe.2020.10.010

Kempe, A., Daley, M. F., McCauley, M. M., Crane, L. A., Suh, C. A., Kennedy, A. M., Basket, M. M., Stokley, S. K., Dong, F., Babbel, C. I., Seewald, L. A., & Dickinson, L. M. (2011). Prevalence of Parental Concerns About Childhood Vaccines. *American Journal of Preventive Med cine*, *40*(5), 548–555. https://doi.org/10.1016/j.amepre.2010.12.025

Khawandanah, J., & Tewfik, I. (2016). Fad Diets: Lifestyle Promises and Health Challenges. *Journal of Food Research*, *5*(6), 80 http://dx.doi.org/10.5539/jfr.v5n6p80

Kim, E., Lelkes, Y., & McCrain, J. (2022). Measuring dynamic media bias. *Proceedings of the National Academy of Sciences*, *119*(32). https://doi.org/10.1073/pnas.2202197119

Kinlock, B. L., Parker, L. J., Bowie, J. v., Howard, D. L., Laveist, T. A., & Thorpe, R. J. (2017). High Levels of Medical Mistrust Are Associated with Low Quality of Life among Black and White Men with Prostate Cancer. *Cancer Control*, *24*(1), 72–77. https://doi.org/10.1177/107327481702400112

Kirk Sell, T., Smith, E., Trotochaud, M., Hosangadi, D., Vasudevan, P., Rivera, Y., Kwik Gronvall, G., Sutton, J., Ruiz, A., & Cicero, A. (2021). *National Priorities to Combat Misin formation and Disinformation for COVID-19 and Future Public Health Threats: A Call for a National Strategy*. https://centerforhealthsecurity.org/sites/default/files/2023-02/210322-misinformation.pdf

Korin, M. R., Araya, F., Idris, M. Y., Brown, H., & Claudio, L. (2022). Community-Based Organizations as Effective Partners in the Battle Against Misinformation. *Frontiers in Public Health*, *10*. https://doi.org/10.3389%2Ffpubh.2022.853736

Kozyreva, A., Lewandowsky, S., & Hertwig, R. (2020). Citizens Versus the Internet: Confronting Digital Challenges With Cognitive Tools. *Psychological Science in the Public Interest*, *21*(3), 103–156. https://doi.org/10.1177/1529100620946707

Krause, N. M., Freiling, I., Beets, B., & Brossard, D. (2020). Fact-checking as risk communication: the multi-layered risk of misinformation in times of COVID-19. *Journal of Risk Research*, *23*(7–8), 1052–1059. https://doi.org/10.1080/13669877.2020.1756385

Krishna, A., & Thompson, T. L. (2019). Misinformation About Health: A Review of Health Communication and Misinformation Scholarship. *American Behavioral Scientist*, *65*( ), 316–332. https://doi.org/10.1177/0002764219878223

LaVeist, T. A., Isaac, L. A., & Williams, K. P. (2009). Mistrust of Health Care Organizations Is Associated with Underutilization of Health Services. *Health Services Research*, *44*(6), 2 93–2105. https://doi.org/10.1111%2Fj.1475-6773.2009.01017.x

Lessenki, M. (2021). *Media Literacy Index 2021 Double Trouble: Resilience to Fake News at the Time of COVID-19 Infodemic*. https://osis.bg/wp-content/uploads/2021/03/MediaLiteracyIndex2021_ENG.pdf

Lewandowsky, S., Ecker, U. K. H., Seifert, C. M., Schwarz, N., & Cook, J. (2012). Misinformation and Its Correction: Continued Influence and Successful Debiasing. *Psychological Science in the Public Interest*, *13*(3), 106–131. https://doi.org/10.1177/1529100612451018

Lippke, S., & Ziegelmann, J. P. (2008). Theory-Based Health Behavior Change: Developing, Testing, and Applying Theories for Evidence-Based Interventions. *Applied Psychology*, *57*(4), 698–716 https://doi.org/10.1111/j.1464-0597.2008.00339.x

Liu, F., Enanoria, W. T. A., Zipprich, J., Blumberg, S., Harriman, K., Ackley, S. F., Wheaton, W. D., Allpress, J. L., & Porco, T. C. (2015). The role of vaccination coverage, individual behaviors, and the public health response in the control of measles epidemics: an agent-based simulation for California. *BMC Public Health*, *15*(1), 447. https://doi.org/10.1186/s12889-015-1766-6

Ma, J., Chen, Y., Zhu, H., & Gan, Y. (2023). Fighting COVID-19 misinformation through an Online Game Based on the Inoculation Theory: Analyzing the Mediating Effects of Perceived Threat and Persuasion Knowledge. *International Journal of Environmental Research and Public Health*, *20*(2). https://doi.org/10.3390%2Fijerph20020980

Mahmud, I., Kabir, R., Rahman, M. A., Alradie-Mohamed, A., Vinnakota, D., & Al-Mohaimeed, A. (2021). The Health Belief Model Predicts Intention to Receive the COVID-19 Vaccine in Saudi Arabia: Results from a Cross-Sectional Survey. *Vaccines*, *9*(8), 864. https://doi.org/10.3390/vaccines9080864

Mamelund, S.-E. (2011). Geography May Explain Adult Mortality from the 1918–20 Influenza Pandemic. *Epidemics*, *3*(1), 46–60. https://doi.org/10.1016/j.epidem.2011.02.001

Maxwell, E. K. (2024). Exploring the COVID-19 Infodemic in Alaska. In University of Alaska, Fairbanks.

McGuire, W. J. (1964). Inducing Resistance to Persuasion. Some Contemporary Approaches. *C. C Haaland and W. O. Kaelber (E s.), Self and Society. An Anthology of Readings, Lexington, Mass. (Ginn Custom Publishing) 1981, Pp. 192-230.* https://opus4.kobv.de/opus4-Fromm/frontdoor/index/index/docId/16094

Melki, J., Tamim, H., Hadid, D., Makki, M., el Amine, J., & Hitti, E. (2021). Mitigating infodemics: The relationship between news exposure and trust and belief in COVID-19 fake news and social media spreading. *PLOS ONE*, *16*(6), e0252830. https://doi.org/10.1371/journal.pone.0252830

Mercy Corps. (2021). *Case Study: Innovative concepts to communicate science during COVID-19*. https://www.mercycorps.org/research-resources/covid-19-learning-and-preparing

Mitchell, A., & Liedke, J. (2021, August 24). About four-in-ten Americans say social media is an important way of following COVID-19 vaccine news. *Pew Research Center*. https://www.pewresearch.org/short-reads/2021/08/24/about-four-in-ten-americans-say-social-media-is-an-important-way-of-following-covid-19-vaccine-news/

Mitchell, A., & Shearer, E. (2021). *News Use Across Social Media Platforms in 2020*. https://www.pewresearch.org/journalism/wp-content/uploads/sites/8/2021/01/PJ_2021.01.12_News-and-Social-Media_FINAL.pdf

Musshafen, L. A., El-Sadek, L., Lirette, S. T., Summers, R. L., Compretta, C., & Dobbs III, T. E. (2022). In-Hospital Mortality Disparities Among American Indian and Alaska Native, Black, and White Patients With COVID-19. *JAMA Network Open*, *5*(3), e224822–e 24822. https://doi.org/10.1001/jamanetworkopen.2022.4822

Myneni, S., Cuccaro, P., Montgomery, S., Pakanati, V., Tang, J., Singh, T., Dominguez, O., Cohen, T., Reininger, B., Savas, L. S., & Fernandez, M. E. (2023). Lessons Learned From Interdisciplinary Efforts to Combat COVID-19 Misinformation: Development of Agile Integrative Methods From Behavioral Science, Data Science, and Implementation Science. *JMIR Infodemiology*, *3*, e40156. https://doi.org/10.2196/40156

New York Times. (2022, April 11). *See How Vaccinations Are Going in our County and State*. New York Times. https://www.nytimes.com/interactive/2020/us/covid-19-vaccine-doses.html

Niforatos, J. D., Lin, L., Narang, J., James, A., Singletary, A., Rose, E., Yax, J. A., & Stull, M. J. (2019). Financial Conflicts of Interest Am ng Emergency Medicine Contributors on Free Open Access Medical Education (<scp>FOAM</scp> ed). *Academic Emergency Medicine*, *26*(7) 814–817. https://doi.org/10.1111/acem.13676

Nikiforakis, N., Kapravelos, A., Joosen, W., Kruegel, C., Piessens, F., & Vigna, G. (2013). Cookieless Monster: Exploring the Ecosystem of Web-Based Device Fingerprinting. *2013 IEEE Symposium on Security and Privacy*, 541–555. https://doi.org/10.1109/SP.2013.43

Nordheim, L. V., Gundersen, M. W., Espehaug, B., Guttersrud, Ø., & Flottorp, S. (2016). Effects of School-Based Educational Interventions for Enhancing Adolescents Abilities in Critical Appraisal of Health Claims: A Systematic Review. *PLOS ONE*, *11*(8), e0161485. https://doi.org/10.1371/journal.pone.0161485

Ojikutu, B. O., Stephenson, K. E., Mayer, K. H., & Emmons, K. M. (2021). Building Trust in COVID-19 Vaccine and Beyond Through Authentic Community Investment. *American Journal of Public Health*, *111*(3), 366–368. https://doi.org/10.2105/ajph.2020.306087

Oyeyemi, S. O., Gabarron, E., & Wynn, R. (2014). Ebola, Twitter, and misinformation: a dangerous combination? *BMJ*, *349*(oct14 5), g6178–g6178. https://doi.org/10.1136/bmj.g6178

Pantserev, K. A. (2020). The Malicious Use of AI-Based Deepfake Technology as the New Threat to Psychological Security and Political Stability. In H. Jahankhani, S. Kendzierskyj, N. Chelvachandran, & J. Ibarra (Eds.), *Cyber Defence in the Age of A.I., Smart Societies and Augmented Humanity* (pp. 37–55). Springer International Publishing. https://link.springer.com/chapter/10.1007/978-3-030-35746-7_3

Parker, R. D., & Meyer, J. A. (2023). Factors Associated with Vaccine Hesitancy in the State of Alaska. *Journal of Community Health*. https://doi.org/10.1007/s10900-023-01271-z

Parker, R. D., & Meyer, J. A. (2024). Vaccine safety beliefs in the state of Alaska. *Public Health in Practice*, *7*, 100482. https://doi.org/10.1016/j.puhip.2024.100482

Patil, U., Kostareva, U., Hadley, M., Manganello, J. A., Okan, O., Dadaczynski, K., Massey, P. M., Agner, J., & Sentell, T. (2021). Health Literacy, Digital Health Literacy, and COVID-19 Pandemic Attitudes and Behaviors in U.S. College Students: Implications for Interventions. *International Journal of Environmental Research and Public Health*, *18*(6), 3301. https://doi.org/10.3390/ijerph18063301

Pei, S., Kandula, S., & Shaman, J. (2020). Differential effects of intervention timing on COVID-19 spread in the United States. *Science Advances*, *6*(49). https://doi.org/10.1126/sciadv.abd6370

Pew Research Center. (2000). *Internet Sapping Broadcasts News Audience*. https://www.pewresearch.org/politics/2000/06/11/internet-sapping-broadcast-news-audience/

Pew Research Center. (2021, April 7). *Social Media Use in 2021*. Pew Research Center. https://www.pewresearch.org/internet/2021/04/07/social-media-use-in-2021/

Pew Research Center. (2022). *Party affiliation among adults in Alaska*. https://www.pewresearch.org/religi n/religious-landscape-study/state/Alaska/party-affiliation/

Pickles, K., Cvejic, E., Nickel, B., Copp, T., Bonner, C., Leask, J., Ayre, J., Batcup, C., Cornell, S., Dakin, T., Dodd, R. H., Isautier, J. M. J., & McCaffery, K. J. (2021). COVID-19 Misinformation Trends in Australia: Prospective Longitudinal National Survey. *Journal of Medical Internet Research*, *23*(1), e23805. https://doi.org/10.2196/23805

Rabaan, A. A., Al-Ahmed, S. H., Haque, S., Sah, R., Tiwari, R., Malik, Y. S., Dhama, K., Yatoo, M. I., Bonilla-Aldana, D. K., & Rodriguez-Morales, A. J. (2020). SARS-CoV-2, SARS-CoV, and MERS-COV: A comparative overview. *Le Infezioni in Medicina*, *28*(2), 174–184.

Ries, M. (2022). The COVID-19 Infodemic: Mechanism, Impact, and Counter-Measures—A Review of Reviews. *Sustainability*, *14*(5), 2605. https://doi.org/10.3390/su14052605

Rica d, J., & Medeiros, J. (2020, April 17). Using misinformation as a political weapon: COVID-19 and Bolsonaro in Brazil. *Harvard Kennedy School, Misinformation Review*. https://misinforeview.hks.harvard.edu/article/using-misinformation-as-a-political-weapon-covid-19-and-bolsonaro-in-brazil/

Roesner, F., Kohno, T., & Wetherall, D. (2012). Detecting and Defending Against Third-Party Tracking on the Web. *9th USENIX Symposium on Networked Systems Design and Implementation*. https://www.usenix.org/conference/nsdi12/technical-sessions/presentation/roesner

Roozenbeek, J., van der Linden, S., & Nygren, T. (2020). Prebunking interventions based on "inoculation" theory can reduce susceptibility to misinformation across cultures. *The Harvard Kennedy School Misinformation Review*, *1*(2). https://misinforeview.hks.harvard.edu/article/global-vaccination-badnews/

Rothkopf, D. (2003, May 11). When the Buzz Bites Back. *The Washington Post*. https://www.washingtonpost.com/archive/opinions/2003/05/11/when-the-buzz-bites-back/bc8cd84f-cab6-4648-bf58-0277261af6cd/

Santos-D'Amorim, K., & Miranda, M. K. (2021). Misinformation, Disinformation, and Malinformation: Clarifying the Definitions and Examples in Disinfodemic Times. *Encontros Bibli: revista eletrônica de biblioteconomia e ciência da informação*, *26*. https://www.redalyc.org/articulo.oa?id=14768130011

Satcher Health Leadership Institute, Morehouse School of Medicine. (2023). *Health Equity Tracker*. https://satcherinstitute.org/research/health-equity-tracker-project/

Shao, C., Ciampaglia, G. L., Varol, O., Yang, K.-C., Flammini, A., & Menczer, F. (2018). The spread of low-credibility content by social bots. *Nature Communications*, *9*(1), 4787. https://doi.org/10.1038/s41467-018-06930-7

Shu, K., Wang, S., & Liu, H. (2018). Understanding User Profiles on Social Media for Fake News Detection. *2018 IEEE Conference on Multimedia Information Processing and Retrieval (MIPR)*, 430–435. https://doi.org/10.1109/MIPR.2018.00092

Silberner, J. (2021). COVID-19: How Native Americans led the way in the U.S. vaccination effort. *BMJ*, *374*, n2168. https://doi.org/10.1136/bmj.n2168

Sommariva, S., Mote, J., Ballester Bon, H., Razafindraibe, H., Ratovozanany, D., Rasoamanana, V., Abeyesekera, S., Muhamedkhojaeva, P., Bashar, T., James, J., & Sani, M. (2021). Social Listening in Eastern and Southern Africa, a UNICEF Risk Communication and Community Engagement Strategy to Address the COVID-19 Infodemic. *Health Security*, *19*(1), 57–64. https://doi.org/10.1089/hs.2020.0226

Southwell, B. G., Brennen, J. S. B., Paquin, R., Boudewyns, V., & Zeng, J. (2022). Defining and Measuring Scientific Misinformation. *The ANNALS of the American Academy of Political and Social Science*, *700*(1), 98–111. https://doi.org/10.1177/00027162221084709

State of Alaska Department of Health and Social Services. (2022). *COVID-19 Vaccination Dashb*oard. State of Alaska Department of Health and Social Services. https://experience.arcgis.com/experience/a7e8be4adbe740a1bad1393894ee4075/

Stoneman, P., Sturgis, P., & Allum, N. (2013). Understanding support for complementary and alternative medicine in general populations: Use and perceived efficacy. *Health: An Interdisciplinary Journal for the Social Study of Health, Illness and Medicine*, *17*(5), 512–529. https://doi.org/10.1177/1363459312465973

Sun, L. H., & Weber, L. (2023, July 26). Doctors who put lives at risk with covid misinformation rarely punished. *Washington Post*. https://www.washingtonpost.com/health/2023/07/26/covid-misinformation-doctor-discipline/

Sundelson, A., Huhn, N., Jamison, A., Pasquino, S.-L., & Kirk Sell, T. (2023). *Infodemic Management Approaches Le ding up to, During, and Following the COVID-19 Pandemic*. https://centerforhealthsecurity.org/sites/default/files/2023-04/230407-nasempaper.pdf

Surgo Ventures. (2023). *How Do We Get America Vaccinated?* https://precisionforcovid.org/vaccinebarriers.html

Suwajanakorn, S., Seitz, S. M., & Kemelmacher-Shlizerman, I. (2017). Synthesizing Obama. *ACM Transactions on Graphics*, *36*(4 , 1–13. https://grail.cs.washington.edu/projects/AudioToObama/siggraph17_obama.pdf

Tangcharoensathien, V., Calleja, N., Nguyen, T., Purnat, T., D'Agostino, M., Garcia-Saiso, S., Landry, M., Rashidian, A., Hamilton, C., AbdAllah, A., Ghiga, I., Hill, A., Hougendobler, D., van Andel, J., Nunn, M., Brooks, I., Sacco, P. L., De Domenico, M., Mai, P., … Briand, S. (2020). Framework for Managing the COVID-19 Infodemic: Methods and Results of an Online, Crowdsourced WHO Technical Consultation. *Journal of Medical Internet Research*, *22*(6), e19659. https://doi.org/10.2196/19659

The Atlantic Monthly Group. (2023). *the COVID Tracking Project* The Atlantic. https ://www.theatlantic.com/author/covid-tracking-project/

The Conversation. (2023, March 13). What the first amendment really says – 4 basic principles of free speech in the U.S. *Free Speech Center at Middle Tennessee State University*. https://firstamendment.mtsu.edu/post/what-the-first-amendment-really-says-4-basic-principles-of-free-speech-in-the-u-s/#:~:text=When%20the%20rights%20and%20liberties%20of%20others,can%20be%20held%20liable%20for%20that%20damage

Traberg, C. S., Roozenbeek, J., & van der Linden, S. (2022). Psychological Inoculation against Misinformation: Current Evidence and Future Directions. *The ANNALS of the American Academy of Political and Social Science*, *700*(1), 136–151. https://doi.org/10.1177/00027162221087936

United Nations International Children's Emergency Fund. (2021, October 1). *UNICEF launches Behaviour Change Observatory to counter mistrust and misinformation about COVID-19 and vaccination*. UNICEF. https://www.unicef.org/ukraine/en/press-releases/unicef-launches-behaviour-change-observatory-counter-mistrust-and-misinformation

U.S. Department of Health and Human Services. (2021). *Confronting Health Misinformation: The U.S. Surgeon General's Advisory on Building a Healthy Information Environment*. https://www.hhs.gov/sites/default/files/surgeon-general-misinformation-advisory.pdf

van der Linden, S., Leiserowitz, A., Rosenthal, S., & Maibach, E. (2017). Inoculating the Public against Misinformation about Climate Change. *Global Challenges*, *1*(2), 1600008. https://doi.org/10.1002/gch2.201600008

Vosoughi, S., Roy, D., & Aral, S. (2018). The spread of true and false news online. *Science*, *359*(6380), 1146–1151. https://doi.org/10.1126/science.aap9559

Vraga, E. K., & Bode, L. (2020). Defining Misinformation and Understanding its Bounded Nature: Using Expertise and Evidence for Describing Misinformation. *Political Communication*, *37*(1), 13 –144. https://doi.org/10.1080/10584609.2020.1716500

Ward, L. A., Black, K. P., Britton, C. L., Tompkins, M. L., & Provost, E. M. (2022). COVID-19 Cases, Hospitalizations, And Deaths Among American Indian or Alaska Native Persons — Alaska, 2020–2021. *MMWR. Morbidity and Mortality Week y Rep rt*, *71*(22), 730–733. http://dx.doi.org/10.15585/mmwr.mm7122a2

Wardle, C., & Derakhshan, H. (2017). *Information Disorder: Toward an Interdisciplinary framework for research and policy making* https://edoc.coe.int/en/media/7495-information-disorder-toward-an-interdisciplinary-framework-for-research-and-policy-making.html

Watkins, I., & Xie, B. (2014). eHealth Literacy Interventions for Older Adults: A Systematic Review of the Literature. *Journal of Medical Internet Research*, *16*(11), e225. https://doi.org/10.2196/jmir.3318

Webster, D. M., & Kruglanski, A. W. (1994). Individual differences in need for cognitive closure. *Journal of Personality and Social Psychology*, *67*(6), 1049–1062. https://doi.org/10.1037//0022-3514.67.6.1049

Wilner, T., & Holton, A. (2020). Breast Cancer Prevention and Treatment: Misinformation on Pinterest, 2018. *American Journal of Public Health*, *110*(S3), S300–S304. https://doi.org/10.2105%2FAJPH.2020.305812

World Health Organization. (2017). *Communicating Risk in Public Health Emergencies*. https://www.who.int/activities/communicating-risk-in-public-health-emergencies

World Health Organization. (2020a, March 11). *WHO Director-General's opening remarks at the media briefing on COVID-19 – 11 March 2020*. https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020

World Health Organization. (2020b). *Novel Coronavirus(2019-nC V) Situation Report – 10.* https://iris.who.int/bitstream/handle/10665/330775/nCoVsitrep30Jan2020-eng.pdf?sequence=1&isAllowed=y

World Health Organization. (2020c). *Cross-Regional Statement n "Infodemic" in the Context of COVID-19*. https://usun.usmission.gov/cross-regional-statement-on-infodemic-in-the-context-of-covid-19/

World Health Organization. (2021). *Infodemic Management: An Overview of Infodemic Management During COVID-19*. https://www.who.int/publications/i/item/9789240035966

Wu, L., Morstatter, F., Carley, K. M., & Liu, H. (2019). Misinformation in Social Media. *ACM SIGKDD Explorations Newsletter*, *21*(2), 80–90. https://doi.org/10.1145/3373464.3373475

Xin, H., Li, Y., Wu, P., Li, Z., Lau, E. H. Y., Qin, Y., Wang, L., Cowling, B. J., Tsang, T. K., & Li, Z. (2022). Estimating the Latent Period of Coronavirus Disease 2019 (COVID-19). *Clinical Infectious Diseases*, *74*(9 , 1678–1681. https://doi.org/10.1093/cid/ciab746

Zhou, P., Yang, X.-L., Wang, X.-G., Hu, B., Zhang, L., Zhang, W., Si, H.-R., Zhu, Y., Li, B., Huang, C.-L., Chen, H.-D., Chen, J., Luo, Y., Guo, H., Jiang, R.-D., Liu, M.-Q., Chen, Y., Shen, X.-R., Wang, X., … Shi, Z.-L. (2020). A pneumonia outbreak associated with a new coronavirus of probable bat origin. *Nature*, *579*(7798), 270–273. https: /doi.org/10.1038/s41586-020 2012-7

Zink, A. (2021, October). Alaska did well early in the pandemic. Then the misinformation and distrust kicked in. *The Washington Post*. https://www.washingtonpost.com/opinions/2021/10/27/alaska-did-well-early-pandemic-then-misinformation-distrust-kicked/

Chapter 2: Classifying COVID-19 Misinformation on Alaska-Based Social Media Using Latent Dirichlet Allocation

2.1 Abstract

Background: The COVID-19 pandemic created an influx of misinformation and false narratives, triggering an infodemic of unparalleled magnitude. Natural language processing is a machine learning method used to gain insight into infodemics, particularly with large datasets. Objectives: In this study, we conducted a secondary analysis of existing data to assess the feasibility of utilizing a social media listening tool and natural language processing methods to produce a model of misinformation topics. We sought to identify and understand the prevalent themes in COVID-19 misinformation. Design: Primary data were collected from select Facebook pages from 2021 to 2022. We utilized LDA (latent Dirichlet allocation), a natural language processing technique, for topic modeling. Methods: Data were preprocessed into a suitable format for input into an LDA model. LDA then identified latent topics by using qualitative interpretation of the most salient words. A temporal trend analysis identified patterns in misinformation over the monitoring period. Results: A total of 4,265 unique posts were collected from 30 websites, out of which four main topics emerged: “treatment,” “vaccine safety,” “false reporting,” and “COVID spread.” Each had a specific peak period coinciding with key events in the pandemic, illustrating the potential benefit of using LDA for identification and classification of COVID-19 misinformation. This approach provides a foundation for addressing misinformation as well as informing evidence-based strategies to combat the misinformation and enhance public health communication.

2.2 Introduction

The emergence of the COVID-19 global health crisis coincided with an unprecedented surge in misinformation and false narratives surrounding the disease. This parallel information pandemic (or infodemic) has had demonstrable effects on the course of the pandemic, including altering transmission patterns (Kim et al., 2019). Though false information has played a role in past outbreaks (Oyeyemi et al., 2014; Pluviano et al., 2022), the amplified role of social media as an information source today enables misinformation to circulate farther and faster than it has previously. According to the Pew Research Center, over half of Americans get news on social

media at least sometimes, with Facebook standing out as a dominant source (Mitchell & Shearer, 2021).

