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A Systematic Literature Review of the Use of Technology as an Emergency Preparedness Tool to Control and Contain the COVID-19 Pandemic

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Emergency Preparedness

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Abstract

Various tools and strategies have been utilized in response to the COVID-19 pandemic. In addition to preexisting measures, novel mechanisms and methods have also been developed since the COVID-19 pandemic began to address several different needs worldwide. Technology, for example, has served as a unique and multifunctional tool to aid with controlling and containing the pandemic. While studies and reviews have been conducted to analyze specific types of technology, such as digital applications, a gap in the literature currently exists that fails to comprehensively understand and compare how multiple types of technology were implemented to address the COVID-19 pandemic. This systematic literature review examined how several types of technology were utilized worldwide to help control and contain the COVID-19 pandemic. Articles were pulled from multiple databases, including CINAHL, Embase, ERIC, and PubMed. The findings from this systematic literature review contribute to understanding the multifaceted capabilities that digital and mobile applications, artificial intelligence, and geographic information systems have in addressing widespread infectious disease outbreaks and aiding with the future development of emergency preparedness plans and procedures.

Chapter 1: Project Description

Specific Aims and Research Question

Since the beginning of the COVID-19 pandemic, several different tools, strategies, and procedures have been developed and implemented to address the situation's unique and often novel needs. This systematic literature review aims to understand how various types of technology have been developed and utilized as emergency preparedness tools to control and contain the COVID-19 pandemic. This literature review focuses on applications of technology and any issues encountered with trying to utilize technology, such as potential ethical concerns. This review defines technology as mobile and digital applications, artificial intelligence, and geographic information systems. The following research question guided the focus of the systematic literature review.

1. How were various types of technology utilized as emergency preparedness tools to help control and contain the COVID-19 pandemic worldwide?

After completing the systematic literature review, the findings from the review were utilized to discuss public health implications and suggest how technology can be incorporated and implemented into various phases of emergency management in the future. These suggestions focused on multiple areas based on the literature review results. Additionally, strengths, limitations, and gaps in evidence from this literature review and the associated articles were also discussed. The review will conclude with a discussion of the implications of the systematic literature review and the formulated technology suggestions for emergency preparedness in the broader field of public health.

Chapter 2: Significance and Background

Development of COVID-19 as a Pandemic

Though it may begin as an isolated case of an illness, new types of infectious diseases can quickly spread across a region, country, and the world and rapidly increase case numbers (Hunter et al., 2020). In late December 2019, a new respiratory virus outbreak started to occur in Wuhan, the capital of the Hubei province in China. Within a month, cases of the new respiratory virus were confirmed in several other countries worldwide (He et al., 2020; Singh & Singh, 2020). During that time, the virus was identified as severe acute respiratory syndrome coronavirus 2 or SARS-CoV-2, with the resulting illness referred to as the 2019 coronavirus disease or COVID-19. As cases of the respiratory disease continued to increase and spread to new countries, the World Health Organization (WHO) officially declared COVID-19 a pandemic on March 11, 2020 (Carvalho et al., 2021; "Listings," 2020). Ultimately, the COVID-19 pandemic tremendously impacted the physical and mental health of millions of individuals across the world, numerous economies, and healthcare and public health systems, resulting in a complex and intricate response (Carvalho et al., 2021; Gavin et al., 2020; He et al., 2020; Udalova, 2021).

While several advancements have been made throughout the past several decades to address and reduce the negative impacts of pandemics, numerous new procedures and tools were developed during the COVID-19 pandemic to aid with the response (Kondylakis et al., 2020). One example of a newly developed tool was the creation and utilization of technology, such as applications or “apps” that could help screen for COVID-19 symptoms and provide guidance to individuals based on their responses (Alanzi, 2021; Kondylakis et al., 2020; Menni et al., 2020; Ramakrishnan et al., 2020). To adequately understand the impacts and benefits of technology to address the COVID-19 pandemic, it is essential to provide an overview of the different types of relevant technology and how they were used in various settings.

Technology Types

Functions of available apps

A frequent function of many COVID-19 apps was to serve as a primary educational platform for individuals to find the most updated information related to the pandemic. This educational information could include any new developments about COVID-19 and potential changes to guidelines and COVID-19 restrictions implemented on a national, state, or local level (Alanzi, 2021; Kondylakis et al., 2020). Another standard function of COVID-19 apps was to help individuals connect with various healthcare professionals to receive different types of care and treatments. These apps allowed individuals to manage appointments more efficiently and interact with a healthcare professional through a virtual consultation while maintaining distancing and lockdown protections. Individuals utilizing this function of COVID-19 apps could be seeking medical advice for a variety of health-related topics, including a potential COVID-19 infection (Alanzi, 2021; John Leon Singh et al., 2021; Kondylakis et al., 2020).