The growing threat of misinformation has compelled public health officials to seek out strategies to combat the confusion, fear, and potentially harmful effects of misinformation among the public. To gain a better understanding of digital misinformation, scholars and public health entities adopted the use of social listening, defined as "tracking and analyzing public conversations on social media, blogs and news commentaries…" (World Health Organization, 2021). Typically conducted with the help of artificial intelligence tools (often natural language processing), social listening aims to identify the presence and dissemination of information, analyze how it is being discussed, and recognize any existing gaps in public knowledge. Gaining an understanding of the information landscape in a population enables public health communicators to customize messages for a particular audience based on their information needs. Further, understanding what misinformation is prevalent in a community can guide efforts to debunk misinformation.

Alaska faces challenges distinct from any other state in the U.S. due to its unique geography and population. According to a recent study, the Arctic is warming nearly four times faster than the rest of the globe (Rantanen et al., 2022), which intensifies the frequency and prevalence of infectious diseases in Arctic communities (Parkinson et al., 2014). Additionally, according to the 2020 U.S. Census, 21.9% of Alaska's population identified as American Indian/Alaska Native (AI/AN) (alone or in combination) (America Counts Staff, 2021). AI/AN populations face increased vulnerability to infectious diseases for multiple reasons, including disparities in healthcare access (Herz, 2020; Hollander, 2020), socioeconomic status (LaVeist, 2005) and sanitation (Eichelberger et al., 2021). The heightened susceptibility of Alaska to emerging health threats like COVID-19 highlights the increased importance of addressing infodemics in this region.

Multiple social listening tools have been developed in response to the COVID-19 infodemic. In January 2021, the WHO launched the pilot platform, Early AI-Supported Response with Social Listening (EARS), which provided a real-time synopsis of the digital COVID-19 information landscape across 30 countries and nine languages (WHO, 2021). Although these types of social listening platforms have been acknowledged as one of the key pillars of infodemic management (Eysenbach, 2002), the integration of this information into public health

practice is not well documented (Purnat et al., 2021). There is little empirical evidence regarding the practical application of social listening tools due in part to the lack of collaboration between researchers and public health practitioners.

Though manual coding methods (such as thematic analysis) can be used to conduct similar research, it is often time and cost intensive in addition to being difficult to replicate. Integrating natural language processing into qualitative research can significantly reduce these costs and enable future data analysis (Abram et al., 2020). Topic modeling is a type of natural language processing that uses an algorithm to analyze a corpus of textual data to generate latent themes within the data (Hannigan et al., 2019). Topic modeling techniques have been applied as a text mining technique extensively to study various aspects of COVID-19 for several reasons (Çallı & Çallı, 2023; Cheng et al., 2022; Danesh et al., 2021; Xie et al., 2021; Xue et al., 2020); they are unsupervised machine learning methods that does not require researchers to develop and apply codebooks on data (which may decrease researcher bias over time) (Abram et al., 2020) and they can identify hidden themes that humans may not be able to interpret (DiMaggio, 2015)

In this study, we conducted a secondary analysis of Facebook comments pertaining to COVID-19 misinformation and analyzed them using latent Dirichlet allocation (LDA) to extract prevailing themes. We aim to establish the feasibility of a social listening tool in Alaska with the goal of providing a foundation for future collaboration with public health entities in Alaska to improve future infodemic response.

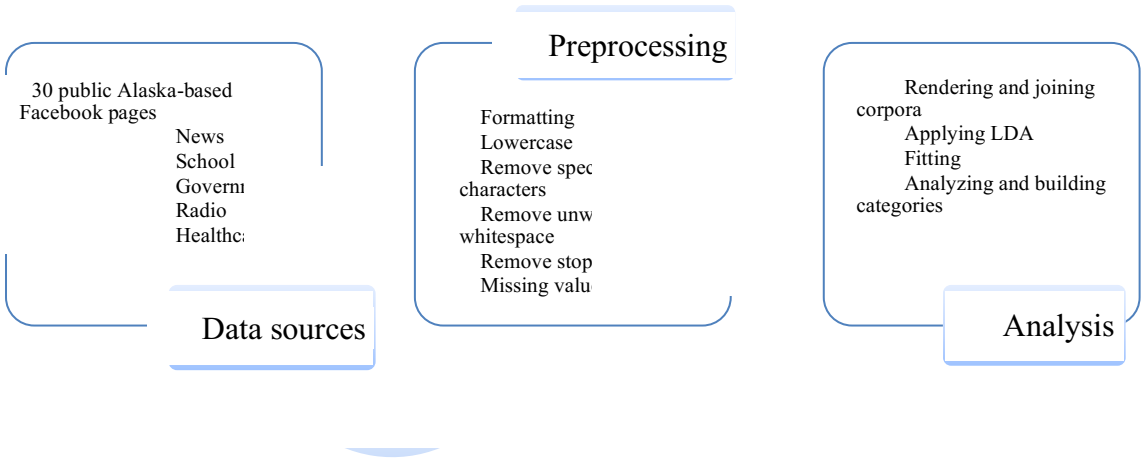
2.3 Methods

2.3.1 Data Collection

This research was a secondary analysis of data collected by an organized team of university and community members to combat COVID-19 misinformation across the state. The multidisciplinary team of students, strategic communications experts and public health professionals monitored select Facebook pages for COVID-19 misinformation (Meyer et al., 2022). Facebook was selected based on the results of a university survey indicating over 70% of Alaskans access Facebook daily (Weiss, 2022). These pre-selected pages were monitored with comments identified as misinformation selected by trained student and professional staff. The flagged post was sent to response team members via a communication platform application (Remind) (see Figure 2.1 below). Volunteer response team members were directed to the post via

direct link, where they were designed to counter the statement with evidence-based science utilizing the Triple E approach, a term developed by (Meyer et al, 2022) to describe how APHIRT volunteer responders where trained to engage when prebunking or debunking COVID-19 misinformation. The original comments and responses were entered into an application built by computer science students to allow for analysis.

Figure 2.1: Methodological framework of the study.



(Maxwell, 2024)

The project's preexisting database used for text mining resulted in a corpus (of documents) from 30 publicly available pages in the state from January 1, 2021, to July 3, 2022. Of the pages monitored, 37% (n=11) were news pages, 23% (n=7) were school-based pages, 17% (n=5) were government pages, 13% (n=4) were radio pages, and 10% (n=3) were pages of healthcare centers. The geographic spread of pages included five regions across the state (Northern (n=3), Interior (n=5), Southwestern (n=2), Southeastern (n=4), Southcentral (n=13), and three state-wide sites. Table 2.1 provides a description of each page.

Table 2.1: Text mining sources by Facebook page, sector, geographic region, and number of followers.

Page Name	Sector	Region	# of Followers
Alaska's News Source	News	State-wide	312,907
Anchorage Daily News	News	Southcentral	274,046
Alaska Department of Health	Government	State-wide	61,000
Fairbanks Daily News Miner	News	Interior	56,631
Alaska Public Media	News	State-wide	38,426
Anchorage School District	School district	Southcentral	36,000
KTVF Fairbanks	Radio	Interior	28,077
KSRM 90 AM	Radio	Southcentral	27,019
Mat-Su Valley Frontiersman	News	Southcentral	24,625
Juneau Empire	News	Southeast	24,210
Mat-Su Borough	Government	Southcentral	24,000
KYUK	Radio	Southwestern	21,803
Bethel School District	School district	Southwestern	16754
Mat-Su School District	School district	Southcentral	14,907
Fairbanks Memorial Hospital	Healthcare	Interior	12,622
Fairbanks North Star Borough School District	School district	Interior	11,000
City and Borough of Juneau	Government	Southeast	11,000
Daily Sitka Sentinel	News	Southeast	9,562
Anchorage Health Department	Government	Southcentral	9,500
Kenai Peninsula Clarion	News	Southcentral	9,300
Homer News	News	Southcentral	8,964
The Arctic Sounder	News	North	8,621
KRBD FM Rainbird Community Radio	Radio	Southeast	8,008
Kenai Peninsula Borough School District	School district	Southcentral	8,000
The Nome Nugget	News	North	7,908
Kenai Peninsula Borough	Government	Southcentral	6,100
Fairbanks Borough	Government	Interior	5,900
City of Utqiagvik	Government	North	3,807
Central Peninsula Hospital	Healthcare	Southcentral	3,090
Mat-Su Regional Medical Center	Healthcare	Southcentral	2,422

(Maxwell, 2024)

The institutional review board approved this study (#2025127) as exempt due to its minimal risk nature and the collection of minimal potentially identifiable data.

2.3.2 Data Preprocessing

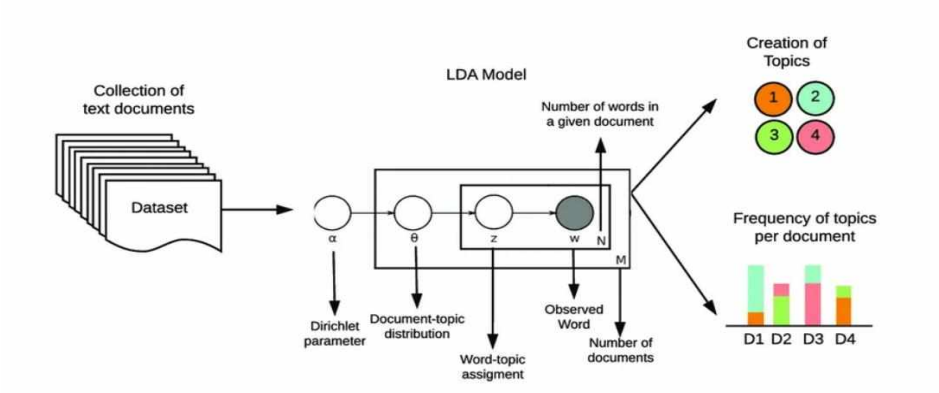
Data preprocessing was completed by L.R.S. using Python version 3.12.0 (Python Software Foundation, 2023) and included the removal of metadata, resulting in three attributes common across all documents: “comment”, “processed_comment” and “date”. Further preprocessing included link removal, lower casing, removing noise (punctuation, emojis, symbols,), removal of any other non-English characters, and removing stop words. Stop words are extremely common words that add little or no value to the document such as “the”, “or”, and “this”. Preprocessing is done to convert unstructured text to structured text and keep only the meaningful text in the corpus. For example, the raw, unstructured document, “Keep the panic and fear going 🤪🤣🤣🤣” was altered to “keep panic fear go” through preprocessing. Finally, the corpus was transformed to a document term matrix. All preprocessing steps were completed using gensim (topic modeling and preprocessing), NLTK (natural language processing), and SciPy (document comparison) and pandas libraries in Python.

2.3.3 Data Analysis

Due to the sample size and brevity of the comments, LDA was selected as the method of analysis. LDA analysis creates a probabilistic generative model, where each document (or in this case, Facebook comment) is represented as a mixture of topics and each topic is a probability distribution over words (Canini et al., 2009). The objective of LDA analysis is to discover topics, or themes, that provide insight into the data corpus (see Figure 2.2).

Topics were rendered based on coherence score (measuring the similarity of each topic in the model) a dendrogram mapping the coherence scores, which we used to determine whether any topics should be combined. We contextualized findings from the unsupervised learning process by interpreting meaning identifying patterns within the topics, and inductively developing themes for the latent topics generated by machine algorithms. Finally, we created data visualizations of the results, including an intertopic distance map and trend analysis.

Figure 2.2: Latent Dirichlet allocation model.

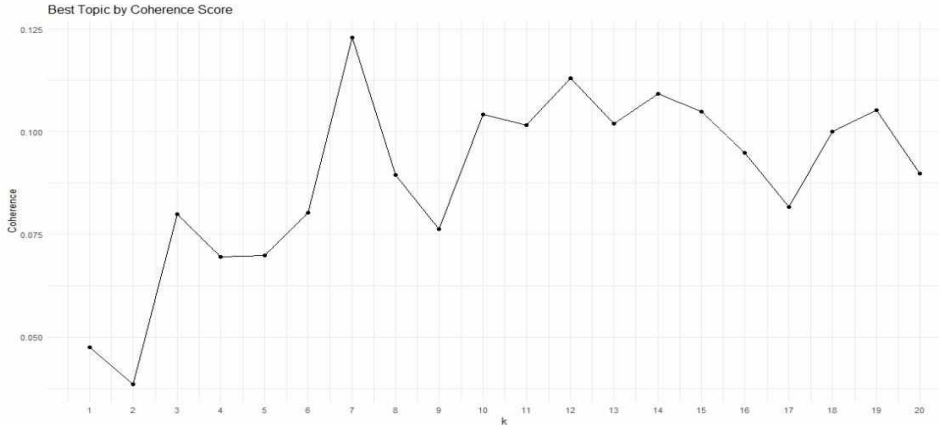


(Buenano-Fernandez et al., 2020)

2.4 Results

A total of 4,265 individual Facebook comments resulted in a corpus of 7,621 unique terms. The most common word throughout the corpus was “people” (appearing 2,858 times across 983 documents), followed by “COVID” (appearing 2,658 times across 811 documents), and “dont” (appearing 1,936 times across 570 documents). Multiple LDA models were executed and assessed based on topic size and coherence measures. Figure 2.3 shows the coherence scores of models trained under different numbers of topics and figure 2.4 shows the topics in relation to one another using Hellinger distance. The highest coherence score was k=7, however, manual inspection of the top 20 words in each topic revealed similarities between several topics.

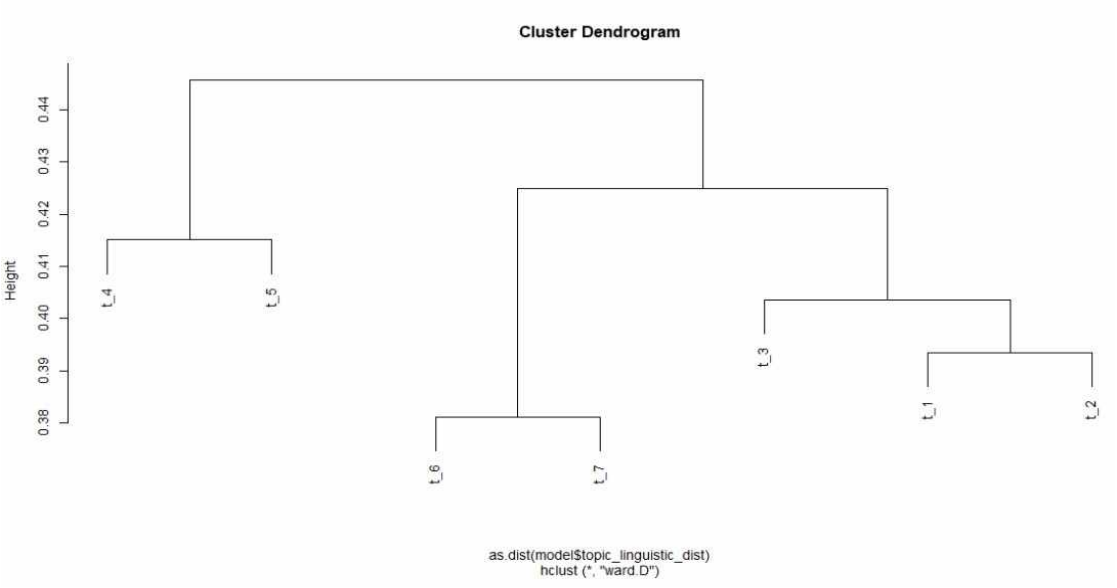
Figure 2.3: Coherence scores of 1-20 topics.



(Maxwell, 2024)

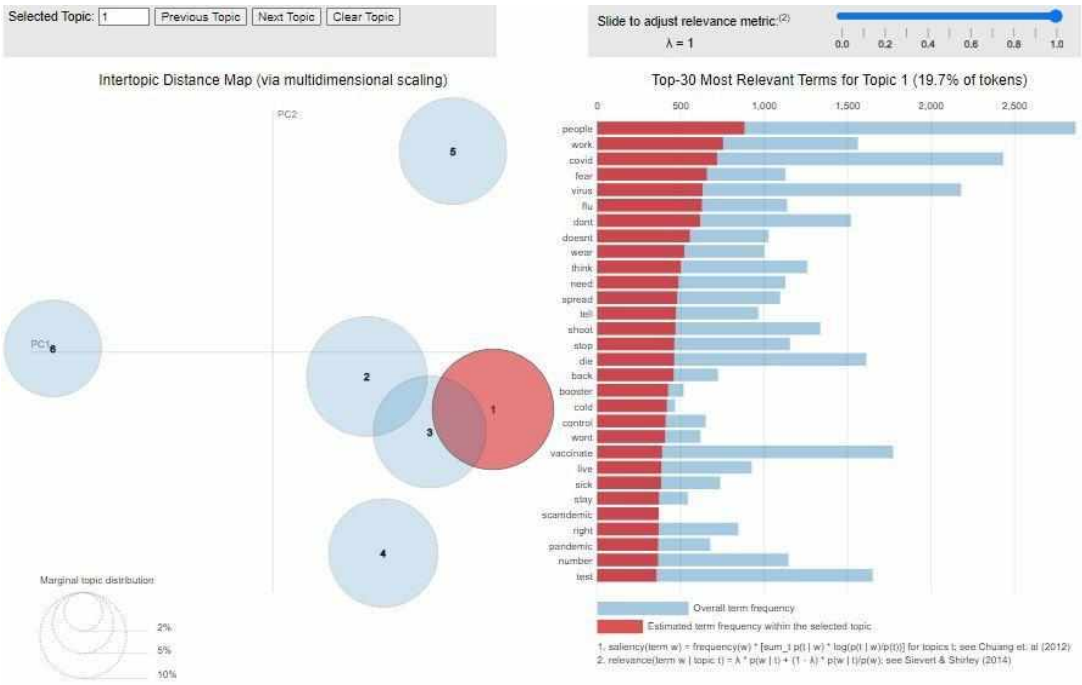
Visualization using a dendrogram of the top 7 topics revealed similar findings (see Figure 2.4); based on Hellinger distance between topics, we combined topics one and two.

Figure 2.4: Dendrogram using Hellinger distance to show similarities between top seven topics.



(Maxwell, 2024)

Figure 2.5: Intertopic-distance map of six-topic model.



(Maxwell, 2024)

Finally, we calculated the topic distance and produced a two-dimensional representation of the topics called an intertopic distance map (see Figure 2.5). In this topic mapping tool, the circles represent each of the topics and the distance represents the distance between topics based on the words in common between the topics. This method revealed a close similarity between topics one, two, and three (visualized by overlapping circles), therefore we combined these topics as well, resulting in four final topics.

Topic modeling was completed by manually labeling the topics based on qualitative interpretation of the most salient words in each topic (see Figure 2.6). The four final topics were "COVID_Spread", "Vaccine_Safety", "Treatment", and "Conspiracy".

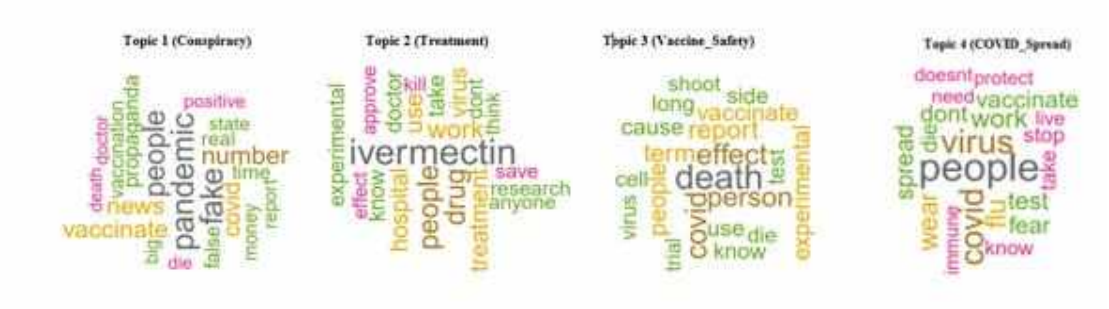
Figure 2.6: The top 20 most salient words across the final four topics.

Conspiracy	**Treatment**	**Vaccine_Safety**	**COVID_Spread**
pandemic	ivermectin	death	people
fake	people	covid	covid
people	drug	effect	virus
number	work	person	flu
news	use	report	wear
vaccinate	hospital	term	work
covid	treatment	people	spread
propaganda	virus	experimental	test
false	take	vaccinate	vaccinate
time	doctor	use	dont
real	know	cause	fear
vaccination	experimental	know	die
money	dont	test	take
state	think	side	stop
big	anyone	long	know
report	research	die	live
die	save	cell	immune
doctor	approve	virus	need
positive	kill	shoot	protect
death	effect	trial	doesnt

(Maxwell, 2024)

Figure 2.7 provides a visualization of this in a word cloud format. The word cloud was created using the TF-IDF technique, which assigns a weight to each term based on the importance of the term both within and across documents, rather than by frequency alone (Bafna & Saini, 2020).

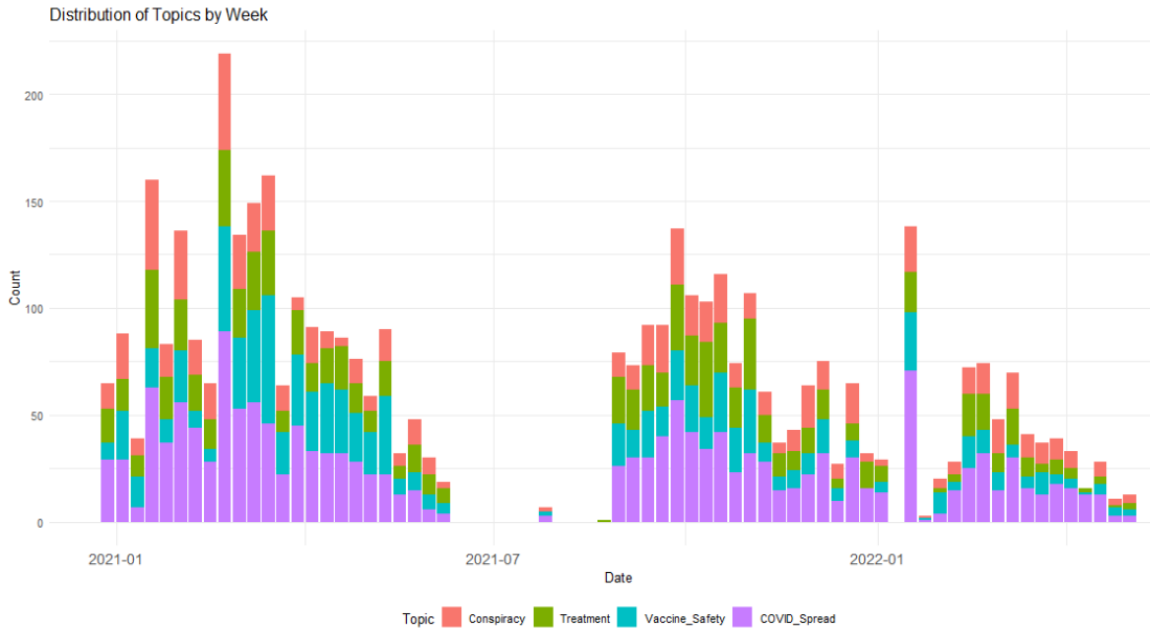
Figure 2.7: TF-IDF word clouds of the most salient words in the four final topics.



(Maxwell, 2024)

The most common topic throughout the corpus was “COVID_spread” (38%, n=1641), followed by “Vaccine_Safety” (22%, n=944), “Treatment” (21%, n=878), and “Conspiracy” (19%, n=802). Figure 2.8 illustrates a temporal trend analysis (Rae, 2014) of topics over the 19 months pages were monitored. Gaps in posts represent periods where data was unavailable or pages were not monitored, not a lack of posts. The week with the highest number of identified misinformation posts was February 22, 2021 (n=219), followed by March 15, 2021 (n=162), January 18, 2021 (n=160), and March 8, 2021 (n=149). Posts classified as “Conspiracy” and “COVID_Spread” peaked the week of February 22, 2021 (“Conspiracy” [n=45], “COVID_Spread” [n=89]). Posts classified as “Treatment” peaked the week of January 18, 2021 (n=37), and “Vaccine_Safety peaked the week of March 15, 2021 (n=60). In addition to the week of February 22, 2022, posts labeled as “Conspiracy” peaked during the weeks of January18, 2021, and February 1, 2021; posts labeled “Treatment” peaked during the weeks of February 22, 2021, and October 11, 2021, and posts labeled “Vaccine_Safety” peaked during the weeks of February 22, 2021 and March 8, 2021. In addition to February 22, 2021, posts labeled “COVID_Spread” peaked during the weeks of January 18, 2021, and September 27, 2021.

Figure 2.8: Topic distribution by week.



(Maxwell, 2024)

2.5 Discussion

This study examines Facebook users' comments identified as COVID-19 misinformation during a 19-month period from 2021 to 2022. Using the LDA topic modelling technique, we developed four topics from the corpus: treatment, vaccine safety, conspiracy, and COVID spread.

"Conspiracy" represented 802 documents (19% of the corpus). This topic was a combination of words relating to various conspiracy theories surrounding COVID-19, including "fake", "propaganda", "money", "state", "agenda", and "control". Posts labeled under this topic included "Yeah no way they would lie to the public when they making Billions of dollars" and "Gotta keep the masses in a constant state of fear.🙄". "Treatment" represented 878 documents (21% of the corpus). This topic was comprised of words relating to COVID-19 treatments, including "ivermectin", "vitamin", "pharma" "hospital", and "fda". Posts labeled under this topic include: "There have to treatments all along, you kept them from the public Media.. Now more poison from CDC you pushing?!" and "And guess what-BOTH pills ingredients-mirror IVERMECTIN….LOL LGB". "Vaccine_Safety" represented 944 documents (22% of the corpus). This topic contained terms related to concerns and opinions about the safety and efficacy of COVID-19 vaccines such as "death", "experimental", "vaccinate", "guinea", and

"clot". Posts labeled under this topic include: "I had inflammation of my lymph nodes so did my nephew could be bc of the stupid shot!" and "How many injections are you all going for? This is unreal. This is not a vaccine. When we had vaccines as children we had 1. Not one every other month". "COVID_Spread" represented 1641 documents (38% of the corpus), and included terms such as: "wear", "spread", "protect", "flu", and "immunity". Examples of posts labeled under this topic include, "Let them be normal adults & choose to wear the ineffective masks or not. The mask party is over. People are taking their freedom back. Why can't people get used to getting back to normal?" and "Wait a minute I thought we were wearing mask to protect others not ourselves so which is it do we wear a mask to protect others or is it protecting us?"

All topics peaked in late winter 2021, at the same time as several significant points during the pandemic. For example, this coincided with the emergence of the "Beta" variant (discovered first in South Africa), the 100 millionth COVID-19 case worldwide and the implementation of a face mask requirement in all public transportation in the United States (Centers for Disease Control and Prevention, 2023). Additionally, this was shortly following the emergency use authorization of the first two mRNA vaccines for COVID-19 on December 11 (Pfizer/BioNTech) and December 18 (Moderna) (Gladstone Institutes, 2022). Finally, a peak in January 2022 occurred at the same time the FDA limited the use of one type of COVID-19 antibody treatment during this month (Shibu & Khandekar, 2022) and the Biden administration announced they would double the amount of Paxlovid (a pill shown to decrease hospitalization from COVID-19) that would be available in the United States (Weiland & Robbins, 2022). In addition, COVID-19 cases were surging in the United States this month; with both Delta and Omicron circulating, the number of hospitalized patients increased by 50% in just one week (Centers for Disease Control and Prevention, 2023).

There are multiple limitations to this study. The data collection process included posts from only 30 public Alaska-based Facebook pages and do not represent offline discourse, posts outside of those pages, or in private user discussions. In addition, there were gaps in data collection, resulting in no available data for some weeks during the 19 months reported. Another limitation of the study is the inherent subjective nature of the text mining method and topic labelling of the LDA analysis. During data collection, users were trained to identify posts containing misinformation, however, this project was still subject to the interpretation of the individual. Additionally, once topics were developed by the machine learning algorithm, they

were assigned labels through a qualitative process completed by an individual. Finally, any posts containing non-English languages were removed from the corpus.

This retrospective study demonstrates the viability of harnessing natural language processing as an alternative to traditional qualitative methods, particularly when analyzing large data sets. Topic modeling can be leveraged to reveal underlying themes within the data with minimal manpower and time availability; further, this method can be used in near real-time, facilitating timely response by public health officials and other personnel addressing the infodemic. The results of this study illustrate the potential of this approach to identify and classify misinformation and facilitate the development of evidence-based interventions to counteract the spread of false information. Topic modeling could be implemented in public health programs and utilized to conduct real-time monitoring of public discourse around relevant health topics, leading to a more insightful and timely response. Similar methods may also provide insights into other issues relevant to health agencies including audience characterization or campaign performance (Golos et al., 2023). Future studies may strengthen the evidence base for using natural language processing in infodemic response by applying alternative models, such as sentiment analysis, social network analysis, or cluster analysis. Additionally, further analysis of sub-populations (including those most at risk) is needed to identify trends in misinformation within those cohorts.

2.6 Acknowledgements

I would like to thank my committee members for their unwavering support and dedication to this project. Thank you to Lydia Stark for your help and assistance with the initial data processing, your help was essential to completing this study.

2.7 Conflicts of Interest

The authors declare that they have no conflicts of interest.

2.8 Author Contributions

Data collection was completed by J.A.M. and the Alaska Public Health Information Response Team. Data preprocessing was completed by E.K.M. and L.R.S. E.K.M. and R.D.P. conceived of the present manuscript and analyses, analyzed the data, and drafted the manuscript.

A.J.R., J.A.M., R.D.P., and T.E.H. provided critical revisions to the manuscript. All authors contributed to the design of the study.

Tuula E. Hollmen

College of Fisheries and Ocean Sciences, University of Alaska-Fairbanks and Alaska SeaLife Center, Seward, AK, U.S.A.

Jennifer A. Meyer

College of Health, University of Alaska Anchorage, Anchorage, AK, USA.

R. David Parker

Yukon-Kuskokwim Health Corporation, Anchorage, AK, USA.

Arleigh J. Reynolds

Sitka Sound Science Center, Sitka, AK, USA.

Lydia R. Stark

University of Alaska Anchorage, Anchorage, AK, USA.

2.9 Sources of Support

This material was also supported in part by the University of Alaska Fairbanks Office of the Vice Chancellor for Research Graduate Student Support Fund, the University of Alaska Fairbanks Graduate School Travel Award and Degree Completion Award, Alaska EPSCoR NSF award #OIA-1757348 and the state of Alaska. This material is also supported in part by the National Science Foundation Arctic Section Doctoral Dissertation Research Improvement Grant Program under Grant No. 2309906. The contents of this article are solely the responsibility of the authors and do not necessarily represent the official views of the NSF or anyone else.

2.10 Data Availability

To access data used for this manuscript, please contact the first author.

2.11 References

Abram, M. D., Mancini, K. T., & Parker, R. D. (2020). Methods to Integrate Natural Language Processing Into Qualitative Research. *International Journal of Qualitative Methods*, *19*, 160940692098460. https://doi.org/10.1177/1609406920984608

America Counts Staff. (2021, August 25). *Alaska: 2020 Census*. https://www.census.gov/library/stories/state-by-state/alaska-population-change-between-census-decade.html

Bafna, P. B., & Saini, J. R. (2020). Marathi Text Analysis using Unsupervised Learning and Word Cloud. *International Journal of Engineering and Advanced Technology*, *9*(3), 338–343. https://doi.org/10.35940/ijeat.C4727.029320

Buenano-Fernandez, D., Gonzalez, M., Gil, D., & Lujan-Mora, S. (2020). Text Mining of Open-Ended Questions in Self-Assessment of University Teachers: An LDA Topic Modeling Approach. *IEEE Access*, *8*, 35318–35330. https://doi.org/10.1109/ACCESS.2020.2974983

Çallı, L., & Çallı, F. (2023). Understanding Airline Passengers during COVID-19 Outbreak to Improve Service Quality: Topic Modeling Approach to Complaints with Latent Dirichlet Allocation Algorithm. *Transportation Research Record: Journal of the Transportation Research Board*, *2677*(4), 656–673. https://doi.org/10.1177/03611981221112096

Canini, K., Shi, L., & Griffiths, T. (2009). Online Inference of Topics with Latent Dirichlet Allocation. In D. van Dyk & M. Welling (Eds.), *Proceedings of the Twelth International Conference on Artificial Intelligence and Statistics* (Vol. 5, pp. 65–72). PMLR. https://proceedings.mlr.press/v5/canini09a.html

Centers for Disease Control and Prevention. (2023). *CDC Museum COVID-19 Timeline*. https://www.cdc.gov/museum/timeline/COVID19.html

Cheng, X., Cao, Q., & Liao, S. S. (2022). An overview of literature on COVID-19, MERS and SARS: Using text mining and latent Dirichlet allocation. *Journal of Information Science*, *48*(3), 304–320. https://doi.org/10.1007/s42001-022-00173-9

Danesh, F., Dastani, M., & Ghorbani, M. (2021). Retrospective and prospective approaches of coronavirus publications in the last half-century: a Latent Dirichlet allocation analysis. *Library Hi Tech*, *39*(3), 855–872. https://doi.org/10.1108/LHT-09-2020-0216

DiMaggio, P. (2015). Adapting computational text analysis to social science (and vice versa). *Big Data & Society*, *2*(2), 205395171560290. https://doi.org/10.1177/2053951715602908

Eichelberger, L., Dev, S., Howe, T., Barnes, D. L., Bortz, E., Briggs, B. R., Cochran, P., Dotson, A. D., Drown, D. M., Hahn, M. B., Mattos, K., & Aggarwal, S. (2021). Implications of inadequate water and sanitation infrastructure for community spread of COVID-19 in remote Alaskan communities. *Science of The Total Environment*, *776*, 145842. https://doi.org/10.1016/j.scitotenv.2021.145842

Eysenbach, G. (2002). Infodemiology: the epidemiology of (mis)information. *The American Journal of Medicine*, *113*(9), 763–765. https://doi.org/10.1016/S0002-9343(02)01473-0

Gladstone Institutes. (2022, March 18). *Milestones in the COVID-19 Pandemic*. https://gladstone.org/news/milestones-COVID-19-pandemic?gclid=CjwKCAjw-eKpBhAbEiwAqFL0miDQgQxplZ3hZ3f4Wwr0QwPT728Q9I13cQ7bdD404iYMjKffJiN4YhoCzS0QAvD_BwE

Golos, A. M., Guntuku, S. C., Piltch-Loeb, R., Leininger, L. J., Simanek, A. M., Kumar, A., Albrecht, S. S., Dowd, J. B., Jones, M., & Buttenheim, A. M. (2023). Dear Pandemic: A topic modeling analysis of COVID-19 information needs among readers of an online science communication campaign. *PLOS ONE*, *18*(3), e0281773. https://doi.org/10.1371/journal.pone.0281773

Hannigan, T. R., Haans, R. F. J., Vakili, K., Tchalian, H., Glaser, V. L., Wang, M. S., Kaplan, S., & Jennings, P. D. (2019). Topic Modeling in Management Research: Rendering New Theory from Textual Data. *Academy of Management Annals*, *13*(2), 586–632. https://doi.org/10.5465/annals.2017.0099

Herz, N. (2020, November 20). Alaska's geography poses unique challenge in getting COVID-19 vaccine, treatments to rural areas. *Alaska Public Media*. https://alaskapublic.org/2020/11/20/alaskas-geography-poses-unique-challenge-in-getting-covid-19-vaccine-treatments-to-rural-areas/

Hollander, Z. (2020, July 27). Two new COVID-19 deaths tied to rural Alaska. *Anchorage Daily News*. https://www.adn.com/alaska-news/2020/07/27/coronavirus-infections-reported-in-rural-alaska-are-most-recent-to-prove-fatal/

Kim, L., Fast, S. M., & Markuzon, N. (2019). Incorporating media data into a model of infectious disease transmission. *PLOS ONE*, *14*(2), e0197646. https://doi.org/10.1371/journal.pone.0197646

LaVeist, T. A. (2005). Disentangling Race and Socioeconomic Status: A Key to Understanding Health Inequalities. *Journal of Urban Health: Bulletin of the New York Academy of Medicine*, *82*(2_suppl_3), iii26–iii34. https://doi.org/10.1111%2Fj.1475-6773.2009.01017.x

Maxwell, E. K. (2024). Exploring the COVID-19 Infodemic in Alaska. In University of Alaska, Fairbanks.

Meyer, J., Chavez Mapaye, J., Edwards, A., Hennessy, T., Hinterberger, T., & Ryan, M. (2022). Addressing Health Misinformation in the Infodemic Era: The Alaska Public Health Misinformation Response Team. In A. Keselman, A. J. Wilson, & C. Arnott Smith (Eds.), *Combating Online Health Misinformation A Professional's Guide to Helping the Public*. Rowman & Littlefield Publishers.

Mitchell, A., & Shearer, E. (2021). *News Use Across Social Media Platforms in 2020*. https://www.pewresearch.org/short-reads/2021/08/24/about-four-in-ten-americans-say-social-media-is-an-important-way-of-following-covid-19-vaccine-news/

Oyeyemi, S. O., Gabarron, E., & Wynn, R. (2014). Ebola, Twitter, and misinformation: a dangerous combination? *BMJ*, *349*(oct14 5), g6178–g6178. https://doi.org/10.1136/bmj.g6178

Parkinson, A. J., Evengard, B., Semenza, J. C., Ogden, N., Børresen, M. L., Berner, J., Brubaker, M., Sjöstedt, A., Evander, M., Hondula, D. M., Menne, B., Pshenichnaya, N., Gounder, P., Larose, T., Revich, B., Hueffer, K., & Albihn, A. (2014). Climate change and infectious diseases in the Arctic: establishment of a circumpolar working group. *International Journal of Circumpolar Health*, *73*(1), 25163. https://doi.org/10.3402/ijch.v73.25163

Pluviano, S., Watt, C., Pompéia, S., Ekuni, R., & Della Sala, S. (2022). Forming and updating vaccination beliefs: does the continued effect of misinformation depend on what we think we know? *Cognitive Processing*, *23*(3), 367–378. https://doi.org/10.1007/s10339-022-01093-2

Purnat, T. D., Vacca, P., Czerniak, C., Ball, S., Burzo, S., Zecchin, T., Wright, A., Bezbaruah, S., Tanggol, F., Dubé, È., Labbé, F., Dionne, M., Lamichhane, J., Mahajan, A., Briand, S., & Nguyen, T. (2021). Infodemic Signal Detection During the COVID-19 Pandemic: Development of a Methodology for Identifying Potential Information Voids in Online Conversations. *JMIR Infodemiology*, *1*(1), e30971. https://doi.org/10.2196/30971

Python Software Foundation. (2023). *Python Language Reference version 3.12.0*. http://www.python.org

Rae, A. (2014). Trend Analysis. In *Encyclopedia of Quality of Life and Well-Being Research* (pp. 6736–6736). Springer Netherlands. https://doi.org/10.1007/978-94-007-0753-5_3062

Rantanen, M., Karpechko, A. Yu., Lipponen, A., Nordling, K., Hyvärinen, O., Ruosteenoja, K., Vihma, T., & Laaksonen, A. (2022). The Arctic has warmed nearly four times faster than the globe since 1979. *Communications Earth & Environment*, *3*(1), 168. https://doi.org/10.1038/s43247-022-00498-3

Shibu, A. M., & Khandekar, A. (2022, January 24). U.S. FDA limits use of Regeneron, Lilly COVID-19 antibody treatments. *Reuters*. https://www.reuters.com/business/healthcare-pharmaceuticals/us-fda-restrict-use-regeneron-lilly-covid-antibody-drugs-wapo-2022-01-24/

State of Alaska Department of Health and Social Services. (2022). *COVID-19 Vaccination Dashboard*. State of Alaska Department of Health and Social Services. https://experience.arcgis.com/experience/a7e8be4adbe740a1bad1393894ee4075/

Weiland, N., & Robbins, R. (2022, January 4). Biden Administration to Increase Supply of 'Game Changer' Pfizer Pill. *New York Times*. https://www.nytimes.com/2022/01/04/us/politics/biden-pfizer-pill-order.html#:~:text=Biden%20Administration%20to%20Increase%20Supply,been%20shown%20to%20reduce%20hospitalizations.

Weiss, L. (2022, January 20). Alaska's COVID Misinformation SWAT Team. *Anchorage Press*.

World Health Organization. (2021, January). *Early AI-supported Response with Social Listening*. https://www.who.int/news-room/feature-stories/detail/who-launches-pilot-of-ai-powered-public-access-social-listening-tool

World Health Organization. (2021). *Infodemic Management: An Overview of Infodemic Management During COVID-19*. https://www.who.int/publications/i/item/9789240035966

Xie, R., Chu, S. K. W., Chiu, D. K. W., & Wang, Y. (2021). Exploring Public Response to COVID-19 on Weibo with LDA Topic Modeling and Sentiment Analysis. *Data and Information Management*, *5*(1), 86–99. https://doi.org/10.2478/dim-2020-0023

Xue, J., Chen, J., Chen, C., Zheng, C., Li, S., & Zhu, T. (2020). Public discourse and sentiment during the COVID 19 pandemic: Using Latent Dirichlet Allocation for topic modeling on Twitter. *PLOS ONE*, *15*(9), e0239441. https://doi.org/10.1371/journal.pone.0239441

Chapter 3: Combatting Vaccine Hesitancy with a Brief Educational Intervention: A Randomized Controlled Trial

3.1 Abstract

Background: Vaccine hesitancy is one of the principal causes behind decreasing vaccination rates in the United States. Many factors can contribute to vaccine hesitancy, including misinformation, lack of trust in institutions, cultural or religious beliefs, personal experience, and social pressures. Public health practitioners have proposed educational campaigns, healthcare provider communications training, motivational interviewing, and other interventions to increase vaccine uptake, with varying degrees of success. Objectives: We aim to conduct a secondary analysis to evaluate the effectiveness of a brief educational intervention in lowering vaccine hesitancy. Design: This manuscript represents a secondary analysis of existing data, which was collected through an online, randomized controlled trial survey with 1,015 respondents. Methods: The survey included a control and three experimental arms; the baseline survey was administered as the control. The experimental arms included the baseline survey plus one of three brief educational interventions. Results: Descriptive analysis revealed that each of the interventions resulted in lower VHCS (vaccine hesitancy composite score) amongst respondents with lower educational attainment ("technical training certificate" and "high school diploma or GED"). Conversely, the VHCS of liberal respondents with higher educational attainment increased with all three interventions. Further analysis showed the annotated list of vaccine years of approval resulted in lower vaccine hesitancy scores when accounting for political orientation and educational level. This study illustrates that interventions may be effective in specific subpopulations and have the opposite effect in others and supports highly targeted audience segmentation method as a best practice when developing protocols to lower vaccine hesitancy.

3.2 Introduction

Vaccines are widely considered one of the most remarkable achievements in public health, with their profound impact demonstrated throughout history. Since the 20th century, vaccines have led to a 90% reduction in the prevalence of ten devastating diseases, including paralytic Poliomyelitis, Diphtheria, and Smallpox (Orenstein & Ahmed, 2017). Just one year of routine childhood immunizations in the United States have prevented an estimated 40,000 deaths and 20 million cases of illness while generating an economic benefit of nearly $69 billion (Zhou

et al., 2014). Nevertheless, 2022 witnessed the most significant decline in global childhood immunization rates in thirty years, according to the WHO and UNICEF (United Nations International Children's Emergency Fund/World Health Organization, 2022). The percentage of children receiving the three-dose diphtheria, tetanus, and pertussis (DTP3) vaccine dropped by five percentage points from 2019 to 81% (United Nations International Children's Emergency Fund/World Health Organization, 2022). A similar trend is observable with adolescent vaccines for preventing invasive meningococcal disease; approximately half were delayed during the COVID-19 pandemic (Tan et al., 2023). Annual influenza immunization rates in the United States have mirrored the patterns seen in COVID-19 vaccination; states with below-average COVID-19 vaccination rates experienced a 4.5 percentage point drop in flu vaccination rates, whereas states with above-average COVID-19 vaccination rates saw an increase of 3.8 percentage points (Leuchter et al., 2022).

Childhood vaccination rates in Alaska have consistently lagged behind the national average. In 2018, coverage of the 7-vaccine series (DTaP/DT/Td, HIB, Polio, Hep-B, MMR, Varicella, and PCV) was 64% in Alaska compared to nearly 70% in the United States (Aho & Pletnikoff, 2023). This gap widened during the COVID-19 pandemic; Alaska's rates dropped to 51% by December 2021, while the United States average remained steady at 70% (Aho & Pletnikoff, 2023). While Alaska's geography compounds some barriers to vaccination (financial constraints, transportation challenges, and limited access to healthcare), vaccine hesitancy remains one of the principal drivers behind declining immunization rates in Alaska (Aho & Pletnikoff, 2023).

The World Health Organization (WHO) defines vaccine hesitancy as "a motivational state of being conflicted about, or opposed to, getting vaccinated; this includes intentions and willingness" (World Health Organization, 2022). The reasons behind vaccine hesitancy are multifaceted and diverse, ranging from safety concerns to a lack of knowledge, religious or cultural beliefs, or vaccine-specific factors (Azarpanah et al., 2021). Recent studies indicate that hesitancy towards the COVID-19 vaccine is strongly associated with a perceived lower risk of the virus, the belief that COVID-19 is not a severe illness, and concerns regarding the vaccine's development timeline (Lazarus et al., 2022; Okubo et al., 2021; Soares et al., 2021). Individuals often have multiple, shifting reasons for vaccine refusal; further, being hesitant toward one vaccine does not necessarily imply hesitancy toward all vaccines (Peters, 2022). In any case, the

proliferation of misinformation, particularly online, has exacerbated vaccine hesitancy, which became distinctly evident during the COVID-19 pandemic (Pierri et al., 2022).

Researchers have conducted numerous studies investigating vaccine hesitancy in high-income countries like the United States (Kweon et al., 2022; Okubo et al., 2021; Romate et al., 2022; Soares et al., 2021), but Alaska's unique geographic and socioeconomic factors set it apart from the rest of the country. Many Alaskan communities are not accessible by road and have limited access to medical facilities and adequate sanitation infrastructure (Eichelberger et al., 2021). In 2021, the state's chief medical officer emphasized the problem of misinformation in the state and its impact on individuals' ability to make informed decisions about their health (Zink, 2021).

This study's secondary analysis of a randomized controlled trial, consisting of a four-arm survey, assessed the effectiveness of brief written interventions in measuring vaccine hesitancy amongst Alaska adults. A secondary outcome identified the demographic characteristics associated with higher vaccine hesitancy scores. The data presented here are part of a dual-phase project designed to investigate vaccine hesitancy in Alaska. This manuscript represents a secondary analysis of existing data.

3.3 Methods

3.3.1 Research Context

This is a follow-up study to a 2022 study in which a random sample of Alaskan adults were surveyed to determine factors associated with vaccine hesitancy and acceptance in Alaska (Parker & Meyer, 2023). In addition to demographics, the survey included six questions regarding vaccine hesitancy, the responses to which produced a pilot metric for vaccine hesitancy. Statistically higher vaccine hesitancy scores existed among individuals who identify themselves as politically conservative, those below the age of forty-nine, individuals with a high school education as their highest level of attainment, and those who identify as religious (Parker & Meyer, 2023). The broad spectrum of scores suggested that vaccine hesitancy is a multifaceted phenomenon that requires customized public health interventions to effectively tackle the underlying factors.

When asked about specific vaccines, the COVID-19 vaccine garnered the lowest level of trust, while some individuals who expressed concerns about the safety of the COVID-19 vaccine

considered other vaccines as safe, indicating that individuals harboring doubts about the safety of the COVID-19 vaccine may maintain confidence in the safety of other vaccines. Additionally, this study uncovered nuances in vaccine hesitancy within subgroups (i.e., outliers amongst liberals and moderates), suggesting that these populations may need alternative interventions. Considering these findings, an opportunity arose for an assessment evaluating the effectiveness of a brief educational intervention in altering perceptions of vaccine safety amongst Alaskans.

3.3.2 Study population

R.D.P and J.A.M. designed the survey and conducted the data collection for this manuscript. The study population consisted of survey participants (n= 1015) aged at least 18 years, who lived in Alaska at the time of the study, and who read English. To achieve predetermined conditions (power of 0.90, effect size of 0.10, and significance level of .05) for multiple linear regression with six predictors, a priori power analysis determined a sample size of 164 individuals was sufficient per arm of the study for a total of 656. However, to achieve a representative sample across the highly diverse population in Alaska, a sample size of 1,000 was selected.

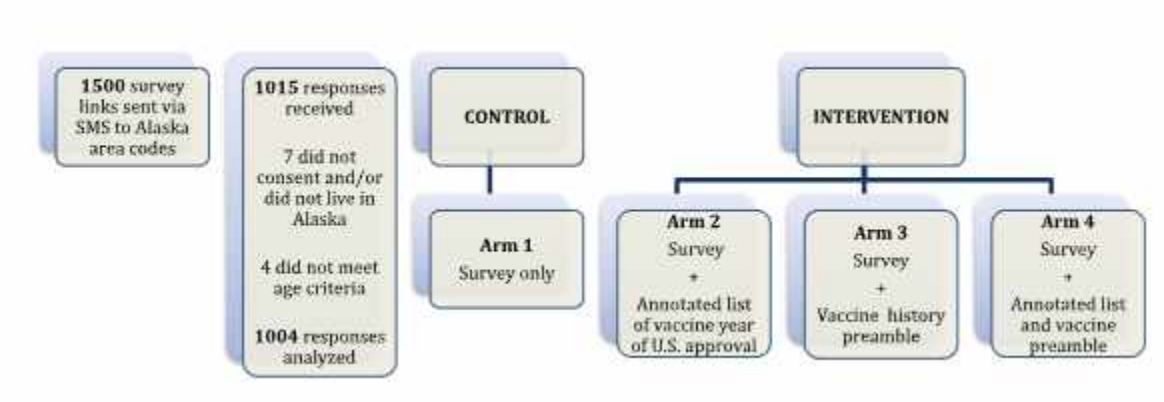
3.3.3. Data collection

R.D.P and J.A.M developed a 20-point online survey with randomization to one of four groups using Qualtrics software (version XM), licensed by the institution. These groups were: survey only (Control), survey with a preamble about the history of vaccines (Arm 1), survey with an annotated list of U.S. vaccine approval year (Arm 2); and survey with both preamble and annotated list (Arm 4) (see Figure 3.1). A private company distributed the survey to an established pool of individuals who have agreed to consider research participation.