A unique and beneficial function of many COVID-19 apps was the ability to aid with contact tracing. Some apps had basic features that allowed users to more accurately determine the individuals they may have come into contact with that might also be exposed. Other apps aided individuals with following quarantine and isolation guidelines based on their exposure and any symptoms they might be experiencing (Alanzi, 2021; John Leon Singh et al., 2021; Kondylakis et al., 2020). Certain apps, however, operated with more complex and advanced features that utilized the location settings and functions on cell phones to help trace and contact individuals that were exposed to or were in close contact with a person who tested positive for

COVID-19 (Ramakrishnan et al., 2020). Regardless of the app's complexity, these contact tracing features were essential in helping reduce the spread of COVID-19, which was a benefit also seen with another feature of countless COVID-19 apps.

Apps as screening tools

In addition to the numerous other beneficial features of COVID-19 apps, symptom screening tools played an essential role in responding to the COVID-19 pandemic. These symptom screening apps allowed individuals to self-screen for various COVID-19 symptoms to determine the likelihood or potential that they might be infected with COVID-19 (Ford et al., 2020; Menni et al., 2020; Ramakrishnan et al., 2020). Depending on the app, individuals could then receive guidance about the next steps that they should take based on their screening responses. For example, if individuals indicated they were experiencing several symptoms related to COVID-19, they may be advised to isolate themselves from other individuals and receive a COVID-19 test (Ford et al., 2020; Menni et al., 2020; Ramakrishnan et al., 2020). Additionally, if an individual did test positive for COVID-19, some of the available symptom screening apps could also be utilized to track the severity of their symptoms and if further healthcare assistance or intervention may be advised. While several of these screening apps were primarily for individuals to self-screen, healthcare workers and other first responders could also utilize these apps to help determine the likelihood of their patient or other individuals being infected with COVID-19 (Ford et al., 2020; Menni et al., 2020; Ramakrishnan et al., 2020).

In addition to being utilized by various individuals, COVID-19 symptom screening and tracking apps were also incorporated into the safety precautions of numerous organizations and institutions. Certain employers, for example, required their employees to complete a COVID-19 screening to determine if it was safe for them to work in person or if they should work from home (Pifer, 2020; Zielinski, 2020). Additionally, other employers had their employees complete a daily COVID-19 screening to track the health status of their workforce to help predict potential impacts to the organization's capabilities (Zielinski, 2020).

Like employers, colleges and universities across the country also incorporated COVID-19 symptom screening tools into their safety guidelines. Before being allowed on campus, students were typically required to complete a screening using a COVID-19 app to determine their likelihood of having COVID-19 (Burbach, 2020; “Creighton,” 2020). If individuals had a moderate to high risk of a COVID-19 infection, they were often recommended to stay in their place of residence, and accommodations were made to aid them with their academic responsibilities. By implementing these required screenings by employers, colleges, and universities, the likelihood of the disease being spread between individuals was reduced as individuals that had a high risk of being infected with COVID-19 were recommended not to come in close contact with other individuals in the community (Burbach, 2020; “Creighton,” 2020).

Artificial Intelligence

Though it is beneficial to track various components associated with the spread of COVID-19, it is also essential to identify and understand new information related to the virus. One practical use of artificial intelligence has been the data mining and analyzing capabilities of multiple platforms. For example, artificial intelligence was utilized to rapidly review many social media posts to determine commonly mentioned words or phrases related to COVID-19, such as new or frequently mentioned symptoms (Ahuja et al., 2020; Vaishya et al., 2020). Additionally, artificial intelligence was also utilized to rapidly review large amounts of journal articles or other credible information sources to determine best practices. With the capabilities of artificial intelligence, large quantities of information can be examined, which can lead to changes to the overall understanding, policies, and response strategies related to COVID-19 (Ahuja et al., 2020; Alimadadi et al., 2020; Vaishya et al., 2020).