In the control arm, participants received the 20-question survey, which included ten demographic questions, three questions determining influenza and COVID-19 vaccine status, one question about vaccine mandate exemptions in school, and six vaccine hesitancy composite score (VHCS) input questions. In the second arm, participants received an identical survey, but the year of U.S. approval was listed adjacent to each possible answer for question 19 ("Which vaccines do you believe are safe? (check all that apply"); arm three was identical to arm one, but a 338-word preamble providing a summary of the history of vaccine development was placed

directly after the demographic questions and before all other questions; arm four was identical to arm one but with the both the annotated list and the preamble. Demographic questions included: year of birth, sex (male, female, other, decline to answer), race (Alaska Native/American Indian, Black, White, Asian or Pacific Islander, other, decline to answer), highest level of education (less than high school, high school diploma or GED, technical training certificate, some college, associate's degree, bachelor degree, graduate degree, decline to answer), political orientation (conservative, liberal, moderate, not political, other, decline to answer), type of health insurance or coverage (select all: Indian Health Service, Medicaid, Medicare, private health insurance, veteran's benefits, uninsured, decline), employment status (select all: full time, part-time, not employed in the paid workforce, retired, disabled, decline to answer), do you consider yourself a religious person (yes, no, decline to answer), home zip code, and were you born in Alaska (yes, no, decline to answer).

Figure 3.1: Participant enrollment workflow.



(Maxwell, 2024)

The University of Alaska Anchorage institutional review board approved this study (Protocol #2025127-4) as exempt due to its minimal risk nature and the collection of minimal potentially identifiable data. Following data collection, the latitude, longitude, zip code, and IP address information were removed to ensure privacy and anonymity.

3.3.4 Data analysis

We imported the raw data into Excel (version 2307) for preliminary cleaning, including removing zip codes and ID columns and transforming data into tidy format. Once complete, we

imported the data into R (version 4.2.1) and performed additional cleaning. Several demographic variables were collapsed and recoded for descriptive analysis due to small numbers, including educational attainment ("Less than high school" and "Decline to answer" collapsed to "NA" [*n* 16 combined]), political orientation ("Decline to answer" collapsed to "NA" [n 28], "Other" and "Not political" collapsed to "Other/not political"), race ("Asian or Pacific Islander" [*n* 28] and "Black" [*n* 11] combined to "Other" and "Decline to answer" [*n* 24] collapsed to "NA" and influenza vaccine uptake, COVID-19 vaccine uptake and COVID-19 booster uptake ("Decline to answer" collapsed to "NA". Likert variables "I trust medical providers when recommending vaccines for adults [18 years or older]" and "I trust medical providers recommending vaccines for children [under 18 years of age]" were coded 1 "Strongly agree" to 5 "Strongly disagree" and Likert variables "All vaccines contain dangerous chemicals" and "It is better to develop immunity by getting sick, rather than getting a vaccine" were reverse coded. The variable "To protect all children, teachers, and staff, state-mandated vaccines should be required in public schools" was recoded: "Yes" to "2", "No" to "1", and "Decline to answer" to "NA". For variable "Which vaccines do you believe are safe? (check all that apply)" the checked vaccines were summed into a score from 0-10 and subsequently reverse coded. Finally, the variable "I have been vaccinated against COVID" was recoded: "Yes" to "1", "No" to "0", and "Decline to answer" to "NA". Overall missingness in the dataset was .18%; due to negligible missingness, "NA" responses were imputed and recoded to "Decline to answer".

We used the responses to the following six questions to create a vaccine hesitancy composite score with a scale of 4-32 (most vaccine-hesitant): "All vaccines contain dangerous chemicals", "I trust medical providers when they recommend vaccines for all adults (persons aged over 18)", "I trust medical providers when they recommend vaccines for children (persons aged under 18)", "To protect all children, teachers, and staff, state-mandated vaccines should be required in public schools", "It is better to develop immunity by getting sick, rather than getting a vaccine", and "Which of the following vaccines are safe (check all that apply)". The questions included in the survey were chosen based on a prior literature review on vaccine hesitancy and the results of the first iteration of the VHCS by Parker & Meyer (Parker & Meyer, 2023). Refinement of the VHCS continues and it has not been externally validated as a measure for vaccine hesitancy. Based on the previous study's findings, we aimed to measure vaccine hesitancy without the influence of COVID-19 vaccination status and, therefore, did not include it

in the VHCS. Additionally, internal consistency of the VHCS (measured by Cronbach's alpha (Cronbach, 1951) decreased when COVID-19 vaccination status was included in the score (*a* 0.752 with COVID-19 vaccination status, α 0.807 without COVID-19 vaccination status). We also included a final question at the end of the survey to assess respondents' opinions on exemptions for school vaccine mandates but decided not to include the question as input for the VHCS so we could measure its association with vaccine hesitancy independently. Given the known positive relationship between school mandates and childhood vaccination uptake in the United States (Lee & Robinson, 2016), we wanted to identify which exemptions were favored.

The distribution of the VHCS did not meet the normality condition for parametric testing (per Shapiro-Wilk test (Shapiro & Wilk, 1965)), so we conducted bivariate analyses between covariates (demographics and the survey trial arm variable) and the VHCS using Kruskal-Wallis tests (Kruskal & Wallis, 1952) followed by post hoc Dunn's tests (Dinno, 2015) for variables with statistically significant results. Covariates included age, sex, annual household income, education attainment, race, religious status, political orientation, whether respondents were born in Alaska, and whether respondents had received at least one COVID-19 vaccine. We evaluated the extreme values in VHCS score differences and verified that they were valid; therefore, we included them in the analysis. We then used a modified backward stepwise approach on a multivariate linear regression to control for potential confounding variables and to identify the most significant predictors of the outcome variable (VHCS). The model was adjusted using the weighted least squares method, which was employed to address heteroscedasticity in the model per the Breusch-Pagan test (Breusch & Pagan, 1979) and residual plots. We chose the best fitting model based on Akaike Information Criteria (AIC) and the adjusted r^2. We then conducted ANOVA tests (Girden, 1992) and Tukey's post hoc tests (Keselman & Rogan, 1977) to further investigate our findings.

3.4 Results

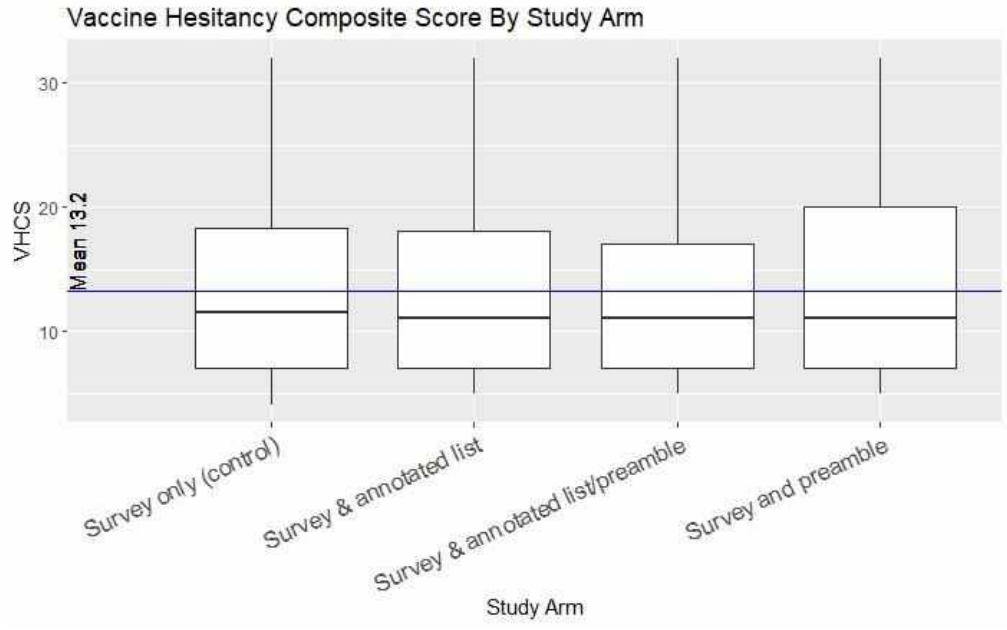
The survey had a 67.7% response rate with 1,015 of 1,500 links sent). We removed seven responses due to non-consent and/or not living in Alaska and three responses due to age under 18 (the age variable was calculated using the date of birth), leaving a total of 1,005 responses.

3.4.1 Description of the sample population

Approximately half of the respondents (50.5%, n = 508) were men, ages 18 to 87 (median = 49.0, mean = 49.4). The largest racial groups represented in the sample included 12.3% (n = 124) Alaska Native or American Indian, 77.4% (n = 776) white, and 4.1% (n = 41) "other". "Some college" was the most frequent education level (29.1% (n = 292). “Moderate” was the most prominent political orientation represented (32.2%, n = 324), followed by conservative (29.3%, n = 294), and liberal (20.4%, n = 205). Table 3.1 displays the complete demographics of the sample by study arm.

The VHCS was calculated for 97.91% of the dataset (n = 984), with scores ranging from 4 to 32 (mean = 13.2, median = 11.0). Table 3.1 shows the VHCS by study arm, with means varying slightly across arms: (control ($\bar{x}$ = 13.2), survey with an annotated list of vaccine approval year ($\bar{x}$ = 13.4), survey with preamble ($\bar{x}$ = 13.6), and survey with preamble and annotated list ($\bar{x}$ = 12.6), however these differences were not statistically significant (p = 0.39) (see Figure 3.2).

Figure 3.2: VHCS by study arm showing mean, standard deviation and extremes.



(Maxwell, 2024)

Table 3.1: Demographic overview of participants (n = 1,005).

Demographics	Survey & annotated list (N=255)	Survey & annotated list/preamble (N=250)	Survey and preamble (N=240)	Survey only (control) (N=260)	Overall (N=1005)
Age					
Mean (SD)	49.1 (16.7)	49.8 (17.0)	49.6 (15.7)	49.0 (15.9)	49.4 (16.3)
Median [Min, Max]	47.0 [20.0, 83.0]	49.0 [20.0, 87.0]	51.0 [18.0, 81.0]	50.0 [19.0, 87.0]	49.0 [18.0, 87.0]
Sex					
Male	123 (48.2%)	121 (48.4%)	135 (56.3%)	129 (49.6%)	508 (50.5%)
Female	131 (51.4%)	128 (51.2%)	103 (42.9%)	130 (50.0%)	492 (49.0%)
Declined	1 (0.4%)	1 (0.4%)	2 (0.8%)	1 (0.4%)	5 (0.5%)
Race					
White	206 (80.8%)	198 (79.2%)	182 (75.8%)	192 (73.8%)	778 (77.4%)
AN/AI	23 (9.0%)	25 (10.0%)	30 (12.5%)	46 (17.7%)	124 (12.3%)
API	6 (2.4%)	8 (3.2%)	8 (3.3%)	6 (2.3%)	28 (2.8%)
Black	4 (1.6%)	1 (0.4%)	3 (1.3%)	3 (1.2%)	11 (1.1%)
Declined	6 (2.4%)	6 (2.4%)	6 (2.5%)	5 (1.9%)	23 (2.3%)
Other	10 (3.9%)	12 (4.8%)	11 (4.6%)	8 (3.1%)	41 (4.1%)

Table 3.1 (cont.)

Educational attainment					
Less than high school	4 (1.6%)	2 (0.8%)	6 (2.5%)	2 (0.8%)	14 (1.4%)
High school or GED	35 (13.7%)	44 (17.6%)	44 (18.3%)	45 (17.3%)	168 (16.7%)
Technical Training Certificate	11 (4.3%)	15 (6.0%)	16 (6.7%)	10 (3.8%)	52 (5.2%)
Some college	77 (30.2%)	73 (29.2%)	68 (28.3%)	74 (28.5%)	292 (29.1%)
Associate's Degree	30 (11.8%)	16 (6.4%)	26 (10.8%)	33 (12.7%)	105 (10.4%)
Bachelor's Degree	60 (23.5%)	50 (20.0%)	46 (19.2%)	63 (24.2%)	219 (21.8%)
Graduate Degree	38 (14.9%)	49 (19.6%)	32 (13.3%)	33 (12.7%)	152 (15.1%)
Declined	0 (0%)	1 (0.4%)	2 (0.8%)	0 (0%)	3 (0.3%)
Annual Income					
< $20,000	16 (6.3%)	15 (6.0%)	19 (7.9%)	18 (6.9%)	68 (6.8%)
20,001 - 30,000	14 (5.5%)	15 (6.0%)	14 (5.8%)	18 (6.9%)	61 (6.1%)
30,001 - 40,000	18 (7.1%)	15 (6.0%)	14 (5.8%)	20 (7.7%)	67 (6.7%)
40,001 - 50,000	17 (6.7%)	18 (7.2%)	13 (5.4%)	18 (6.9%)	66 (6.6%)
50,001 - 60,000	20 (7.8%)	11 (4.4%)	13 (5.4%)	11 (4.2%)	55 (5.5%)
60,001 - 70,000	24 (9.4%)	21 (8.4%)	16 (6.7%)	18 (6.9%)	79 (7.9%)

Table 3.1 (cont.)

70,001 - 80,000	9 (3.5%)	23 (9.2%)	22 (9.2%)	19 (7.3%)	73 (7.3%)
80,001 - 90,000	13 (5.1%)	13 (5.2%)	19 (7.9%)	14 (5.4%)	59 (5.9%)
90,001 - 100,000	24 (9.4%)	22 (8.8%)	24 (10.0%)	23 (8.8%)	93 (9.3%)
100,001+	97 (38.0%)	97 (38.8%)	82 (34.2%)	101 (38.8%)	377 (37.5%)
Missing	3 (1.2%)	0 (0%)	4 (1.7%)	0 (0%)	7 (0.7%)
Political orientation					
Conservative	75 (29.4%)	72 (28.8%)	80 (33.3%)	67 (25.8%)	294 (29.3%)
Liberal	47 (18.4%)	66 (26.4%)	40 (16.7%)	52 (20.0%)	205 (20.4%)
Moderate	83 (32.5%)	75 (30.0%)	79 (32.9%)	87 (33.5%)	324 (32.2%)
Not political	26 (10.2%)	20 (8.0%)	24 (10.0%)	34 (13.1%)	104 (10.3%)
Declined	8 (3.1%)	8 (3.2%)	7 (2.9%)	5 (1.9%)	28 (2.8%)
Other	16 (6.3%)	9 (3.6%)	10 (4.2%)	15 (5.8%)	50 (5.0%)
Born in Alaska					
No	163 (63.9%)	161 (64.4%)	156 (65.0%)	154 (59.2%)	634 (63.1%)
Yes	92 (36.1%)	87 (34.8%)	84 (35.0%)	106 (40.8%)	369 (36.7%)
Declined	0 (0%)	2 (0.8%)	0 (0%)	0 (0%)	2 (0.2%)

Table 3.1 (cont.)

Received at least one COVID vaccination					
Yes	191 (74.9%)	197 (78.8%)	177 (73.8%)	196 (75.4%)	761 (75.7%)
No	58 (22.7%)	51 (20.4%)	60 (25.0%)	60 (23.1%)	229 (22.8%)
Declined	6 (2.4%)	2 (0.8%)	2 (0.8%)	4 (1.5%)	14 (1.4%)

(Maxwell, 2024)

Subgroup analyses show that VHCS tended to decrease from the control arm to experimental arms only amongst respondents with lower educational attainment ("technical training certificate" and "high school diploma or GED"). The VHCS of respondents who identified as liberal and had higher educational attainment tended to *increase* with all three interventions, whereas moderates and conservatives had mixed results across interventions.

Through bivariate analysis, we identified significant differences in VHCS in five variables: religiosity, primary race, political orientation, educational attainment, and COVID-19 vaccination status. There were no significant differences in VHCS regarding age, gender, household income, employment status, and whether respondents were born in Alaska.

Political ideology was the strongest indicator of VHCS, with conservatives having the highest mean VHCS ($\bar{x}$ = 17.87) followed by other/not political ($\bar{x}$ = 15.99), moderates ($\bar{x}$ = 11.00), and liberals ($\bar{x}$ = 7.31). Having received a COVID-19 vaccination was an indicator of lower VHCS; those who had received a vaccine had a mean VHCS of 10.76 compared to 20.82 for those who had not. Mean VHCS decreased with additional formal education; respondents with a high school diploma or GED had a mean score of 16.03, followed by training/technical certificate ($\bar{x}$ = 14.15), some college ($\bar{x}$ = 14.00), associate's degree ($\bar{x}$ = 14.02), bachelor's degree ($\bar{x}$ = 11.06), and graduate degree ($\bar{x}$ = 10.03). Respondents who identified as religious scored a higher VHCS ($\bar{x}$ = 15.70) than those who did not ($\bar{x}$ = 10.80). We performed a multivariate linear regression model with the VHCS as the outcome and initially included six predictor variables, including the variables listed above as significant predictors and the study

arm. A backward stepwise process eliminated variables with *p*-values > .05, and the subsequent weighted model included five predictor variables (educational attainment with high school or GED as referent, political orientation with conservative as referent, religiosity with religious affiliation as referent, COVID-19 vaccination status with no prior vaccine as referent, and study arm with the control as referent). The initial model had an AIC of 6007 and an adjusted r^2 .4687. Based on descriptive analyses showing differences in VHCS across arms when stratified by political orientation and educational attainment, we conducted ANOVA tests and Tukey's post hoc tests. These tests showed a significant difference between VHCS in the annotated year of approval study arm (*p* .011) and Tukey's test revealed the annotated list survey performed statistically poorer than other arms (*p* .018, which led us to collapse all other arms. A final model with the collapsed arm variable had an adjusted r^2 .6878 and AIC of 7071, explaining 68.78% of the variability in the data. A final ANOVA with the new model showed a statistically significant difference between arms when accounting for political orientation and education level (*p* .0132). Table 3.2) provides a summary of findings derived from the final model.

Table 3.2: Multiple regression findings on vaccine hesitancy and associated factors (n = 1,005). – indicates reference group.

Characteristic	**Beta**	**95% CI**[1]	**p-value**
Study Arm			
Other	—	—	
Annotated	0.37	-0.46, 1.2	0.4
Political orientation			
Conservative	—	—	

Table 3.2 (cont.)

Declined	-0.36	-2.7, 2.0	0.8
Liberal	-10	-11, -8.7	<0.001
Moderate	-6.8	-7.8, -5.7	<0.001
Other/not political	-0.78	-1.9, 0.36	0.2
Educational attainment			
HSE	—	—	
Associate's Degree	0.00	-1.4, 1.4	>0.9
Bachelor's Degree	-2.3	-3.5, -1.1	<0.001
Declined	-3.6	-10, 3.3	0.3
Graduate Degree	-2.8	-4.1, -1.4	<0.001
Some college	-0.09	-1.1, 0.94	0.9
Technical Training Certificate	-0.55	-2.5, 1.4	0.6
Religiosity			

Table 3.2 (cont.)

Yes	—	—	
No	-2.0	-2.8, -1.1	<0.001
Received at least on COVID vaccination	-9.0	-9.9, -8.1	<0.001

[1] CI = Confidence Interval

[1] CI = Confidence Interval

(Maxwell, 2024)

Table 3.3 shows the overwhelming majority (90%) of respondents believed there should be some exemptions to vaccine mandates in public schools. Medical exemptions were the most accepted exemptions (62%), followed by parental freedom of choice (45%) and religious reasons (34%). Mean VHCS was highest amongst those in favor of parental freedom of choice exemptions and lowest amongst those not in favor of parental freedom of choice exemptions.

Table 3.3: Reasons for exemptions to vaccine mandates in school. *"Vaccine exemptions should be allowed in public schools for (check all that apply)".*

Documented medical reasons only		**Religious reasons**		**Parental freedom of choice**		**There should be no exemptions in public schools**		**Decline to answer**	
Yes (62%) (N=627)	**No** (38%) (N=377)	**Yes** (34%) (N=388)	**No** (66%) (N=616)	**Yes** (45%) (N=452)	**No** (55%) (N=552)	**Yes** (10%) (N=100)	**No** (90%) (N=904)	**Yes** (2%) (N=20)	**No** (98%) (N=984)

(Maxwell, 2024)

3.5 Discussion

In the months immediately following COVID-19 vaccine availability in the United States, Alaska was held up as a success story, leading the nation in vaccine coverage in early 2021 (Cirruzzo, 2021). However, by August 2023, only 14% of Alaskans had received an updated booster dose, making it the 36th most vaccinated state (Centers for Disease Control and

Prevention, 2023a). Recent qualitative and quantitative studies in Alaska have shown vaccine acceptance (or rejection) as a complex, highly variable decision-making process (Eichelberger et al., 2023; Hahn et al., 2022; Parker & Meyer, 2023). In this research, consistent with results from the preliminary study, VHCS spanned the full range of possible scores (4-32) and varied widely even within subgroups. Demographic associations with higher vaccine hesitancy mirrored findings in the previous iteration of the VHCS (Parker & Meyer, 2023) and extant literature; lower VHCS resulted in respondents with a graduate degree compared to those with a high school diploma or GED (β = -2.8; 95% CI: -4.1, -1.4; $p < .001$) and in those who identify as politically liberal compared to conservative (β = -10.0; 95% CI: -11.0, -8.7 ; $p < .001$). We also found that respondents who identified as non-religious were more likely to have a lower VHCS when compared to those who did (β = -2.0; 95% CI: -2.8, -1.1; $p < .001$) and, expectedly, respondents who had received a COVID-19 vaccine were more likely to have a lower vaccine hesitancy score compared to those who had not (β = -9.0; 95% CI: -9.9, -8.1; $p < .001$). Despite this strong association, we maintain that it is important to separate vaccination status from vaccine hesitancy, as vaccine apprehension may persist throughout the hesitancy spectrum, including among vaccinated individuals (Eichelberger et al., 2023).

Further analysis using ANOVA and Tukey's tests showed that the survey with the annotated list of years of vaccine approval was the only arm that performed significantly differently from the other arms. This arm was associated with significantly higher vaccine hesitancy scores, controlling for education, political orientation, religiosity and COVID vaccine status. In the raw scores, the data showed that within some subgroups, educational interventions were effective in lowering VHCS, namely amongst respondents with lower formal education attainment ("technical training certificate" and "high school diploma or GED"). VHCS were consistently lower in the intervention arms in this cohort, suggesting that similar written educational interventions may effectively decrease hesitancy in this population.

Interestingly, in some subgroups (liberal respondents with a bachelor's or graduate degree), intervention groups had *higher* VHCS than the control group. This suggests that within highly educated liberal populations, educational interventions may have the opposite of the desired effect and that vaccine belief perseverance (a phenomenon where "people maintain or even strengthen their beliefs and attitudes in response to disconfirming evidence" (Anglin, 2019, p. 176)) may be more prevalent in this population. Additionally, outliers were present at the

upper end of the VHCS distribution in respondents who identified as “liberal” and “moderate”, suggesting a subset of liberals and moderates do not conform with the majority (a finding which was not present in conservatives). These findings indicate a distinct subset of highly educated, politically liberal individuals who are less accepting of vaccines, and thus, further studies should be conducted to investigate what types of interventions may be more effective in this population.

As of the 2020-2021 school year, approximately 4.6% of kindergarteners in Alaska have vaccine exemptions (Seither et al., 2022). Alaska permits medical and religious exemptions for school and childcare vaccines and is not one of the fifteen states that allow philosophical exemptions. Medical exemptions must be signed by a medical professional (MD, DO, NP, or PA) and state that the immunization would be “injurious to the health” of the child or that the child has immunity to the pathogen (State of Alaska, 2017). Religious exemptions require a signed and notarized statement from the parent or guardian that immunization “conflicts with the tenets and practices of the church or religious denomination of which the applicant/parent/guardian is a member” (State of Alaska, 2013). To our knowledge, no available data describes the breakdown by type of exemption in Alaska. In this study, nearly two-thirds (62%) of respondents were in favor of allowing medical exemptions to vaccine mandates in schools, compared to only one-third (34%) in favor of religious exemptions and 45% in favor of parental freedom of choice (or philosophical) exemptions. As exemption rates continue to rise in Alaska (and the United States generally) (Seither et al., 2022), a multifaceted approach has been proposed to increase vaccine uptake, including more robust vaccine education, financial incentives by way of taxation and/or health insurance costs and changes to policy increasing the barriers to obtaining an exemption (though this may present ethical and administrative challenges) (Constable et al., 2014).

This study had several limitations. Recruitment for the study was through a company with established pools of individuals who had previously exhibited a willingness to engage in research opportunities. These participants may not be representative of the general population of Alaska, which led us to oversample as a correction. Additionally, our survey was only offered in the English language and was available through text message and internet access, excluding individuals who lacked access to these resources and/or did not speak English. Notably, internet access and mobile coverage are less likely to be available in the remote regions, which are home to 48% of the state’s Alaska Native/American Indian population as of 2010 (Fall, 2019).