Geographic Information Systems

While various COVID-19 digital applications played a significant role in addressing the COVID-19 pandemic, geographic information systems were another other vital pieces of technology utilized as emergency preparedness tools. Geographic information systems, for example, played a critical role in helping identify COVID-19 hotspots or areas with rapidly increasing reported case counts. By quickly identifying these areas, actions could be taken to prevent the further spread of the disease and analyze specific factors that led to an increased spread of the disease (Carballada and Balsa-Barreiro, 2021; Mollalo et al., 2020). Geographic information systems also contributed to increasing the quality of care in certain areas by identifying regions facing more severe consequences of the pandemic due to socioeconomic and demographic factors. By recognizing these health disparities, resource management could be focused on ensuring equal treatment and responses effort for all areas impacted by the COVID-19 pandemic (Carballada and Balsa-Barreiro, 2021; Mollalo et al., 2020).

Gaps in Literature and Rationale for Review

While some information about digital and mobile applications, artificial intelligence, and geographic information systems utilized for the COVID-19 pandemic is available, the literature associated with these aspects of technology has not been organized into systematic discussions (Almalki & Giannicchi, 2021). Current research fails to comprehensively review and compare various types of technology in the context of emergency preparedness and public health tools to control and contain the COVID-19 pandemic worldwide. The research conducted through this systematic literature review will further contribute to understanding the benefits and potential drawbacks of utilizing technology as an emergency preparedness and public health tool for addressing infectious disease outbreaks. With a more comprehensive understanding of the utilization of technology, more effective strategies for emergency preparedness and management can be developed and implemented.

Chapter 3: Methodology

Formulating a Research Question

The first step in this systematic literature review was developing a research question to guide the process of searching various databases and selecting articles for further review and analysis (Tawfik et al., 2019; Wilson et al., 2017). While the topic of technology utilization in emergency preparedness and response has the potential for a very broad review, this study focused specifically on how technology was utilized to address the COVID-19 pandemic globally. Therefore, the following research question will be the focus of the systematic literature review.

1. How were various types of technology utilized as emergency preparedness tools to help control and contain the COVID-19 pandemic worldwide?

Evaluation and Selection

Inclusion and Exclusion Criteria

After the research question was established, six different categories of inclusion and exclusion criteria were developed, as indicated in Figure 1. These categories consist of technology type, disease application, outcomes, type of publication, publication date, and language (Tawfik et al., 2019; Wilson et al., 2017). The purpose and utilization of these criteria can be broken down into two different phases. The first phase of application aided in the preliminary review of various components of articles, such as language, publication date, and publication type, during the initial literature search. The second phase of utilization for the inclusion and exclusion criteria aided in further evaluation of the articles selected for a more in-depth review by applying the criteria related to technology type, disease application, and outcomes (Tawfik et al., 2019; Wilson et al., 2017).

Figure 1

Inclusion and Exclusion Criteria for Article Selection

Concept	Inclusion Criteria	Exclusion Criteria
Technology Type	- Associated with mobile and digital applications, artificial intelligence, geographic information systems and mapping.	- Not associated with mobile and digital applications, artificial intelligence, and geographic information systems and mapping.
Disease Application	- Technology utilized to address COVID-19.	- Technology not utilized to address COVID-19.
Outcomes	- Mobile and digital applications utilized as tools or resources to control and/or contain the COVID-19 pandemic. - Artificial intelligence utilized as a tool or resource to control and/or contain the COVID-19 pandemic. - Geographic information systems and mapping utilized as a tool or resource to control and/or contain the COVID-19 pandemic.	- Mobile and digital applications were not utilized as a tool or resource to control and/or contain the COVID-19 pandemic. - Artificial intelligence was not utilized as a tool or resource to control and/or contain the COVID-19 pandemic. - Geographic information systems mapping was not utilized as a tool or resource to control and/or contain the COVID-19 pandemic.
Type of Publication	- Academic journals publications and articles	- Non-academic journal publications or articles
Publication Date	- Published after the year 2020	- Published before the year 2020
Language	- English Language	- Non-English Language