Though substantial research analyzing the effectiveness of interventions to address vaccine hesitancy exists, this study provides insight into several enduring questions. Much of the existing research investigates changes in intention to vaccinate after interventions, while this study examines shifts in attitudes towards vaccination. This is an important distinction, as studies indicate that a change in attitude does not always precede a change in the decision to vaccinate (mandates, increased accessibility, and logistical interventions such as reminder calls are relatively effective in increasing uptake but are not likely to change attitudes) (Sadaf et al., 2013). This study shows that brief educational interventions may effectively shift vaccine perceptions among individuals without a college education. Additionally, these interventions may yield the opposite effect in highly educated liberal populations, prompting the need for further research on promising interventions for this group. Finally, while misinformation and lack of knowledge play a role in decision-making around vaccination, there is also a vital social component. Interpersonal interactions, past experiences, and individual personality each have considerable influence on vaccine attitudes (Eichelberger et al., 2023), none of which are impacted by educational interventions. However, this research suggests that highly targeted interventions are needed to reach the "movable middle" (Centers for Disease Control and Prevention, 2023b) and that further research is needed to determine which approaches are suitable for specific groups.

3.6 Acknowledgments

I would like to thank my committee members for their unwavering support and dedication to this project.

3.7 Conflicts of Interest

The authors declare that they have no conflicts of interest.

3.8 Author Contributions

R.D.P and J.A.M. conducted the preliminary study upon which this manuscript was based. All primary data collection of the data used in this manuscript was conducted by R.D.P and J.A.M. E.K.M. and R.D.P conceived of the present manuscript and analyses, analyzed the data, and drafted the manuscript. A.J.R., R.D.P., J.A.M., and T.E.H provided

critical revisions to the manuscript. All authors provided contributions to the conception and the design of the study.

Tuula E. Hollmen
College of Fisheries and Ocean Sciences, University of Alaska-Fairbanks and Alaska SeaLife Center, Seward, AK, U.S.A.
Jennifer A. Meyer
College of Health, University of Alaska Anchorage, Anchorage, AK, USA.
R. David Parker
Yukon-Kuskokwim Health Corporation, Anchorage, AK, USA.
Arleigh J. Reynolds
Sitka Sound Science Center, Sitka, AK, USA.

3.9 Supplementary Materials

See Appendix A for full vaccine hesitancy survey (annotated list of years of vaccines approval and preamble included).

3.10 Sources of Support

This material is based upon work supported in part by a grant from the Alaska Department of Health. This material was also supported in part by the University of Alaska Fairbanks Office of the Vice Chancellor for Research Graduate Student Support Fund, the University of Alaska Fairbanks Graduate School Travel Award and Degree Completion Award, Alaska EPSCoR NSF award #OIA-1757348 and the state of Alaska. This material is also supported in part by the National Science Foundation Arctic Section Doctoral Dissertation Research Improvement Grant Program under Grant No. 2309906. The contents of this article are solely the responsibility of the authors and do not necessarily represent the official views of the NSF or anyone else.

3.11 Data Availability

To access data used for this manuscript, please contact the first author.

3.12 References

Aho, S., & Pletnikoff, P. (2023). *Epidemiology Bulletin*. https://epi.alaska.gov/bulletins/docs/b2023_05.pdf

Anglin, S. M. (2019). Do beliefs yield to evidence? Examining belief perseverance vs. change in response to congruent empirical findings. *Journal of Experimental Social Psychology*, *82*, 176–199. https://doi.org/10.1016/j.jesp.2019.02.004

Azarpanah, H., Farhadloo, M., Vahidov, R., & Pilote, L. (2021). Vaccine hesitancy: evidence from an adverse events following immunization database, and the role of cognitive biases. *BMC Public Health*, *21*(1), 1686. https://doi.org/10.1186/s12889-021-11745-1

Breusch, T. S., & Pagan, A. R. (1979). A Simple Test for Heteroscedasticity and Random Coefficient Variation. *Econometrica, Econometric Society*, *47*(5), 1287–1294.

Centers for Disease Control and Prevention. (2023a, August 24). *COVID-19 Vaccinations in the United States*. COVID Data Tracker. https://covid.cdc.gov/covid-data-tracker/#datatracker-home

Centers for Disease Control and Prevention. (2023b, August 24). *What Is Vaccine Confidence?* Vaccines and Immunizations. https://www.cdc.gov/vaccines/covid-19/vaccinate-with-confidence.html#:~:text=Vaccinate%20with%20Confidence%20is%20the,diseases%20in%20the%20United%20States.

Cirruzzo, C. (2021, March 9). Alaska Leads COVID-19 Vaccination Efforts by Coordinating With Tribes and Receiving Territory Vaccine Allocations. *U.S. News & World Report*. https://www.usnews.com/news/best-states/articles/2021-03-09/q-a-how-alaska-is-leading-in-covid-19-vaccination-efforts#:~:text=Part%20of%20Alaska's%20success%20in,as%20its%20large%20veteran%20population.

Constable, C., Blank, N. R., & Caplan, A. L. (2014). Rising rates of vaccine exemptions: Problems with current policy and more promising remedies. *Vaccine*, *32*(16), 1793–1797. https://doi.org/10.1016/j.vaccine.2014.01.085

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*(3), 297–334. https://doi.org/10.1007/BF02310555

Dinno, A. (2015). Nonparametric Pairwise Multiple Comparisons in Independent Groups using Dunn's Test. *The Stata Journal: Promoting Communications on Statistics and Stata*, *15*(1), 292–300. https://doi.org/10.1177/1536867X1501500117

Eichelberger, L., Dev, S., Howe, T., Barnes, D. L., Bortz, E., Briggs, B. R., Cochran, P., Dotson, A. D., Drown, D. M., Hahn, M. B., Mattos, K., & Aggarwal, S. (2021). Implications of inadequate water and sanitation infrastructure for community spread of COVID-19 in remote Alaskan communities. *Science of The Total Environment*, *776*, 145842. https://doi.org/10.1016/j.scitotenv.2021.145842

Eichelberger, L., Hansen, A., Cochran, P., Hahn, M., & Fried, R. (2023). COVID-19 vaccine decision-making in remote Alaska between November 2020 and November 2021. *International Journal of Circumpolar Health*, *82*(1). https://doi.org/10.1080/22423982.2023.2242582

Fall, J. A. (2019). *Alaska Population Trends and Patterns, 1960–2018*. https://www.adfg.alaska.gov/static/home/library/pdfs/subsistence/Trends_in_Population_Summary_2019.pdf

Girden, E. (1992). *ANOVA*. SAGE Publications, Inc. https://doi.org/10.4135/9781412983419

Hahn, M. B., Fried, R. L., Cochran, P., & Eichelberger, L. P. (2022). Evolving perceptions of COVID-19 vaccines among remote Alaskan communities. *International Journal of Circumpolar Health*, *81*(1). https://doi.org/10.1080/22423982.2021.2021684

Keselman, H. J., & Rogan, J. C. (1977). The Tukey multiple comparison test: 1953–1976. *Psychological Bulletin*, *84*(5), 1050–1056. https://doi.org/10.1037/0033-2909.84.5.1050

Kruskal, W. H., & Wallis, W. A. (1952). Use of Ranks in One-Criterion Variance Analysis. *Journal of the American Statistical Association*, *47*(260), 583–621. https://doi.org/10.1080/01621459.1952.10483441

Kweon, S.-S., Yun, I., Choi, C., Ryu, S.-Y., Cho, J. H., & Shin, M.-H. (2022). Factors Associated with COVID-19 Vaccine Hesitancy in Korea. *Chonnam Medical Journal*, *58*(1), 43. https://doi.org/10.4068/cmj.2022.58.1.43

Lazarus, J. V., Wyka, K., White, T. M., Picchio, C. A., Rabin, K., Ratzan, S. C., Parsons Leigh, J., Hu, J., & El-Mohandes, A. (2022). Revisiting COVID-19 vaccine hesitancy around the world using data from 23 countries in 2021. *Nature Communications*, *13*(1), 3801. https://doi.org/10.1038/s41467-022-31441-x

Lee, C., & Robinson, J. L. (2016). Systematic review of the effect of immunization mandates on uptake of routine childhood immunizations. *Journal of Infection*, *72*(6), 659–666. https://doi.org/10.1016/j.jinf.2016.04.002

Leuchter, R. K., Jackson, N. J., Mafi, J. N., & Sarkisian, C. A. (2022). Association between COVID-19 Vaccination and Influenza Vaccination Rates. *New England Journal of Medicine*, *386*(26), 2531–2532. https://doi.org/10.1056/NEJMc2204560

Maxwell, E. K. (2024). Exploring the COVID-19 Infodemic in Alaska. In University of Alaska, Fairbanks.

Okubo, R., Yoshioka, T., Ohfuji, S., Matsuo, T., & Tabuchi, T. (2021). COVID-19 Vaccine Hesitancy and Its Associated Factors in Japan. *Vaccines*, *9*(6), 662. https://doi.org/10.3390/vaccines9060662

Orenstein, W. A., & Ahmed, R. (2017). Simply put: Vaccination saves lives. *Proceedings of the National Academy of Sciences*, *114*(16), 4031–4033. https://doi.org/10.1073/pnas.1704507114

Parker, R. D., & Meyer, J. A. (2023). Factors Associated with Vaccine Hesitancy in the State of Alaska. *Journal of Community Health*. https://doi.org/10.1007/s10900-023-01271-z

Peters, M. D. J. (2022). Addressing vaccine hesitancy and resistance for COVID-19 vaccines. *International Journal of Nursing Studies*, *131*, 104241. https://doi.org/10.1016/j.ijnurstu.2022.104241

Pierri, F., Perry, B. L., DeVerna, M. R., Yang, K.-C., Flammini, A., Menczer, F., & Bryden, J. (2022). Online misinformation is linked to early COVID-19 vaccination hesitancy and refusal. *Scientific Reports*, *12*(1), 5966. https://doi.org/10.1038/s41598-022-10070-w

Romate, J., Rajkumar, E., Gopi, A., Abraham, J., Rages, J., Lakshmi, R., Jesline, J., & Bhogle, S. (2022). What Contributes to COVID-19 Vaccine Hesitancy? A Systematic Review of the Psychological Factors Associated with COVID-19 Vaccine Hesitancy. *Vaccines*, *10*(11), 1777. https://doi.org/10.3390/vaccines10111777

Sadaf, A., Richards, J. L., Glanz, J., Salmon, D. A., & Omer, S. B. (2013). A systematic review of interventions for reducing parental vaccine refusal and vaccine hesitancy. *Vaccine*, *31*(40), 4293–4304. https://doi.org/10.1016/j.vaccine.2013.07.013

Seither, R., Laury, J., Mugerwa-Kasujja, A., Knighton, C. L., & Black, C. L. (2022). Vaccination Coverage with Selected Vaccines and Exemption Rates Among Children in Kindergarten — United States, 2020–21 School Year. *MMWR. Morbidity and Mortality Weekly Report*, *71*(16), 561–568. https://doi.org/10.15585/mmwr.mm7116a1

Shapiro, S. S., & Wilk, M. B. (1965). An analysis of variance test for normality (complete samples). *Biometrika*, *52*(3–4), 591–611. https://doi.org/10.1093/biomet/52.3-4.591

Soares, P., Rocha, J. V., Moniz, M., Gama, A., Laires, P. A., Pedro, A. R., Dias, S., Leite, A., & Nunes, C. (2021). Factors Associated with COVID-19 Vaccine Hesitancy. *Vaccines*, *9*(3), 300. https://doi.org/10.3390/vaccines9030300

State of Alaska, D. of P. H. (2013, July 1). *State of Alaska Religious Exemption Form*. https://www.ccthita.org/services/family/headstart/documents/SOA_immunization_religious_exemption_Form.pdf

State of Alaska, D. of P. H. (2017, June). *Medical Exemption/ Immunity Form.* https://health.alaska.gov/dph/Epi/iz/Documents/Medical-Exemption-and-Immunity-Form.pdf

Tan, L. (L. J.), Safadi, M. A. P., Horn, M., Regojo Balboa, C., Moya, E., Schanbaum, J., Pimenta, P., Lambert, E., Soumahoro, L., Sohn, W.-Y., Bruce, T., & Ruiz García, Y. (2023). Pandemic's influence on parents' attitudes and behaviors toward meningococcal vaccination. *Human Vaccines & Immunotherapeutics*, *19*(1). https://doi.org/10.1080/21645515.2023.2179840

United Nations International Children's Emergency Fund/World Health Organization. (2022). *COVID-19 pandemic fuels largest continued backslide in vaccinations in three decades*. https://www.who.int/news/item/15-07-2022-covid-19-pandemic-fuels-largest-continued-backslide-in-vaccinations-in-three-decades

World Health Organization. (2022). Understanding the behavioural and social drivers of vaccine uptake WHO position paper –. *Weekly Epidemiological Record*, *97*(20), 209–224. https://www.who.int/publications-detail-redirect/who-wer9720-209-224

Zhou, F., Shefer, A., Wenger, J., Messonnier, M., Wang, L. Y., Lopez, A., Moore, M., Murphy, T. V., Cortese, M., & Rodewald, L. (2014). Economic Evaluation of the Routine Childhood Immunization Program in the United States, 2009. *Pediatrics*, *133*(4), 577–585. https://doi.org/10.1542/peds.2013-0698

Zink, A. (2021, October). Alaska did well early in the pandemic. Then the misinformation and distrust kicked in. *The Washington Post*

Chapter 4: Exploring the Impact of the Infodemic on COVID-19 Responders in Alaska: A One Health Approach

4.1 Abstract

Background: The COVID-19 pandemic has been accompanied by an unprecedented infodemic, characterized by the proliferation of both accurate and misleading information. Efforts to better describe the impacts of misinformation during the pandemic can facilitate the development of tools and policies aimed at managing future infodemics. Objectives: We aimed to investigate the infodemic experiences of COVID-19 responders and identify themes that cut across sectors. Design: This study explored how the circulation of false, incomplete, and excessive information affected individuals responding to the COVID-19 pandemic, including healthcare providers, public health professionals, leadership, members of the media, K-12 school staff, tribal organizations, and others. Methods: Using a One Health framework to guide recruitment, we conducted 21 semi-structured interviews over video conference and analyzed them using mixed inductive/deductive thematic analysis. Results: Our findings coalesced around three principal themes: misinformation management, misinformation impacts and lessons learned. Building trust, promoting equity, and ensuring adequate resources (such as staffing and time) stood out as critical components to successfully combating misinformation. Conversely, a lack of communication/collaboration and intense politicization of COVID-19 made the response exceedingly difficult. The infodemic had direct impacts on the community, professional practice across fields and mental and physical health, many of which will have a continued effect moving forward. The lessons learned from this study can be applied towards efforts to better prepare us for the next public health emergency by enabling a more informed and agile response.

4.2 Introduction

The COVID-19 pandemic has caused nearly seven million deaths as of September 2023, (World Health Organization, 2023) making SARS-CoV-2 one of the deadliest pathogens in history Following the spread of COVID-19 around the world was another type of pandemic, characterized by unreliable information and confusion. This information epidemic, or infodemic, presented additional challenges for public health authorities at a scale never seen before.

Infodemics, defined as an overabundance of information—some accurate and some not—that occurs during an epidemic (Tangcharoensathien et al., 2020), have emerged as a significant threat to public health in the information age. The proliferation of digital platforms has compounded the effects of infodemics, posing novel challenges for individuals, communities, and societies. The overwhelming volume, speed, and reach of misinformation circulating online is unprecedented, contributing to confusion and a distorted understanding of critical information. Disinformation campaigns designed to exploit cognitive biases and manipulate public opinion are becoming increasingly sophisticated, and public trust in institutions has never been lower (Jones, 2022). The consequences of infodemics have tangible impacts, making it difficult for individuals to make informed decisions about their health and impeding effective outbreak response (Corinti et al., 2022).

The body of literature centered around infodemics has grown tremendously since 2020. Studies identified lack of health literacy (Mokhtari & Mirzaei, 2020), increased social media usage (Almomani & Al-Qur'an, 2020; Li et al., 2020; Naeem et al., 2021) and changes in publication policies (Kearsley & Duffy, 2020) as a few of the driving forces behind infodemics while others have proposed various countermeasures, such as education/training (Wormer, 2020), strategies to increase information accessibility (Looi et al., 2021; Marwitz, 2021) and altering policies on social media platforms (Zarocostas, 2020). A systematic review found many studies focused on investigating the broader impacts of the infodemics, citing psychological issues, eroding trust, unproven treatments, panic buying, economic recession, xenophobia, and other social issues (Pian et al., 2021). Others concentrated on the individual consequences of infodemics on mental health (Elbarazi et al., 2022; Shoib et al., 2022; Xiong et al., 2020; Ying & Cheng, 2021), sleep quality (Jung & Oh, 2022) and nutrition (Gavaravarapu et al., 2022). Far fewer studies have evaluated the impacts of the infodemic on those responding to COVID-19, such as healthcare professionals (Ismail et al., 2022) or Red Cross employees (Heyerdahl et al., 2021). The direct, real-life implications of an infodemic during a public health emergency, particularly amongst those on the front line, are less well-understood.

This study uses semi-structured interviews to explore how the circulation of false, incomplete, and excessive information affected individuals responding to the COVID-19 pandemic, including healthcare providers, public health professionals, leadership, members of the media, K-12 school staff, tribal organizations, and others.

4.3 Methods

4.3.1 Research Approach & Design

Addressing the health security issues posed by infodemics is multidisciplinary by nature, requiring expertise from many typically divergent domains. Medical doctors, epidemiologists, social scientists, journalists, and virologists are only some of the stakeholders needed to understand and communicate the science behind an outbreak. Effective risk communication during a public health emergency requires a collaborative approach to ensure transparency, clear communication, and informed decision-making at the individual and policy levels. Interdisciplinary approaches, such as the One Health approach, have been proposed as a promising perspective when tackling infectious disease outbreaks due to their emphasis on interconnectedness, coordination, and collaboration. The American Veterinary Medical Association defines One Health as the collaborative effort of multiple disciplines—working locally, nationally, and globally—to attain optimal health for people, animals, and the environment (Tan et al., 2017). Case studies have documented the successful operationalization of One Health in various contexts, including vaccination programs (Tan et al., 2017) and a priori investigations to improve resource efficiency and cost-savings (Rostal et al., 2018).

In the context of infodemics, this approach can facilitate cross-sectoral collaboration, building the capacity to communicate evidence-based, accessible information when it is most needed. The One Health paradigm recognizes this need for collaboration and partnership across disciplines when combatting infodemics (Alam & Chu, 2020). However, despite this, limited attention has been given to One Health as an approach to infodemic management. In this study, we employed a One Health approach to conduct 21 semi-structured interviews and analyzed them using mixed inductive/deductive thematic analysis.

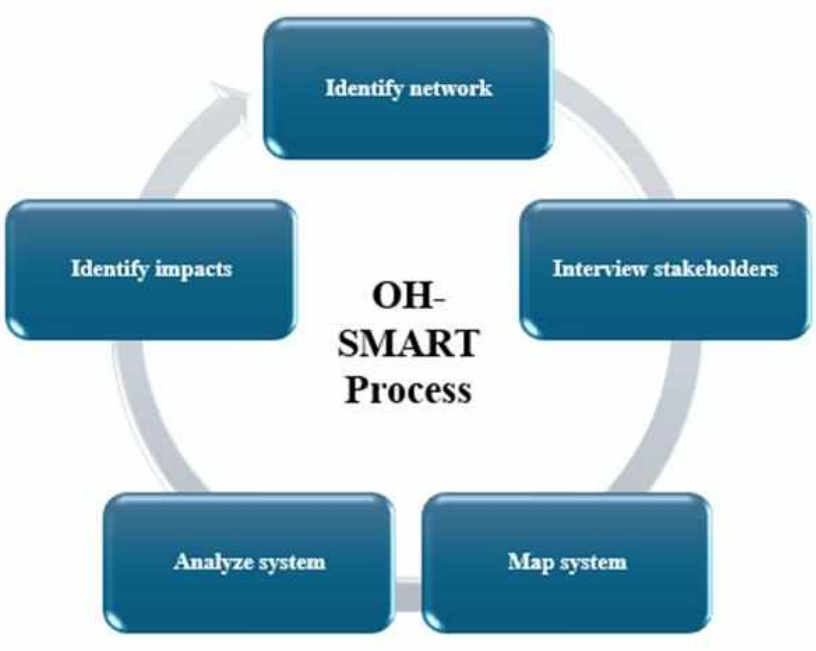
4.3.2 Participant Selection

Interview participants were selected using a concept mapping process developed within the One Health field called the One Health Systems Mapping and Analysis Resource Toolkit (OH-SMART). Developed by the University of Minnesota's One Health Global Initiative, OH-SMART is an interactive process that fosters working across organizational and disciplinary lines when preparing or responding to disease outbreaks (Global One Health Initiative - University of Minnesota College of Veterinary Medicine, 2023). This robust, adaptable

framework enables a comprehensive assessment of processes while identifying gaps and points of continuity within a system. The tool was successfully piloted in West Sumatra, Indonesia to enhance multi-agency collaboration around infectious disease outbreaks and has since been used in zoonotic disease prioritization workshops to maximize efficiencies and enhance systems operations in the United States (Centers for Disease Control and Prevention et al., 2017). Though the toolkit has been used extensively in infectious disease response, this is the first time it has been applied to assess health communication and misinformation.

The OH-SMART model consists of six unique steps: identify the network of interest, interview stakeholders, map the system, analyze the system, identify opportunities for improvement, and develop a plan to realize improvements (see Figure 4.1). The tool comprises various modules and components, allowing users to tailor assessments to specific needs and objectives.

Figure 4.1: Adapted OH-SMART process map



(University of Minnesota College of Veterinary Medicine, 2023)

In this research, we adapt the final two steps to reflect the goal of selecting interview participants by altering step five from "identify opportunities" to "identify impacts" and removing step six. The process resulted in a process systems map of how the COVID-19

infodemic has impacted and created ripple effects on individuals, private entities, and public agencies.

Using the OH-SMART framework as a guide, we sourced public documents and media for information to identify key state, local, and tribal organizations responsible for various aspects of the COVID-19 response in Alaska (see Figure 4.2). These sources included academic journals, local and regional newspapers articles, extension for community healthcare outcomes (ECHO) video calls co-sponsored by the University of Alaska and the state of Alaska and the Alaska Emergency Operations Plan. Throughout the interview process, participants were also given the opportunity to suggest additional interviewees.

4.3.3 Data Collection

Semi-Structured Interviews

Interviews were between 22 and 50 minutes (mean = 31) and participants were offered a $50 gift card as an incentive for their participation. To be eligible, participants were involved in the COVID-19 response (identified through the OH-SMART process), were at least 18 years of age, fluent in the English language, and signed the digital informed consent form prior to being interviewed. We reached out to potential interviewees by email and through the social media platform LinkedIn and after written consent was provided, an IRB-approved informed consent form was sent via Docusign. All interviews were recorded and transcribed with Zoom transcription service, and participants were assigned a study ID for confidentiality. The key for the study IDs was kept on a secured digital document and only available to individuals identified in the IRB-approved protocol. Semi-structured interviews were completed by the first author between January and March 2024 on the video conference software Zoom (version 5.16.2). The interview protocol (see supplementary materials) centered around topics related to COVID-19 misinformation including job duties, general contact with misinformation, response activities and barriers to response, impacts of COVID-19 misinformation on professional duties, mental health and misinformation, and other areas of interest. The University of Alaska Anchorage institutional review board approved this study (Protocol #2032885-1) as exempt due to its minimal risk nature and the collection of minimal potentially identifiable data.

Figure 4.2: Stakeholder oval of interview participants.

(Maxwell, 2024)

4.3.4 Data Analysis

All transcribed interviews were downloaded into Microsoft Word and checked for quality assurance by listening to audio files and manually correcting errors and adding relevant notes (such as coughing, laughing, etc.). At this time, transcriptions were de-identified and imported into Nvivo (version 14) qualitative analysis software for coding. We used thematic analysis methods to identify common themes among individuals with diverse roles and responsibilities during the COVID-19 pandemic. Thematic analysis is an adaptable qualitative research approach that allows researchers to investigate and group major concepts weaved throughout interviews (Nowell et al., 2017). We began by reading through each interview and conducting initial coding using *a priori* codes derived from a literature review. Codes were iterated upon and adjusted after each interview was coded and memos were added on an ongoing basis to provide the initial context for synthesizing codes into broader themes. The codebook consisted of 19 final codes (the full codebook is available in the supplementary materials).

4.4 Results

4.4.1 Study participants

We interviewed a total of 21 participants, from six broad occupational sectors: 29% healthcare providers (MD, DO, RN, PharmD, n=6), 5% state and local leadership (legislator, n=1), 33% public health (epidemiologist, communications specialist, contact tracer, n=7), 14% non-profit (research, community organization, n=3), 14% academic (professor, superintendent, n= 3), and 5% media (reporter, n=1). 29% (n=6) of the sample population was male and 10% (n=2) of interview participants worked at a tribal organization. Participants represented five regions across the state: 38% statewide (n=8), 33% southcentral (n=7), 14% southeast (n=3), 5% interior (n=1), 10% southwest (n=2).

Figure 4.3: Word cloud of the most frequently used words in the interview text.

(Maxwell, 2024)

Initial analysis included running the "Word Frequency" query on the full set of interviews using NVivo, which identified a starting point for potential themes (see Figure 4.3). This query resulted in six words with the highest frequencies: "information", "vaccine", "work", "people", "health", and "misinformation". This graphic reveals the words used most commonly

across all interviews, providing insight into cross cutting themes. With this information as a baseline, we grouped all instances of each code, reviewed the content for emerging themes within codes. “Direct quotes” was also used as a code but was not included in the analysis as it was only used to identify potential exemplary quotations.

4.4.2 Themes

Three major themes emerged across the interview data: misinformation management, impacts of misinformation and lessons learned. There was notable overlap in these topics; for example, the lack of resources noted under ‘misinformation management’ may have contributed to the impacts of misinformation on professional practice. A process map of some of these interactions is shown in Figure 4.4..

Misinformation Management

During interviews, significant discussion centered around factors participants identified as key components as well as barriers to successful misinformation management. Critical components identified included adequate resources, building trust through communication, and efforts to ensure an equitable response.

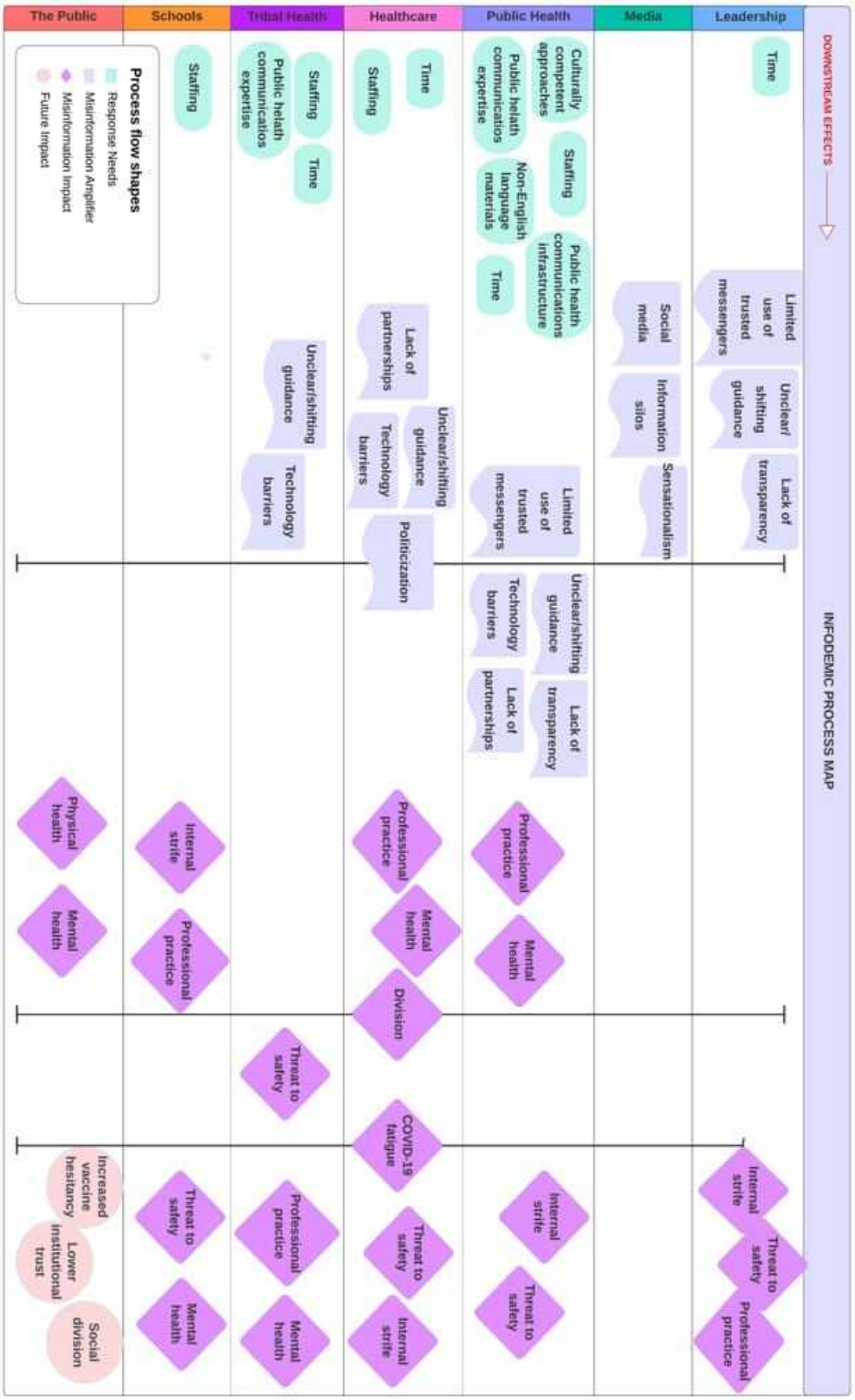
Resources

The most frequently mentioned resources that were lacking were staffing and time. High turnover was a common thread across interviews, particularly as the pandemic waned. The reasons cited for this included burnout and a rethinking of life priorities.

> *“We worked very long hours. We worked most days of the week for I think nine months…I think a lot of us had young children and were seeing the effects of not being with them as much as we wanted to. Misinformation was the constant trigger that hit us each time we talked to friends and family members we engaged in on social media.”* [105]

> *“It was like another full-time job on top of our normal full-time job.”* [124]

Figure 4.4: Infodemic process map.



(Maxwell, 2024)

In addition to a shortage of staff in general, participants emphasized that there were not many health communications professionals in the state of Alaska who had the expertise to successfully manage misinformation. This capacity was noted by a participant in a public health leadership position as "*one of the most important ingredients to being able to effectively combat misinformation*" [107]. On a broader scale, participants identified a lack of communications infrastructure in general as a major point of deficiency in the COVID-19 response.

"Ongoing budget cuts, that sort of thing that, you know, is constantly denuding the ability for state governments to manage a response and a lack of any sort of federal coordinated infrastructure compounded [staffing issues] by making folks like me, instead of coordinating the response, work to develop the infrastructure needed to manage it." [116]

Trust

The next critical component of misinformation management identified was trust. Participants from across sectors said that the information being shared by official sources (such as the CDC or healthcare providers) was often confusing, incorrect, or changing on a regular basis. One participant shared:

"*I think it just put a lot of doubt in the public's mind as far as whether what was being recommended was actually necessary, and if it actually really did help protect them and their community*."[102]

In addition to unclear guidance, the messenger wasn't always well-suited for the audience. One public health employee stated:

"I think we [public health] have to be comfortable with the fact that we are not going to be the trusted messenger for everyone. And I think it's a key task for health communications, professionals to ask, 'who is the trusted messenger'? [105]

Participants noted the increasing difficulty and decreasing success of using official public health channels to convey health information due to the public's lack of trust. To counter this,

one participant noted the importance of engaging with tribal leaders when working with AI/AN communities while another discussed their approach in their region:

"*We're here in conservative MatSu and we tried to partner with people that we thought that most people would listen to. So, like, we did numerous projects with [a high-ranking government official], and we did projects with the mayors of Wasilla, Palmer, and the borough, like respected public figures on the on the righter side of things, hoping that using them as messengers, and they were all super cooperative.*" [124]

Equity

The third and final key component identified as necessary to manage misinformation was equity. Participants emphasized the importance of addressing language barriers by disseminating information and guidance in different languages (which was noted as lacking in some regions). Even when non-English guidance was issued, it often fell behind and was not updated regularly, leading some individuals to feel their community was "falling through the cracks". One participant even noted that some misinformation campaigns were specifically targeting individuals who spoke English as a second language. A small business owner who is bilingual stated:

"You know, most of the time they'll say, 'well, you know, you can go to the web page, and you can use Google translator'. Well, no, Google translator is not going to do it 100% accurately. Small business owners do not have the time to go looking for things. We are working from the minute we get to our business, sometimes, even until we get home. And why do they think that we're going to go looking for stuff when our job is to, you know, keep the business running." [109]

In addition to language, other cultural differences were identified as being important for officials to recognize while developing response plans; for example, vaccination campaigns designed for Samoan communities may look different than those for AI/AN or Hispanic communities. Other equity-related issues included access to technology (particularly in remote regions) and historical trauma.

"*I think most rural Alaskan Native communities have a history of respiratory illness, like really grabbing hold of a community and burning its way through. Then, given the unique infrastructure challenges that our communities face, it's like, you know, help and resources can be hours or days away. And so that was really hard."* [120]

Barriers

The barriers to a successful response to COVID-19 misinformation were a strong focus throughout the interviews. The most prominent of these was ineffective coordination of communication between government sectors at all levels. Participants identified cohesion and consistency in communication as being crucial during any emergency and that during the pandemic, there was conflicting information from the highest levels. When discussing the CDC, one participant said:

"Many times, we felt like we were in a test to kind of be experimented upon like, 'Okay, well, just make sure you get us all your data. We understand you're struggling, best of luck". And then, they would eagerly be looking to see what's working and what isn't. We're supposed to be preparing better for the next one, but at whose expense? So, I think the biggest challenge was generally the lack of the infrastructure that was needed to coordinate our public health response. Coming from the CDC."[116]

Others pointed towards communication breakdown at the state level:

"*I think within the State of Alaska, like many government entities we were very siloed in our approach. Of course, there is the emergency operation center that was stood up to break those silos down. But that organization didn't really didn't know how to do its job very well. For example, we were using outdated information sharing policies and practices."* [116]

The disjointed nature of the information flowing from the CDC to the state made things more difficult for responders when even simple mistakes had deleterious consequences.

"*The misinformation that was sometimes the most problematic… it was actually just like the honest mistakes that partners and collaborators would make in communicating. All it really took was for one person to send an email to a group of partners misidentifying the group that could*

get vaccinated next and all the phone lines would be tied up with people who are frustrated that they couldn't find where they could get vaccinated because they were being turned away." [105]

Participants believed instances like these led to apathy and disinterest amongst those who would have otherwise been likely to follow guidance. One participant noted that this was especially true given that, "*What we were recommending here was not easy. They are very difficult challenges for people that could make it difficult for them to go to work or go to school."* [102] Additionally, several participants pointed out the reality that oftentimes misinformation and rumors spread more quickly and easily than the truth. They described combating misinformation as 'whack-a-mole', an 'uphill battle' and that once it was said, "*it would be impossible for us to fully put the cat back in the bag."* [105]

"A lot of effort has to go into proving one little comment that somebody can just make up on the spot. To share the truth behind what they said can just take hours and hours and hours, and by then, whoever had seen that... they're no longer even interested in hearing the long truth of it." [102]

There was one barrier to managing COVID-19 misinformation that nearly every participant raised: politicization. Participants felt that COVID-19 in general had been intensely politicized, which hampered their ability to take steps towards managing misinformation. This had effects at all levels of government, as one participant noted the shift in policy from one mayor to another:

"We went from having a mayor who was a believer in science, who looked at the data and made some tough choices to a major who had no experience in government at all and was unwilling to do anything to restrict public activity in the name of controlling the epidemic. The differences are just so stark in what happened with disease rates, hospitalizations, compliance in vaccination…everything. I think a lot of that was an impact of misinformation. [110]

When referencing the results of a survey about public attitudes towards COVID-19 vaccination, one participant said:

"There was actually a whole back and forth about the second survey and whether we were allowed to publish it or not. And I think it's kind of buried on the website somewhere. I think the [high-ranking government official]'s office ended up not wanting us to publish it." [114]

Others also mentioned the high-ranking government appointees and elected officials as well as employees at various levels of government not being comfortable with their work, leading them to "*not really act on anything*." [114] One participant recalled a specific incident where this dynamic, *"ended up with the [high-ranking government official] calling out our efforts. I mean, in particular, in a press conference to say that he was under the impression HIPAA privacy laws had been violated, etc., etc. So again, none of that was true. None of it was actually at all related to any of our practices*.[116] Similarly, participants pointed out that some members of leadership were saying one thing in public (guided by political ideology), while doing another in private:

"On occasion, well-known personalities or leaders who became ill with COVID had the vaccine and took in the usual treatments and got better, but in public venues were saying we shouldn't be encouraging vaccine, and … would have fundraisers where nobody was masking. And so, it felt like there was some doublespeak, and that there was a recognition that politically, if they said that out loud that they would lose support from a certain percentage of their voters, even though we had taken care of some of those people in the hospital. It felt a little different than what they were saying publicly."[112]

The same participant recognized that politicization could occur on the opposite side of the coin as well. They expressed frustration about the inflexibility of COVID-19 guidance stating:

"*We knew very early, if you've had COVID, the likelihood that you get severely ill and end up in the hospital is really low. I mean, we could see that within months. And so, you know, having natural disease is quite protective. Why do you have to say that it isn't?"* [112]

Impacts of Misinformation

Another large portion of the interview content focused on the impacts of COVID-19 misinformation on various aspects of their experience. This topic was a central focus of the study

and thus, many questions in the interview protocol and many follow-up probing questions were asked during this part of the interviews. The impacts of misinformation fell into four categories: impacts on community, impacts on professional practice, impacts on health and health behavior, and future/enduring impacts.

Impacts On Community

The impacts of COVID-19 misinformation on communities throughout Alaska was undeniable. One of the most cited consequences of misinformation was division within communities.

"There was just this political, social divide that happened which I would care to never experience again." [122]

" I think that's impacted families and friendships in ways that, like, people might not have anticipated. And just suddenly, people have really strong opinions about this preventative medicine, and that's not something that had previously been so politicized. So, I think that was a real challenge to some of our communities and some of our social networks." [103]

"We obviously have this population sector in our community who has very strong beliefs to the right end of the political scale, and they were pretty vocal. Small again, contextually small in number, but they were banding. They were, you know, pretty assertive, I would say. I won't say aggressive, although they were at times very aggressive, assertive in their response to our decisions." [122]

Others noted social pressures as a motivating factor for some individuals. For example, if those close to you were inclined to get vaccinated (or not), you may feel pressured to do the same for fear of being ostracized or damaging the relationship.

"There was an employer who… required testing of their employees every day…they either had to prove they were vaccinated or get tested. There were employees who were indeed vaccinated, but they still lined up every day to get tested because they didn't want their friends to know they were vaccinated like, there is this shame of being vaccinated." [124]

Impacts on Professional Practice

Unsurprisingly, the impact of the infodemic on participants' professional practice was profound. Individuals from all sectors reported that fighting misinformation was a constant battle that they were unprepared for, and multiple interviewees used the phrase, "building the plane as we're flying it". Many noted that addressing misinformation took a lot of time away from other duties, detracted from the quality of their work and made it harder for them and their staff to do their jobs. The extensive efforts put forth towards combating misinformation left people feeling frustrated. One physician said:

"Many people were quite adamant about their views. Didn't really matter what studies or what evidence I presented. There wasn't really gonna ever be a real discussion about it. 'Oh, you shouldn't be vaccinating moms, because it'll harm the baby'. Even though now we know to vaccinate Mom, especially late in pregnancy. It's much better for babies... People didn't really wanna look at the data. Many patients…we try…I tried. I think I'll say it was sad… But by the end of 2021, many of us just weren't putting a lot of effort into individual education anymore. We were just doing the very best we could in a difficult time, because it really was not highly valued." [112]

"The trajectory changed from serving and trying to reach the most vulnerable people to focusing on a small minority of people who, you know, honestly, I don't think that their minds were going to be changed. There was just so much effort being put into that population at the expense of some of the other populations, and I think that just felt also very frustrating. And kind of led to that feeling of like, well do I really want to keep doing this?" [117]

Misinformation also had direct ramifications on participants' abilities to do their jobs. One participant stated that a local radio station refused to host COVID-19 related advertising while another involved in contact tracing said:

"We have individuals who are refusing to participate, for example, because their employer did not want them to. We had a well-known case of a childcare center… where they were not allowing their employees to call out sick if they were diagnosed with COVID. And so, it became very difficult. They did not want to participate in our contact tracing because they were afraid that the state would inform their employer that they were participating in that effort, and they

would get in trouble from their employer for even participating later on at the call center. It was a constant ordeal." [116]

Another participant mentioned having difficulty setting up vaccine clinics:

"We tried to do it [clinics] at church churches, and they wouldn't want to do it. I guess there was a lot of misinformation about the vaccine being made out of embryo cells. And there's this big controversy. So, we had to like, publish in the newspaper about the Pope… It was like holding people's hand on every single thing that we did." [109]

Participants with clinical experience expressed some of the new challenges they faced when having one-on-one conversations with patients about COVID-19. For example, many patients refused COVID-19 treatments and vaccines who had never had issues with either before, which was difficult for providers to reconcile with. In an effort to make a difference, one provider stated:

"When things were really bad, some of us would feel like we could write a letter, and at least influence a little bit…you kind of have an ethical obligation to try to speak out and do something. So, we did that, there were enough of us in the same frame of mind that we could do that on occasion, and maybe help a little bit." [112]

"Where I guess we have been trained is when we're in a visit with a patient, and we're talking to them about 'Here's the vaccines your kids need, here's what they do. Here's the risks, here's the benefits. What are your concerns like, let's talk about that.' That's what we're trained to do. But we're not trained to deal with angry Facebook posts or people screaming at you at a school board meeting, or people throwing pamphlets at your building." [115]

Unfortunately, in some cases, the dialogue around these issues became threatening. A public health professional recalled two such instances:

"I had one public health nurse - somebody who was angry at her after a school board meeting, talking about vaccination rates and when the schools needed to close versus be open, [she] was followed out to her vehicle. People were scared." [115]

"One of our health centers had a woman who, for probably 18 months, was regularly bringing this literature to the health center, insisting that we were killing kids by giving them COVID vaccines. Finally, we had to do a 'do not trespass' with the police…There were flyers plastered all over or thrown all over the parking lot of one of the other health centers up north about how the COVID vaccine is killing kids and you're killing kids, and you need to be stopped." [115]

These situations were not limited to public health staff, as one K-12 school employee recounted:

"We did have a situation in the district where that small group got really revved up, I would say, both at the city and at the school district. They were part of some bigger front across the country, and started generating paperwork, demanding that we stop mandatory testing. It was like legal paperwork, but it wasn't legal paperwork...And it was basically saying, you know, directly to me, 'If you don't stop this, we're gonna start charging you, fining you $25,000 a day' type thing. It was threatening and it was hand delivered like he wanted me to sign it. I said, 'Well, I don't know who you are, number one and number two, I'm not signing anything so you can hand me anything you want, but I'm not signing.' But it did really escalate to the point where the city was very worried about my safety and I had to talk to [the local police department], who gave me some advice and told me what to do if…because this group sort of, the next level was a citizen's arrest that they thought they might do." [122]

Participants also discussed aggression they faced over the phone, leading contact tracers to become hesitant to call for fear of being berated.

"We had staff members from the call center who were being told, 'I've gotten your name. I know who you are. We're gonna be coming to your house and hurt[ing] you.' And so, we actually had people leave the effort because of that. So, you know, some very dramatic impacts of misinformation there stemming from you know again, the concept that the vaccine was a political weapon was being leveraged against them and those they loved." [116]

Finally, participants also noted that the polarization around COVID-19 created internal issues at work as well; some employees did not believe in certain recommendations while others

were unhappy with what they perceived as a lack of precaution by coworkers and/or their employer's policy.

Impacts of Health/Health Behavior

The ripple effects of COVID-19 misinformation also had repercussions on individuals' physical and mental health. Responders described countering misinformation as stressful, tearful, and inflammatory and that they felt overwhelmed by the depth of the responsibility. Several participants talked about this experience ushering in the end of their work in public health with one participant saying:

"They would have these meetings where they would have these very grim suggestions like, maybe you could find a room where you could go cry for two minutes…I don't work there anymore. So that was one way that I dealt with it." [113]

Physicians and other clinical providers had insight on the ramifications of misinformation on physical health. These anecdotes were some of the most tangible and tragic impacts heard throughout the interview process.

"I remember another husband and wife that were admitted to the hospital. Both had very bad COVID, one was worse than the other. And I was talking to them, and they were, you know, this guy was adamantly against the vaccine, and then we had a bit of discussion about it. Then he's like, 'You know, now, come to think about it, Fauci is actually a good Catholic Christian guy, and I'm into Christ. I'm into that, so I guess I will take the vaccine now.' And I was like, 'Well, both you and your wife are very sick in the hospital, this is not the exact time we, you know, do the vaccines. You can get one after. But, you know, it would have been useful to have this a month ago or two months ago.' And so that was just very disappointing to see people, some young people, who should not have become ill…who had very severe disease or didn't make it…who were adamantly against the vaccine and, you know, would not have died by most statistical assessments." [112]

"When people came in, and we recommended evidence-based treatments that give them the very best chance to survive…many patients did not want those, because they said, 'Well, we hear people that get it don't survive'. Many of the people wanted ivermectin, which we were not

agreeing to give people in the hospital. We would explain to them, 'You have bad COVID, and you have a 20 to 50% chance of not making it... And then they would actually get upset or try to, you know, almost threaten to sue you when you're giving…when they're refusing the correct medicine... That was…that's just very, very hard to know how to take good care of people in that situation…At the same time, it's hard to deny somebody something that they're convinced is gonna help them. That feels really bad." [112]

Future Impacts

The COVID-19 information epidemic will have lasting effects that go beyond the pandemic itself. One participant working in education expressed concern about how the division sowed during the pandemic would impact children in the future. Many people who are still working in their sectors (and some who are not) conveyed concern about the lack of trust established during the pandemic.

"It eroded trust and that's the issue. And that's a problem that we have to deal with now. That's part of it is, people were looking for that consistency, and they saw so much inconsistency and that really eroded the trust that we had, and I think you know, if we could go back, I think part of it would be to let people know this is a fluid situation. It's changing constantly, and we need to just change with it." [111]

One of the downstream trends of this distrust is declining vaccination coverage, particularly with childhood vaccines. Participants noted that they are even struggling to vaccinate the children of parents who vaccinated their previous children. When a vaccine clinic was planned at one of the schools it had to be canceled because the outrage from parents was overwhelming. This is taking place outside of schools as well:

"We did a vaccine point of dispensing [clinic] here in [participants' city] in the fall, and we had been doing them almost annually for years where we provide flu vaccines. For many years we would do this event in the fall and no matter what time of day, what day of the week, what location we did them, we saw about 300 people. So, we were expecting to have about 300 people this year, and we had 88." [119]

Lessons Learned

The final cross-cutting theme identified was lessons learned. First, participants believed that creating and maintaining more partnerships with a wider breadth of stakeholders would have been beneficial for the response. Several individuals specifically alluded to strengthening ties with organizations outside of public health, such as businesses, schools, healthcare, community-based organizations, and local government. They stressed the importance of establishing the infrastructure needed to maintain those relationships long-term, when not in an emergency. Involving and valuing the contributions of non-public health organizations helps to better tailor messages and interventions as needed. This would also enable more cohesive collaboration and messaging across different sectors of society. When identifying a need during the response, one participant stated:

"Having more visibility into what other people are doing, because I think it felt like there was a lot of recreating the wheel. You know, across the country." [117]

Others felt that the role of misinformation during the pandemic was underestimated and that there was a need for tools specifically designed to manage it. The Alaska Public Health Information Response Team was identified by multiple participants as being one of the only efforts aimed at reducing misinformation in the state.

"I'm just very grateful that they [APHIRT] we're able to do that. And really, I think they helped make a difference." [107]

When referencing tools for contact tracers to use to counter misinformation, one participant noted:

"Instead of having refined scripts, having a catalog that could be easily referenced. So certain phrases. individual concepts were brought up, they [contact tracers] could flip to that component and try to respond. That also allowed us to integrate on a daily basis new information that was out there on the news so we would stay topical much more efficiently than if we would have crafted a very refined and developed script." [116]

A few participants identified policy changes that would have made managing the infodemic easier, including establishing borough-level public health powers. Another participant expressed their frustration over the lack of repercussions for providers who spread false information.

"I think the discouraging thing is that our system doesn't have in place adequate protections or guardrails to really advocate best for everybody here. For example, if you're a licensed provider, you can tell people that you can take stem cells out of their blood and re-inject it into a joint, and you'll walk again. It could be complete voodoo and you could charge cash for that. And unless you can prove that they were, you know, irreparably harmed from that, there's really no oversight and control." [112]

Finally, many participants felt that a lack of science and media literacy is a driving force behind misinformation vulnerability, even amongst those with expertise in the field.

"There are just so many more options now, and you can, in fact, just live in your own information space and not hear any information counter to what you don't believe in and we know that we tend to go to information sources and media sources that already confirm our existing values and beliefs." [111]

"I don't think you can combat it like topic by topic or question by question. I think it has to be more comprehensive, and I think, going back to that belief and understanding of science." [103]

I think independently interpreting data is very hard and takes a lot of time. People are busy and it takes a lot of time to do that. So, if you watch a certain media personality every night and find their arguments compelling historically and you like the interpretation… it makes you feel better than the alternative interpretation, you're likely to trust that interpretation. And then you're likely to confirm that by searching literature and finding confirmatory support." [112]

4.5 Discussion

The information landscape during the COVID-19 pandemic was marked by an overabundance of information, yet many messages remained unclear or were persistently challenged throughout the pandemic. A growing body of research is focused on investigating the causes, effects, and nuances of the COVID-19 infodemic (Islam et al., 2020; Mourad et al., 2020;

Pian et al., 2021; Ries, 2022) and in this study, we sought out to develop qualitative themes from the first-hand experiences of individuals involved in the COVID-19 response. Drawing from a One Health methodology, we used semi-structured interviews to identify crosscutting issues in misinformation management, the impacts of misinformation and lessons learned.

Many of the themes we discovered were consistent with previous research. A 2021 study exploring misinformation amongst Red Cross employees in France found that information silos further polarized people and led to an increasing sense of apathy about controlling the disease (Heyerdahl et al., 2021). The social stigma around COVID-19 experienced by study participants has been investigated in previous studies and shown to be deleterious to the management of COVID-19 (Bhanot et al., 2021; Ramaci et al., 2020). The impacts of misinformation on the physical health of the public have also been discussed in previous research. Participants in these interviews discussed false cures, including bleach, UV light, ivermectin, and hydroxychloroquine having negative effects on patients, while prior research highlighted death and injury caused by these and various other 'treatments' including alcohol consumption and *Datura* seeds, (Ahmed Siddiqui et al., 2020; Hassanian-Moghaddam et al., 2020; Pradesh, 2020).

The infodemic management guidelines outlined by the WHO also bare many similarities to the techniques identified by participants. The WHO's four pillars of infodemic management are: listen to concerns, communicate risk and distill science, promote resilience to misinformation and engage and empower communities (Tangcharoensathien et al., 2020). The importance of each of these points surfaced in different forms during interviews as lessons learned: develop social listening tools, adhere to emergency communication principles, promote science literacy, and strengthen partnerships across the community. Participants echoed previous findings showing that low levels of science and media literacy are correlated with belief in conspiracies (Berkman et al., 2010) and intention to spread conspiracies (Williams Kirkpatrick, 2021) and that this lack of foundational literacy must be included as part of any effective infodemic management guidelines. A lack of trust between the public and COVID-19 responders was alluded to many times throughout interviews as being a foundational issue in infodemic management. Trust is a critical component to successful public health interventions and misinformation can further deteriorate what trust does exist, resulting in public disregard for evidence-based guidance and recommendations (Thorburn Bird & Bogart, 2003).

One of the other sentiments shared across many participants in this study was the collective sense that responders were doing the best they could with what they had at the time. Many expressed that despite their team members being "driven" and "smart", they felt trapped by the limitations of the system and that they knew that successfully managing misinformation was an impossible task. Integrating a One Health approach into future response plans may alleviate this issue by encouraging more collaboration within official organizations and across external partners. Participants also expressed that many of the mental and emotional impacts of managing misinformation were difficult to disentangle from the many other challenging tasks involved in responding to COVID-19. One participant explained, *"misinformation was just like one piece of the dysfunctional COVID experience."* [113] Participants' experiences with threats of violence and intimidation were repeated across interviews and have been mirrored in previous studies (McKay et al., 2020).

This study had several limitations. First, though we were able to interview at least one individual from each of our desired sectors, our results are not representative of any single sector on its own. Limited resources and time did not allow for theme saturation within each sector, therefore, results only reflect a small portion of COVID-19 responders in Alaska. Second, our sample population included individuals who continued employment at the same organization, potentially resulting in some self-censoring. Third, the final themes derived from these interviews are a synthesis of general trends across interviews and were not necessarily unanimous. In fact, some participants expressed the opposite opinions and experiences of others, further illustrating that the population of COVID-19 responders is not a monolith.

This study sheds light on how misinformation affected responders across sectors during the COVID-19 response in Alaska. In a state with diverse populations and unique geographical challenges, the consequences of misinformation can be amplified, leading to disparities in health outcomes and exacerbating existing vulnerabilities. By exploring firsthand experiences through semi-structured interviews, this research provides valuable insights into the specific challenges faced by Alaskan responders in navigating the infodemic. The study underscores the utility of adopting a collaborative, One Health approach to infodemic management, emphasizing the need for interdisciplinary cooperation to ensure effective communication and decision-making during public health emergencies.

The number of studies concentrated on infodemics has surged since the COVID-19 pandemic began. As a burgeoning field, more research is needed to better understand the nuances of misinformation dissemination and its comparative effects on professional practices. Additionally, exploring the effectiveness of interventions, such as the Alaska Public Health Information Response Team, could inform strategies for combating misinformation in similar contexts. Furthermore, longitudinal studies could assess the long-term effects of the infodemic on public trust, mental health, and community resilience, providing valuable insights for future preparedness and response efforts. Results from these studies may offer useful insights into policy decisions that would enable more sustainable, preventative measures to lessen the presence and impacts of misinformation in future health emergencies. This small qualitative study provides valuable insight into the challenges posed by infodemics in an Alaskan setting but underscores the need for continual research to address preventive strategies and enhance our ability to anticipate and respond to future health emergencies.

4.6 Acknowledgments

I would like to thank my committee members for their unwavering support and dedication to this project. Thank you to all of the interview participants who gave their time and energy participating in this study.

4.7 Conflicts of Interest

The authors declare that they have no conflicts of interest.

4.8 Author Contributions

E.K.M. conducted primary data collection, conceived of the present manuscript and analyses, analyzed the data, and drafted the manuscript, A.J.R., R.D.P., J.A.M., and T.E.H provided critical revisions to the manuscript. All authors provided contributions to the conception and the design of the study.

Tuula E. Hollmen

College of Fisheries and Ocean Sciences, University of Alaska-Fairbanks and Alaska SeaLife Center, Seward, AK, U.S.A.

Jennifer A. Meyer
College of Health, University of Alaska Anchorage, Anchorage, AK, USA.
R. David Parker
Yukon-Kuskokwim Health Corporation, Anchorage, AK, USA.
Arleigh J. Reynolds
Sitka Sound Science Center, Sitka, AK, USA.

4.9 Supplementary Materials

See Appendix B for interview protocol and consent form.

4.10 Sources of Support

This material was also supported in part by the University of Alaska Fairbanks Office of the Vice Chancellor for Research Graduate Student Support Fund, the University of Alaska Fairbanks Graduate School Travel Award and Degree Completion Award, Alaska EPSCoR NSF award #OIA-1757348 and the state of Alaska. This material is also supported in part by the National Science Foundation Arctic Section Doctoral Dissertation Research Improvement Grant Program under Grant No. 2309906. The contents of this article are solely the responsibility of the authors and do not necessarily represent the official views of the NSF or anyone else.

4.11 Data Availability

Data used in this manuscript will be available at the NSF Arctic Data Center (https://arcticdata.io/).

4.12 References

Ahmed Siddiqui, M. Y., Mushtaq, K., Mohamed, M. F. H., Al Soub, H., Hussein Mohamedali, M. G., & Yousaf, Z. (2020). “Social Media Misinformation”—An Epidemic within the COVID-19 Pandemic. *The American Journal of Tropical Medicine and Hygiene*, *103*(2), 920–921. https://doi.org/10.4269/ajtmh.20-0592

Alam, N., & Chu, C. (2020). COVID-19 Pandemic: Tackling 'Infodemics' Through an Integrated One Health–Social Science Approach. *Proceedings of the Royal Society of Queensland*, *128*, 99–111. https://www.royalsocietyqld.org/wp-content/uploads/Proceedings%20128%20v2/08_Alam_and_Chu_Web.pdf

Almomani, H., & Al-Qur'an, W. (2020). The extent of people's response to rumors and false news in light of the crisis of the Corona virus. *Annales Médico-Psychologiques, Revue Psychiatrique*, *178*(7), 684–689. https://doi.org/10.1016/j.amp.2020.06.011

Berkman, N. D., Davis, T. C., & McCormack, L. (2010). Health Literacy: What Is It? *Journal of Health Communication*, *15*(sup2), 9–19. https://doi.org/10.1080/10810730.2010.499985

Bhanot, D., Singh, T., Verma, S. K., & Sharad, S. (2021). Stigma and Discrimination During COVID-19 Pandemic. *Frontiers in Public Health*, *8*. https://doi.org/10.3389/fpubh.2020.577018

Centers for Disease Control and Prevention, United States Department of Agriculture, United States Department of Health and Human Services, United States Department of the Interior, Environmental Protection Agency, National Oceanic and Atmospheric Association, Delaware Department of Agriculture, Virginia Department of Health, & Maryland Department of Natural Resources. (2017). *Prioritizing Zoonotic Diseases for Multisectoral, One Health Collaboration in the United States*. https://www.cdc.gov/one-health/media/pdfs/us-ohzdp-report-508.pdf

Corinti, F., Pontillo, D., & Giansanti, D. (2022). COVID-19 and the Infodemic: An Overview of the Role and Impact of Social Media, the Evolution of Medical Knowledge, and Emerging Problems. *Healthcare*, *10*(4), 732. https://doi.org/10.3390/healthcare10040732

Elbarazi, I., Saddik, B., Grivna, M., Aziz, F., Elsori, D., Stip, E., & Bendak, E. (2022). The Impact of the COVID-19 "Infodemic" on Well-Being: A Cross-Sectional Study. *Journal of Multidisciplinary Healthcare*, *Volume 15*, 289–307. https://doi.org/10.2147/JMDH.S346930

Gavaravarapu, S. M., Seal, A., Banerjee, P., Reddy, T., & Pittla, N. (2022). Impact of 'infodemic in pandemic' on food and nutrition related perceptions and practices of Indian internet users. *PLOS ONE*, *17*(4), e0266705. https://doi.org/10.1371/journal.pone.0266705

Global One Health Initiative - University of Minnesota College of Veterinary Medicine. (2022). *One Health Systems Mapping and Analysis Resource Toolkit (OH-SMART)*. https://oh-smart.umn.edu/

Hassanian-Moghaddam, H., Zamani, N., Kolahi, A.-A., McDonald, R., & Hovda, K. E. (2020). Double trouble: methanol outbreak in the wake of the COVID-19 pandemic in Iran—a cross-sectional assessment. *Critical Care*, *24*(1), 402. https://doi.org/10.1186/s13054-020-03140-w

Heyerdahl, L. W., Lana, B., & Giles-Vernick, T. (2021). The Impact of the Online COVID-19 Infodemic on French Red Cross Actors' Field Engagement and Protective Behaviors: Mixed Methods Study. *JMIR Infodemiology*, *1*(1), e27472. https://doi.org/10.2196/27472

Islam, M. S., Sarkar, T., Khan, S. H., Mostofa Kamal, A.-H., Hasan, S. M. M., Kabir, A., Yeasmin, D., Islam, M. A., Amin Chowdhury, K. I., Anwar, K. S., Chughtai, A. A., & Seale, H. (2020). COVID-19–Related Infodemic and Its Impact on Public Health: A Global Social Media Analysis. *The American Journal of Tropical Medicine and Hygiene*, *103*(4), 1621–1629. https://doi.org/10.4269/ajtmh.20-0812

Ismail, N., Kbaier, D., Farrell, T., & Kane, A. (2022). The Experience of Health Professionals With Misinformation and Its Impact on Their Job Practice: Qualitative Interview Study. *JMIR Formative Research*, *6*(11), e38794. https://doi.org/10.2196/38794

Jones, J. M. (2022, July 5). Confidence in U.S. Institutions Down; Average at New Low. *Gallup*. https://news.gallup.com/poll/394283/confidence-institutions-down-average-new-low.aspx

Jung, G., & Oh, J. (2022). Factors Affecting Health-Related Quality of Life among Healthcare Workers during COVID-19: A Cross-Sectional Study. *Medicina*, *59*(1), 38. https://doi.org/10.3390/medicina59010038

Kearsley, R., & Duffy, C. C. (2020). The COVID-19 information pandemic: how have we managed the surge? *Anaesthesia*, *75*(8), 993–996. https://doi.org/10.1111/anae.15121

Li, H. O.-Y., Bailey, A., Huynh, D., & Chan, J. (2020). YouTube as a source of information on COVID-19: a pandemic of misinformation? *BMJ Global Health*, *5*(5), e002604. https://doi.org/10.1136/bmjgh-2020-002604

Looi, J. C., Allison, S., Bastiampillai, T., & Maguire, P. A. (2021). Clinical update on managing media exposure and misinformation during COVID-19: recommendations for governments and healthcare professionals. *Australasian Psychiatry*, *29*(1), 22–25. https://doi.org/10.1177/1039856220963947

Marwitz, K. K. (2021). The pharmacist's active role in combating COVID-19 medication misinformation. *Journal of the American Pharmacists Association*, *61*(2), e71–e74. https://doi.org/10.1016/j.japh.2020.10.022

Maxwell, E. K. (2024). Exploring the COVID-19 Infodemic in Alaska. In University of Alaska, Fairbanks.

McKay, D., Heisler, M., Mishori, R., Catton, H., & Kloiber, O. (2020). Attacks against health-care personnel must stop, especially as the world fights COVID-19. *The Lancet*, *395*(10239), 1743–1745. https://doi.org/10.1016/S0140-6736(20)31191-0

Mokhtari, H., & Mirzaei, A. (2020). The tsunami of misinformation on COVID-19 challenged the health information literacy of the general public and the readability of educational material: a commentary. *Public Health*, *187*, 109–110. https://doi.org/10.1016/j.puhe.2020.08.011

Mourad, A., Srour, A., Harmanani, H., Jenainati, C., & Arafeh, M. (2020). Critical Impact of Social Networks Infodemic on Defeating Coronavirus COVID-19 Pandemic: Twitter-Based Study and Research Directions. *IEEE Transactions on Network and Service Management*, *17*(4), 2145–2155. https://doi.org/10.1109/TNSM.2020.3031034

Naeem, S. Bin, Bhatti, R., & Khan, A. (2021). An exploration of how fake news is taking over social media and putting public health at risk. *Health Information & Libraries Journal*, *38*(2), 143–149. https://doi.org/10.1111/hir.12320

Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic Analysis. *International Journal of Qualitative Methods*, *16*(1), 160940691773384. https://doi.org/10.1177/1609406917733847

Pian, W., Chi, J., & Ma, F. (2021). The causes, impacts and countermeasures of COVID-19 "Infodemic": A systematic review using narrative synthesis. *Information Processing & Management*, *58*(6), 102713. https://doi.org/10.1016/j.ipm.2021.102713

Pradesh, A. (2020, April 7). Twelve taken ill after consuming 'coronavirus shaped' datura seeds. *The Hindu*. https://www.thehindu.com/news/national/andhra-pradesh/twelve-taken-ill-after-consuming-coronavirus-shaped-datura-seeds/article31282688.ece

Ramaci, T., Barattucci, M., Ledda, C., & Rapisarda, V. (2020). Social Stigma during COVID-19 and its Impact on HCWs Outcomes. *Sustainability*, *12*(9), 3834. https://doi.org/10.3390/su12093834

Ries, M. (2022). The COVID-19 Infodemic: Mechanism, Impact, and Counter-Measures—A Review of Reviews. *Sustainability*, *14*(5), 2605. https://doi.org/10.3390/su14052605

Rostal, M. K., Ross, N., Machalaba, C., Cordel, C., Paweska, J. T., & Karesh, W. B. (2018). Benefits of a one health approach: An example using Rift Valley fever. *One Health*, *5*, 34–36. https://doi.org/10.1016/j.onehlt.2018.01.001

Shoib, S., Armiya'u, A. Y., Das, N., Hussaini, S. S., Ahmed, E. M. S., & Chandradasa, M. (2022). Suicide in the context of infodemic during COVID-19 pandemic: A global perspective. *Annals of Medicine & Surgery*, *80*. https://doi.org/10.1016/j.amsu.2022.104070

Tan, J., Wang, R., Ji, S., Su, S., & Zhou, J. (2017). One Health strategies for rabies control in rural areas of China. *The Lancet Infectious Diseases*, *17*(4), 365–367. https://doi.org/10.1016/S1473-3099(17)30116-0

Tangcharoensathien, V., Calleja, N., Nguyen, T., Purnat, T., D'Agostino, M., Garcia-Saiso, S., Landry, M., Rashidian, A., Hamilton, C., AbdAllah, A., Ghiga, I., Hill, A., Hougendobler, D., van Andel, J., Nunn, M., Brooks, I., Sacco, P. L., De Domenico, M., Mai, P., … Briand, S. (2020). Framework for Managing the COVID-19 Infodemic: Methods and Results of an Online, Crowdsourced WHO Technical Consultation. *Journal of Medical Internet Research*, *22*(6), e19659. https://doi.org/10.2196/19659

Thorburn Bird, S., & Bogart, L. M. (2003). Birth Control Conspiracy Beliefs, Perceived Discrimination, and Contraception among African Americans: An Exploratory Study. *Journal of Health Psychology*, *8*(2), 263–276. https://doi.org/10.1177/1359105303008002669

Williams Kirkpatrick, A. (2021). The spread of fake science: Lexical concreteness, proximity, misinformation sharing, and the moderating role of subjective knowledge. *Public Understanding of Science*, *30*(1), 55–74. https://doi.org/10.1177/0963662520966165

World Health Organization. (2023). *WHO Coronavirus (COVID-19) Dashboard*. https://COVID19.who.int/

Wormer, H. (2020). German Media and Coronavirus: Exceptional Communication—Or Just a Catalyst for Existing Tendencies? *Media and Communication*, *8*(2), 467–470. https://doi.org/10.17645/mac.v8i2.3242

Xiong, J., Lipsitz, O., Nasri, F., Lui, L. M. W., Gill, H., Phan, L., Chen-Li, D., Iacobucci, M., Ho, R., Majeed, A., & McIntyre, R. S. (2020). Impact of COVID-19 pandemic on mental health in the general population: A systematic review. *Journal of Affective Disorders*, *277*, 55–64. https://doi.org/10.1016/j.jad.2020.08.001

Ying, W., & Cheng, C. (2021). Public Emotional and Coping Responses to the COVID-19 Infodemic: A Review and Recommendations. *Frontiers in Psychiatry*, *12*. https://doi.org/10.3389/fpsyt.2021.755938

Zarocostas, J. (2020). How to fight an infodemic. *The Lancet*, *395*(10225), 676. https://doi.org/10.1016/S0140-6736(20)30461-X

Chapter 5: Summary and Future Directions

5.1 Summary

At the 2020 Munich Security Conference, WHO director-general Tedros Adhanom Ghebreyesus stated, “We're not just fighting a pandemic; we're fighting an infodemic”. As time went on during the pandemic, the reality of the infodemic became increasingly relevant to the COVID-19 response, bringing to light not only the challenges of managing a novel infectious disease but also the pervasive issue of misinformation. This paper delves into the multifaceted aspects of COVID-19 misinformation, focusing on its impact, prevalence, and implications for public health response, particularly in the unique context of Alaska and the Circumpolar North.

The unprecedented surge in misinformation was propagated through both social media platforms and traditional media channels. This infodemic significantly influenced public perceptions, behaviors, and responses to the pandemic, highlighting the critical need for effective communication strategies and information management in public health emergencies. The complexity of misinformation, fueled by fear, uncertainty, and a rapidly changing information landscape, has posed substantial challenges to public health authorities worldwide.

The experience of the Circumpolar North region, including Alaska, presents unique challenges and vulnerabilities. The region's climatic changes, environmental shifts, and diverse demographics contribute to increased susceptibility to emerging health threats such as zoonotic diseases and infectious outbreaks. The heightened vulnerability of Indigenous populations in this region further underscores the importance of addressing misinformation and enhancing health literacy to mitigate the impact of public health emergencies. Addressing health security issues like the COVID-19 infodemic requires a multidisciplinary approach involving experts from various domains, including veterinary sciences, epidemiology, social sciences, and virology. Effective risk communication strategies, grounded in transparent and evidence-based information, are essential to counter misinformation and build public trust in health interventions.

The aim of this dissertation is to gain a better understanding of the dynamics and impacts of the COVID-19 infodemic in Alaska. These studies employed frameworks and methods from multiple fields, including One Health, epidemiology, strategic health communications, and

infodemic management techniques identified in prior research. Below is a brief summary of the core findings from each chapter.

5.1.1 Chapter 2

The paper explored the use of social listening as a method of data collection along with latent Dirichlet allocation (LDA) for classifying COVID-19 misinformation on Alaska-based social media platforms. This approach provided insights into the data corpus by developing prevailing themes including treatment, vaccine safety, conspiracy, and COVID spread, offering a structured framework for understanding and addressing misinformation trends. Leveraging natural language processing techniques like LDA topic modeling holds promise for real-time monitoring and analysis of digital misinformation, enabling timely and targeted interventions by public health authorities.

Looking ahead, there is a pressing need to continue advancing research and methodologies to combat misinformation effectively. Future studies should explore alternative models such as sentiment analysis, social network analysis, and cluster analysis to gain deeper insights into misinformation dynamics and audience behaviors. Further, employing these models through collaborations between researchers, public health practitioners, policymakers, and communities will be crucial to developing comprehensive and contextually relevant strategies for infodemic management.

5.1.2 Chapter 3

Vaccines stand as one of the most significant accomplishments in public health, saving millions of lives and preventing numerous diseases globally. However, recent trends indicate a concerning decline in childhood immunization rates, both globally and specifically in Alaska. The rise of vaccine hesitancy, exacerbated by the COVID-19 pandemic and fueled by misinformation, has posed challenges to public health efforts, necessitating comprehensive strategies to address these issues effectively. The decline in childhood vaccination rates in Alaska, compounded by its unique geographic and socioeconomic factors, underscores the importance of understanding and mitigating vaccine hesitancy. Vaccine hesitancy is a complex phenomenon influenced by various factors such as safety concerns, lack of knowledge, cultural beliefs, and misinformation. Vaccine hesitancy is strongly associated with perceptions of risk

related to both the disease and the vaccine itself, as well as concerns about the vaccine's development process and safety profile.

The COVID-19 pandemic highlighted the impact of misinformation on vaccine acceptance and hesitancy. Misinformation spreads rapidly through social media and other online platforms, contributing to doubts and hesitations regarding vaccines. This phenomenon has been observed in Alaska, where vaccine hesitancy has been a longstanding issue, further exacerbated by limited access to healthcare and educational resources in certain communities. This paper utilized an online randomized controlled trial survey to measure the effectiveness of brief educational interventions in addressing vaccine hesitancy. The study's randomized controlled trial assessed the impact of different interventions on vaccine hesitancy scores among Alaska adults, shedding light on the effectiveness of targeted educational interventions in a specific population and its subgroups.

Findings from the study indicate that while brief educational interventions can effectively shift vaccine perceptions among individuals with lower formal education, the impact varies among different demographic groups. Highly educated liberal populations, for instance, may exhibit different responses to educational interventions, highlighting the need for tailored approaches based on specific characteristics and beliefs. The study also investigated vaccine exemptions, exploring public attitudes towards medical and religious exemptions in school vaccination mandates. Understanding public perceptions and preferences regarding exemptions is crucial for policymakers and public health officials to develop comprehensive strategies to improve vaccine uptake rates.

Moving forward, it is essential to continue research efforts aimed at understanding the underlying drivers of vaccine hesitancy, particularly in regions like Alaska with limited extant research and distinct challenges. Tailored interventions, educational campaigns, and policy measures should be developed to address the multifaceted nature of vaccine hesitancy and promote informed decision-making regarding immunization. Additionally, addressing misinformation and enhancing health literacy remain key pillars in combating vaccine hesitancy. While challenges related to vaccine hesitancy persist, ongoing research and targeted interventions may offer solutions for improving vaccination rates and safeguarding public health. By understanding the diverse factors influencing vaccine attitudes and behaviors, we can work

towards a future where immunization remains a cornerstone of disease prevention and public well-being.

5.1.3 Chapter 4

The COVID-19 information epidemic, characterized by unreliable and confusing information, posed substantial challenges for public health authorities globally. Infodemics, defined as an overabundance of both accurate and inaccurate information during an epidemic, have emerged as a major threat in the digital age, fueled by the rapid dissemination of information through digital platforms. The impact of infodemics extends beyond just confusion; it impedes individuals' ability to make informed decisions about their health and hinders effective outbreak responses. The body of literature on infodemics has grown significantly, identifying factors like lack of health literacy, increased social media usage, and changes in publication policies as contributors. Various countermeasures have been proposed, such as education and training, strategies to increase information accessibility, and policy changes on social media platforms. However, the direct, real-life implications of infodemics, especially on frontline responders like healthcare professionals, are not well-understood.

This study utilized semi-structured interviews to explore how the proliferation of false, incomplete, and excessive information affected individuals responding to the COVID-19 pandemic, including healthcare providers, public health professionals, and others. Through thematic analysis, the study aimed to identify common issues in misinformation management, understand the impacts of misinformation, and draw lessons learned from the experiences of respondents.

The results of this study highlighted the profound challenges posed by infodemics during the COVID-19 response in Alaska, including detrimental impacts on professional practice, and physical and mental health. It emphasized the need for a collaborative, interdisciplinary approach—such as a One Health methodology—to effectively manage infodemics. The findings reinforced the importance of building trust, promoting science literacy, and engaging communities in combating misinformation. Future research may focus on further investigating the long-term impacts on public trust, mental health, and community resilience. This ongoing research is crucial for developing sustainable strategies to mitigate misinformation's presence and impacts in future health emergencies.

5.2 Future Directions

The principal findings of this dissertation have several important implications for future research and public health practice, particularly relating to Circumpolar regions. First, it is not only possible, but feasible for a small-medium sized public health department to monitor and track trends in misinformation on digital platforms using natural language processing in real-time. We recommend that state and local public health agencies engage these and similar techniques to better understand the dynamics of the misinformation spreading in their locality. Like politics, all misinformation is local – and while a national or international infodemic tracking tool may be useful to gain broad insights, a more local approach is necessary to develop interventions and messaging suited to the population of interest. Further, while traditional qualitative methods would likely be too time and resource intensive for a health department to realistically implement, the natural language processing utilized in this research requires a much smaller investment while yielding similar results. The protocols for data collection used in this study would not be usable for practice in the current form but could be adapted using artificial intelligence to identify social media posts containing misinformation. Future research utilizing these, or similar methods may help bring misinformation identification and analysis into standard public health practice. By doing so, we can enable government agencies to better understand the patterns of misinformation and thus, develop more tailored, informed risk communication strategies.

Second, while vaccine hesitancy is only one potential consequence of misinformation, the strategies aimed at combatting vaccine hesitancy can often be used to combat other manifestations of misinformation. In the third chapter of this dissertation, we investigated the effectiveness of educational interventions to combat vaccine hesitancy and found that the result was dependent on the subgroup within the study population. This reinforces findings from previous research showing that health risk communication and educational messaging is most effective when designed for a specific audience. For example, in this study we found our educational interventions lowered vaccine hesitancy in individuals with lower levels of educational attainment but had an opposite effect on those who were highly educated. For this reason, it is essential that public health communicators have a strong understanding of their audience as well as what messaging strategies have been shown to be most effective in those populations. This includes understanding how to incorporate culturally competent materials into

communication strategies when appropriate. More research is needed for public health practitioners to have this information when they need it, particularly in regions and populations that are less well-studied in the health communications field, such as the Circumpolar North.

Our third recommendation centers around the results from the qualitative interviews conducted amongst COVID-19 responders in chapter four. This study found that the infodemic had profound impacts on both COVID-19 responders and the public during the pandemic, including impacts on communities, professional practice, and physical and mental health. There were also several barriers identified by participants who were on the frontlines during the peak of the pandemic, many of which were a result of the system surrounding them. For this reason, our next recommendation is to focus on building resilience to misinformation at the individual and community levels, rather than focusing on measures which can only be enacted during an active response. Building health, media and science literacy within the population is a key piece to this strategy (with an emphasis on media literacy, as the growth of social media is unlikely to slow in the near future). Strengthening literacy through investment in K-12 science education and training programs (such as citizen science) are proposed as a sustainable countermeasure to misinformation which may promote resilience to infodemics.

Our final recommendation to enhance infodemic management is to increase collaboration between key partners of pandemic response. During interviews, many participants emphasized the critical importance of leveraging trusted messengers in communities rather than relying primarily on official bodies like public health departments. These individuals, (whether they are well-known healthcare providers, religious leaders, tribal leaders, hometown heroes or other individuals who are respected in a community), have existing trust in communities, something which is often very challenging for officials to gain in an emergency. This is especially important in rural communities of Alaska, where there is often a history of 'outsiders' entering a community for a short period and the relationship is not maintained over time. For these reasons, we echo the recommendations of several interview participants who stated the need for increased coordination and collaboration with community-based organizations. It is important to note that each of these recommendations is made in the broad context of infodemic management in general and more studies are needed to identify in what populations and contexts these recommendations may be more (or less) effective.

The COVID-19 pandemic illustrated the reality that addressing misinformation during public health emergencies requires concerted effort and cooperation between many partners. By leveraging technology, interdisciplinary expertise, and community engagement, we can improve public health outcomes, and foster informed decision-making amidst complex and evolving health challenges. The results of this dissertation provide a starting point for future research investigating infodemics and misinformation more broadly in the in hopes of building towards a more prepared, informed, and resilient Alaska.

Appendix A: Supplemental Material

VH- AP

Start of Block: Default Question Block

Q1 Welcome to a UAA survey for Alaskans on Health Concerns!

Please select the box to indicate you are a human.

Page Break

Q3 First we are going to ask some questions about you and your background.

Q4 What is your sex?

- Male (1)
- Female (2)
- Decline to answer (3)

*

Q5 What is your four-digit year of birth? (YYYY)

_____

Q6 What is your primary race?

- ○ Alaska Native / American Indian (1)
- ○ Asian or Pacific Islander (2)
- ○ Black (3)
- ○ White (4)
- ○ Other (5)
- ○ Decline to answer (6)

Q7 What is your highest level of education?

- ○ Less than high school (1)
- ○ High school diploma or GED (2)
- ○ Technical Training Certificate (3)
- ○ Some college (4)
- ○ Associate's Degree (5)
- ○ Bachelor's Degree (6)
- ○ Graduate Degree (7)
- ○ Decline to answer (8)

Q8 What is your current employment status? (select all that apply)

- [ ] Full time (1)
- [ ] Part time (2)
- [ ] Not employed in the paid workforce (3)
- [ ] Retired (4)
- [ ] Disabled (5)
- [ ] Decline to answer (6)

*

Q9 What is your total household income? (all sources of income)

_____

Q10 What type of health coverage (or insurance) do you have? (select all that apply)

- [ ] Indian Health Service (1)
- [ ] Medicaid (2)
- [ ] Medicare (3)
- [ ] Private Health Insurance (4)
- [ ] Veteran's Benefits (5)
- [ ] Uninsured (6)
- [ ] Decline to answer (7)

Q11 What is your home zip code?

_____

Page Break

Q12 Do you consider yourself a religious person?

- ○ Yes (1)
- ○ No (2)
- ○ Decline to answer (3)

Q13 Which best describes your political views?

- ○ Conservative (1)
- ○ Liberal (2)
- ○ Moderate (6)
- ○ Not political (3)
- ○ Other (4)
- ○ Decline to answer (5)

Q14 Were you born in Alaska?

- ○ Yes (1)
- ○ No (2)
- ○ Decline to answer (3)

Page Break

Q15 Next, we ask you to read a brief history on vaccines in the United States.

Q16 Vaccines have been used for almost 1,000 years beginning with a smallpox protection using scabs of infected persons to protect uninfected persons in Turkey, Africa, and parts of Europe in the 1100s. Almost 700 years later, this process was introduced in Great Britain and by 1798, the first vaccination was created against smallpox. Before 1900, vaccines were available for rabies, diphtheria, cholera, typhoid, and the plague.

In 1902, vaccine safety became regulated in the United States due to deaths in 1901 from contaminated vaccines. Once approved, vaccines continue to be improved for easier administration, (for instance a nasal mist), to increase protection (multiple types of virus), reduce side effects (dosage, needle size), and to improve safety.

Between 1915 and 1995, vaccines were approved in the US for whooping cough (pertussis), influenza, tuberculosis, yellow fever vaccine, tetanus, polio, measles, mumps, hepatitis A, hepatitis B, meningitis, and chicken pox. During this time, in 1947, combination vaccines were created and approved, including diphtheria and tetanus as well as measles, mumps, and rubella.

In 2005, the first meningitis vaccine was approved in the US, following by the shingles vaccine (for persons 50+ in 2006). In 2014, the human papillomavirus (HPV) was approved to prevent viral transmission as well as to prevent more than 90% of cancers caused by the virus.

In the US, measles, polio, rubella, pertussis, mumps, and other diseases were eradicated and/or severely reduced in their transmission. Given the success of vaccination programs in the US and other nations beginning in the early 20th century, you are probably here because an ancestor received a vaccine.

The most recent vaccine developed was against COVID- 19. Researchers estimated that in the

US, between December 2020 and November 2022, the COVID-19 vaccine prevented more than 3,000,000 deaths and over 18,000,000 hospitalizations. Of the more than 670,000,000 doses of the COVID-19 vaccine, there have been preliminary reports of 19,224 deaths of persons after receiving a vaccine. After investigation, 9 deaths have been found to be associated with the Johnson & Johnson vaccine.

Page Break

Q17 Next, we ask you about your thoughts on vaccines.

Page Break

Q18 I trust medical providers when recommending vaccines for adults (18 years or older).

- ○ Strongly Agree (1)
- ○ Somewhat agree (2)
- ○ Neither agree nor disagree (3)
- ○ Somewhat disagree (4)
- ○ Strongly disagree (5)

Q19 I trust medical providers recommending vaccines for children (under 18 years of age).

- ○ Strongly Agree (1)
- ○ Somewhat agree (2)
- ○ Neither agree nor disagree (3)
- ○ Somewhat disagree (4)
- ○ Strongly disagree (5)

Q20 All vaccines contain dangerous chemicals.

- ○ Strongly Agree (1)
- ○ Somewhat agree (2)
- ○ Neither agree nor disagree (3)
- ○ Somewhat disagree (4)
- ○ Strongly disagree (5)

Q21 Which vaccines do you believe are safe? (select all)

- [ ] Chicken Pox (US approved in 1995) (1)
- [ ] COVID (US approved in 2022) (2)
- [ ] Flu (US approved 1942) (3)
- [ ] Hepatitis A (US approved 1995) (4)
- [ ] Hepatitis B (US approved 1991) (5)
- [ ] Human papillomavirus (HPV, US approved 2014) (6)
- [ ] Meningitis (US approved 2005) (7)
- [ ] Pneumonia (US approved 1983) (8)
- [ ] Shingles US approved 2006) (9)
- [ ] Measles, Mumps, & Rubella (US approved 1947) (10)

Q22 It is better to develop immunity by getting sick, rather than getting a vaccine.

- ○ Strongly agree (1)
- ○ Somewhat agree (2)
- ○ Neither agree nor disagree (3)
- ○ Somewhat disagree (4)
- ○ Strongly disagree (5)

Q23 I have gotten a flu shot since August 2022.

- ○ Yes (1)
- ○ No (2)
- ○ I intend to get my shot. (3)
- ○ Decline to answer (4)

Q24 I have been vaccinated against COVID.

- ○ Yes (1)
- ○ No (2)
- ○ Decline to answer (3)

Q25 I have received at least one COVID booster.

- ○ Yes (1)
- ○ No (2)
- ○ Decline to answer (3)

Q26 To protect all children, teachers, and staff, vaccines should be required in public schools.

- ○ Yes (1)
- ○ No (2)
- ○ Decline to answer (3)

Q27 Vaccine exemptions should be allowed in public schools for (select all)

- ☐ Religious reasons (1)
- ☐ Parental freedom of choice (2)
- ☐ Documented medical reasons only (3)
- ☐ There should be no exemptions in public schools (4)

Page Break

End of Block: Default Question Block

Appendix B: Supplemental Material

Version Date:
12.21.2023 Form
Version: 610.00.4

UNIVERSITY OF ALASKA FAIRBANKS
THE IMPACT OF MISINFORMATION ON THE COVID-19 RESPONSE IN ALASKA
Adult Consent Form

This form can be read to you if you ask.
This form will tell you about a research study you can join. This study is being done by the University of Alaska Fairbanks as part of a PhD student's research. If you have questions, please ask. Take as much time as you need to decide. If you choose to be in the study, you will need to sign this form.

KEY INFORMATION

What is the purpose, procedures, and duration of the study?
The purpose of this study is to investigate the impact of misinformation on the COVID-19 response in Alaska. This study will enroll about 20 subjects, who will be interviewed in 2024. You are being asked to participate in this study because you have been identified as part of the COVID-19 response. Interviews will focus on your experience of misinformation as a COVID-19 responder. Interviews will last approximately 30 minutes and will take place at a scheduled time, coordinated between you and the researcher. We will ask several questions about the barriers and challenges of misinformation and your experiences with those barriers/challenges.

What are the possible risks and discomforts?
Participation in this study has very minimal risk. Participation will involve talking about COVID-19, which may produce emotional distress. Additionally, the time involved in participating in this study may be a minor inconvenience in your daily routine. There is a very minimal chance of contracting COVID-19 as a result of participating in this study. A contactless interview approach based on phone calls and video conferences will be preferred to limit risk.

Will you benefit from taking part in this study?
The direct benefit for study subjects is the opportunity to contribute unique knowledge and first-hand experience in an effort to address COVID-19 misinformation in Alaska.

What is the name of this research study?
The Impact of Misinformation on the COVID-19 Response in Alaska.

Why is this study being done?
This study is being done to gain a better understanding of how misinformation about COVID-19 affected healthcare, public health and other actors.

What is the goal of the study?
The goal of this study is to investigate the impact of misinformation on different parts of the COVID-19 response in Alaska.

Why am I being asked to be in the study?
You are being asked to voluntarily participate in this study because you have been identified as an important part of the COVID-19 response.

Who should not be in the study?
If you are under 18 years old or do not speak English fluently.

Who has reviewed and approved this study?
This study has been approved by the Alaska Area Institutional Review Board (IRB). IRBs review proposed studies to make sure they follow federal regulations for the protection of human participants in research.

Who is funding this study?
Funding for this study is coming from the National Science Foundation.

If I agree to be in this study, what will I be asked to do?
If you decide to be in this study, we will ask you to do several things:
Sign this consent form, coordinate with the researcher to schedule an interview time, participate in a 30- minute interview, provide your email to receive a $50 gift card for your participation.

Will specimens be taken or stored?
No.

How many people will be in the study?
20

How much of my time will this study take?
1 hour. 30 minutes for the interview and 30 minutes for scheduling and reviewing the consent form.

How much time will the whole study take?
Approximately 1 year.

Is there any risk or discomfort from the study?
Potential loss of confidentiality is a risk of participating in this study, though we will make every effort to prevent anyone who is not on the research team from knowing that you gave information, or what the information is. Participants will not be told any information about other participants. The information that you give will not be used in any future studies, even if personal identifiers are removed.

This list tries to anticipate any potential risks the study has, however, there may be some risks that are currently unknown.

What are the possible risks of this study to my community?
Risks of a study to a community are not always known. The people involved in this study have worked closely with the University of Alaska Fairbanks to make a plan to lessen the risk of harm to your community. This plan says all presentations or publications must be approved by University of Alaska Fairbanks leadership.

How will I benefit from this study?
There will be no direct benefits to you, but the study will help us learn more about misinformation during the COVID-19 pandemic.

Will I be paid to be in the study?

Yes. Participants will receive $50 in gift cards for your time and inconvenience. Gift cards will be sent to the participant within 2 weeks of interview completion.

Who will be able to see my records?
The research team will not access any of your medical records for this study.

How will you protect my confidentiality?
All information will be kept confidential to the extent that is possible. Information we collect from you will be stored with your study identification number. All identifiable information will be stored on a secure online server and only the doctoral student and the principal advisor will have access to it. Summary data that can no longer be connected to you will not be used for future research. Consent forms and any information collected on paper will be stored in locked cabinets and electronic data in password protected secure computer files. Data will be kept for at least 3 years after the funding period ends. It may be kept longer, but all protections of the data must stay in place. Data will be completely destroyed when it is no longer needed.

Government staff sometimes review studies such as this one to make sure they are being done safely and legally. If a review of this study takes place, your records may be examined. The reviewers will protect your privacy.

What happens to the findings from the study?
Results from this study will not be given to individual participants, however they will be available in open source peer-reviewed journals which can be viewed online. Names will not appear in any report or papers resulting from this study. All results that are made public will be summary results, they will not report anything that would identify a person. If any significant new information about COVID-19 misinformation in Alaska comes out and is related to your willingness to participate in this research, research staff will inform you.

Data will be retained indefinitely at the Arctic Data Center. The University of Alaska Fairbanks retains the link between identifiers and unique research subject identifiers for 6 years after the study closes for the potential benefit to the research participant. Papers will be written for publication in scientific literature. These papers will be reviewed and approved by the publisher before being published.

Can I refuse to be in the study?
Yes, taking part in this study is your choice. If you do decide to join the study, you can leave it at any time. There are no consequences for leaving the study. To do so, you can contact the researcher at the email below. Your decision will have no impact on your medical care.

Who do I call if I have questions later or I decide to leave the study?
If you have any questions or study-related injuries or complaints, you may contact the Principal Investigator or the co- Principal Investigator:

{Dr. Arleigh Reynolds, ajreynolds@alaska.edu
Emily Maxwell, elmaxwell@alaska.edu}

If you have any questions about your rights as a study participant, you may call the Alaska Area Institutional Review Board (AAIRB):

Yvonne R. Tanape-Druce, AAIRB Administrator
907-729-3924 (collect calls accepted)
akaalaskaareaIRB@anthc.org
Dr. Shanda Lohse, AAIRB Chairperson
akaalaskaareaIRB@anthc.org

To be in this study, please sign your initials in the appropriate box and then sign the statement below.

	I agree *Please initial*	I disagree *Please initial*
1. **CONSENT FOR FUTURE CONTACT**		

I have read or been told about this research study and all of my questions have been answered to my satisfaction. I have been offered a copy of this consent. **I agree to be in the study.**

Name of participant: _____

Signature of Participant: X _____

Date: _____

Appendix B.2: Supplemental Material

The Impact of Misinformation on the COVID-19 Response in Alaska
NSF#2309906
Stakeholder Interview Guide

BEFORE BEGINNING - HAS CONSENT FORM BEEN SIGNED?

Interviewees: Key informants who had decision-making or response roles related to the COVID-19 response in Alaska (e.g., school officials/staff, communications officials, emergency responders/managers, community health workers, healthcare providers, tribal state/municipal/local government leadership, media, pharmacists, and public health officials in Alaska etc.)

Interviewer name: Emily Maxwell

Preamble:

Hi XX. Thank you so much for taking the time out of your day to participate in this study, I really appreciate it. Like I said in the email, my name is Emily Maxwell and I am a PhD student in the interdisciplinary program at UAF. I am studying epidemiology, and I am researching the impact of misinformation on the COVID-19 response in Alaska. As part of the project, I am interviewing people who were involved in the COVID-19 response. The interview will be about 30 minutes and I will ask you a series of questions, but there will also be room for you to provide additional information that isn't specifically asked.

To give a little background, for my research I am using a specific definition for misinformation: "information considered incorrect based on the best available evidence from relevant experts at the time". That said, for this interview, the definition of misinformation will be somewhat subjective, and you can answer the questions with your own definition in mind.

I will not attribute any of your statements to you or identify you in any other way such as stating your specific place of work or job title. Throughout the interview if you have any questions or need clarification, please let me know. If you are uncomfortable with any questions, let me know and we will skip that question. Do you have any questions before we begin?

Great. I will go ahead and hit record.

Section 1: Professional Role

1. What is your name?

2. During the COVID pandemic, what was your organization and title?

Section 3: Experiences with Misinformation and COVID-19

1. Would you describe your professional role during the pandemic response?

2. Can you describe any times where you came across COVID-19 misinformation in your professional role?

    How many times/how frequently did this happen?

3. Can you describe any ways that misinformation impacted your ability to do your job?

    Probe, if needed.

4. Aside from [describe what they have discussed so far] can you think of any other impacts of COVID-19 misinformation that you noticed in your professional role?

    If yes, please explain.

5. Did COVID misinformation have any impact on your mental health, either directly or indirectly?

6. Can you describe any active steps you took to counter misinformation in your professional role?

    Did you face any barriers when taking those steps? If yes, please describe.

    Overall, do you feel your organization supported you in taking those steps?

    Why or why not?

7. In your opinion, how could [insert participant's organization type (i.e., health agencies, THOs, nonprofits, etc.)] make combatting misinformation easier?

8. In what ways did your organization take steps to counter misinformation?

9. Do you feel your organization's response to misinformation was adequate? Why or why not?

10. Can you think of any information/tool/partnership or other form of support that would help manage misinformation in the future that was not available during the pandemic?

Section 4: Wrap-up

11. Is there anything else you would like to add about your experience with COVID-19 misinformation in your professional role that we haven't touched on?

12. Do you have suggestions for other individuals who had a decision-making or response role related to COVID-19 whom you think we should speak with?

Thank you very much for taking the time to participate in this interview. I will end the recording. Your responses have been very helpful, and I think having your perspective is going to add a lot to the study. You should receive an email shortly with an Amazon giftcard as a small thank you for your help. Have a great day.

Appendix C: IRB Approvals

Alaska Area Institutional Review Board

4315 Diplomacy Drive - IRB
Anchorage, AK 99508

DATE: February 16, 2023

TO: Arleigh Reynolds, PhD, DVM
Principal Investigator
UAF 182 Arctic Health Research Building
2141 Koyukuk Drive
Fairbanks, AK 99775

FROM: Alaska Area Institutional Review Board (IHS IRB #2)

STUDY TITLE: The Impact of Misinformation on the Covid-19 Response in Alaska
IRB REFERENCE #: 2023-01-004-1
SUBMISSION TYPE: New Project

ACTION: APPROVED
APPROVAL DATE: February 14, 2023
NEXT REPORT DUE: February 28, 2026
REVIEW TYPE: Expedited Review

REVIEW CATEGORY: 45 CFR 46.110 (6)(7)

Dear Dr. Reynolds:

The Alaska Area Institutional Review Board (AAIRB) has given approval through Expedited Review to the protocol [1983059-1] The Impact of Misinformation on the Covid-19 Response in Alaska. Tribal approval is required in addition to IRB approval. The protocol was approved on February 14, 2023.

Per 45 CFR 46.109 (f)(1), unless an IRB determines otherwise, continuing review is not required for expedited research categories. As a reminder, the protocol and all accompanying documents may not have modifications for this decision to remain valid. Prior to making any changes to the protocol you must receive approval from the AAIRB. Every 36 months the AAIRB requires a status report. **The Next Report Due date for this project is February 28, 2026.** Upon completion of the project an AAIRB Closure Application and all required documents must be submitted.

As a reminder, it is your responsibility as Principal Investigator (PI) to maintain the status of your project by tracking and monitoring all activities related to the protocol. All research approved by the AAIRB is subject to 45 CFR 46 "Protection of Human Subjects" regulations, the US Food and Drug Administration regulations and the principles of the Belmont Report. Investigators are expected to be familiar with these provisions and to strictly adhere to all requirements. You are required to have all personnel involved in the research complete the training at www.citiprogram.org, once every 36 months with a 75% proficiency in all modules. Retain your completion certificates from the Collaborative Institutional Training Initiative (CITI).

All research involving staff, patients, or resources at the Alaska Native Medical Center (ANMC) must be reviewed and approved by ANMC's parent organizations after the AAIRB approval is obtained. The parent organizations of ANMC are the Alaska Native Tribal Health Consortium (ANTHC) and Southcentral Foundation (SCF). Tribal review and approval is required for all research protocols prior to initiation. Any manuscripts or abstracts for publication or presentations involving ANMC staff, patients, or resources

must also be reviewed and receive tribal approval prior to submission. To initiate tribal review with ANTHC please contact ResearchReviewCmtee@anthc.org and with SCF contact scfresearchreview@scf.cc. Please allow at least 8 weeks for tribal review and approval.

If you have further questions for the AAIRB you may contact us at akaalaskaareaIRB@anthc.org or call (907) 729-3924.

Sincerely,

Yvonne R. Tanape-Druce
Alaska Area Institutional Review Board
IRB Administrator

IRB Authorization Agreement

Name of Institution or Organization Providing IRB Review (Institution A):
Indian Hlth Service IRB #2 [1]
IRB Registration #: IRB00000636
Federal wide Assurance (FWA) #: FWA00008394

Name of Institution Relying on the Designated IRB (Institution B):
University of Alaska Fairbanks [2]
IRB Registration #: IRB00000991
Federal wide Assurance (FWA) #: FWA00001041

The Officials signing below agree that Institution B may rely on the designated IRB for review and continuing oversight of its human subject research described below:

(___) This agreement applies to all human subject research covered by Institution B's FWA.

(_X_) This agreement is limited to the following specific protocol(s):
Name of Research Project: The Impact of Misinformation on the Covid-19 Response in Alaska
IRB Reference #: 2022-01-004-I
Name of Institution B Principal Investigator: Dr. Ashleigh Reynolds
Sponsor or Funding Agency: National Science Foundation – Doctoral Dissertation Research Improvement Grant
Award Number, if any: 1919208

(___) Other (describe):

The Reviewing Institution (Institution A) agrees to the following in regard to the above listed research protocol or activities:

I. Provide initial and continuing review in accordance with 45 CFR 46 and its FWA.

II. Arrange for prompt reporting to the Relying Institution's IRB of any of the following, as defined and determined by the Reviewing Institution's IRB:

   a. Any unanticipated events or problems involving risks to subjects or others.

   b. Any serious or continuing non-compliance.

c. Any suspension or termination of IRB approval.

III. Comply with all applicable Federal, State, and Local laws and regulations.

IV. IRB meeting minutes will be made available to the Relying Institution's IRB upon request.

V. Copy the Relying Institution on all correspondence to regulatory agencies if reporting of an event is required.

The Relying Institution (Institution B) remains responsible for the following:

I. Ensuring research activities at its site are in compliance with the IRB's determinations and with the terms of its OHRP-approved Assurance.

II. Adhering to its institutional conflict of interest policies and procedures and providing the reviewing Institution with any applicable COI management plan related to the study.

III. Ensuring principal investigators and other research personnel involved in the research are appropriately qualified and meet its institutional standards for eligibility to conduct research, including but not limited to having the required professional staff appointments, credentialing, insurance coverage, and background checks for their assigned role in the research and training in the protection of human subjects.

This document must be kept on file at both institutions and provided to OHRP upon request. This agreement will become effective upon the date of the last signature by the institutional officials below and will remain in effect until such time that either institution provides 30 days written notice of termination to the other institution.

Signature of Signatory Official (Institution A):

Francis F. Frazier -S

Digitally signed by Francis F. Frazier -S
Date: 2023.04.06 12:09:55 -04'00'

Date: _____

Print Full Name: Rear Admiral Francis Frazier, MSN/FNP, MPH

Institutional Title: Director, Office of Public Health Support, Indian Health Services

Signature of Signatory Official (Institution B):

DocuSigned by:
Nettie La Belle-Hamer

Date: April 3, 2023

Print Full Name: Dr. Nettie La Belle-Hamer

Institutional Title: Institutional Official / Vice Chancellor for Research

[1]Contact for Institution A:
Alaska Area Institutional Review Board, 4315 Diplomacy Drive – IRB, Anchorage AK 99508, 907-729-3924
[2]Contact for Institution B:
UAF, Office of Research Integrity, PO Box 757270, Fairbanks, AK 99775-7270, 907-474-7800