Conducting Literature Search

Search strategy

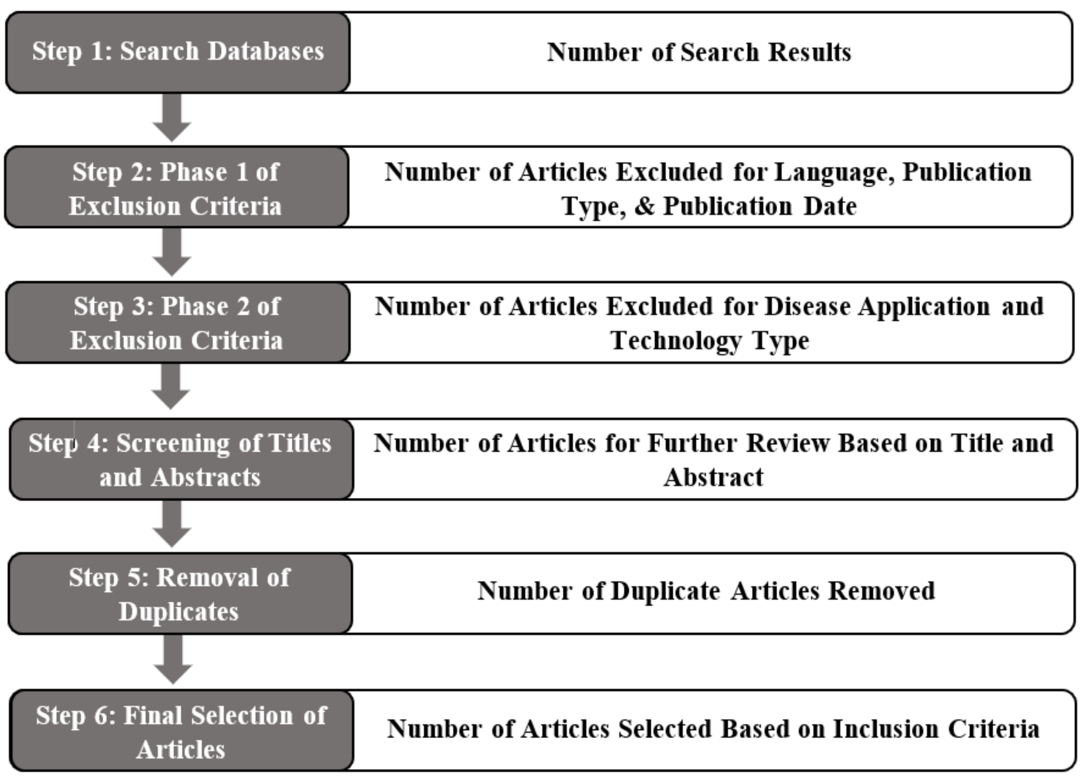
After the inclusion and exclusion criteria were developed, the literature search was guided by creating multiple search strategies. The search strategies created for the literature search involved multiple components and concepts necessary for finding and selecting appropriate and credible resources to be considered and included in the final review (Tawfik et al., 2019; Wilson et al., 2017). To help facilitate and manage these strategies, concept charts were created that list keywords and alternate terms specific to each of the different databases. The primary keywords listed in these charts and incorporated into the search strategies included digital applications, mobile applications, artificial intelligence, geographic information systems, COVID-19, emergency preparedness, prevention, containment, and control. These charts were also developed to track the number of results produced from each search strategy and the number of excluded articles based on the established criteria (Tawfik et al., 2019; Wilson et al., 2017). An example of a concept chart can be found in Appendix A.

Through the use of concept charts and multiple search strategies, the literature search was then conducted through a six-step process, as demonstrated in Figure 2, and utilized for four different databases, including CINAHL, Embase, ERIC, and PubMed. The first step in the search process was to determine the number and type of articles that would result from testing or searching each of the developed search strategies (Tawfik et al., 2019; Wilson et al., 2017). Based on the results of the searches, the second step of the process was then initiated to exclude articles that did not meet the inclusion criteria for language, publication type, and publication date. Additionally, more articles were excluded in the third step of the process based on whether or not they met the inclusion criteria set for disease application and technology type (Tawfik et al., 2019; Wilson et al., 2017).

Once the initial phases of excluding articles were completed, the remaining articles were reviewed in more detail during step four, based on their titles and abstracts. To prevent any articles from being included multiple times, duplications were removed in step five of the literature search process (Tawfik et al., 2019; Wilson et al., 2017). Lastly, step six involved the selection of the final articles that would then be reviewed in complete detail and included in the review and analysis. All final articles were saved, categorized, and organized using the reference management software Zotero (Tawfik et al., 2019; Wilson et al., 2017).

Figure 2

Six-Step Literature Search and Article Selection Process



Data Extraction

Data extracted from the selected articles can be categorized into multiple areas based on the three types of technology that served as the focus for this review. For digital and mobile applications, extracted data was organized into the areas of detection and screening, contact tracing, and limitations. Artificial intelligence extracted data were categorized into diagnosing and screening, disease forecasting, tracking, trend identification, and limitations. Lastly, extracted data related to geographic information systems were organized into the three areas of mapping case spread, identification of population vulnerabilities, and contact tracing.

Chapter 4: Results

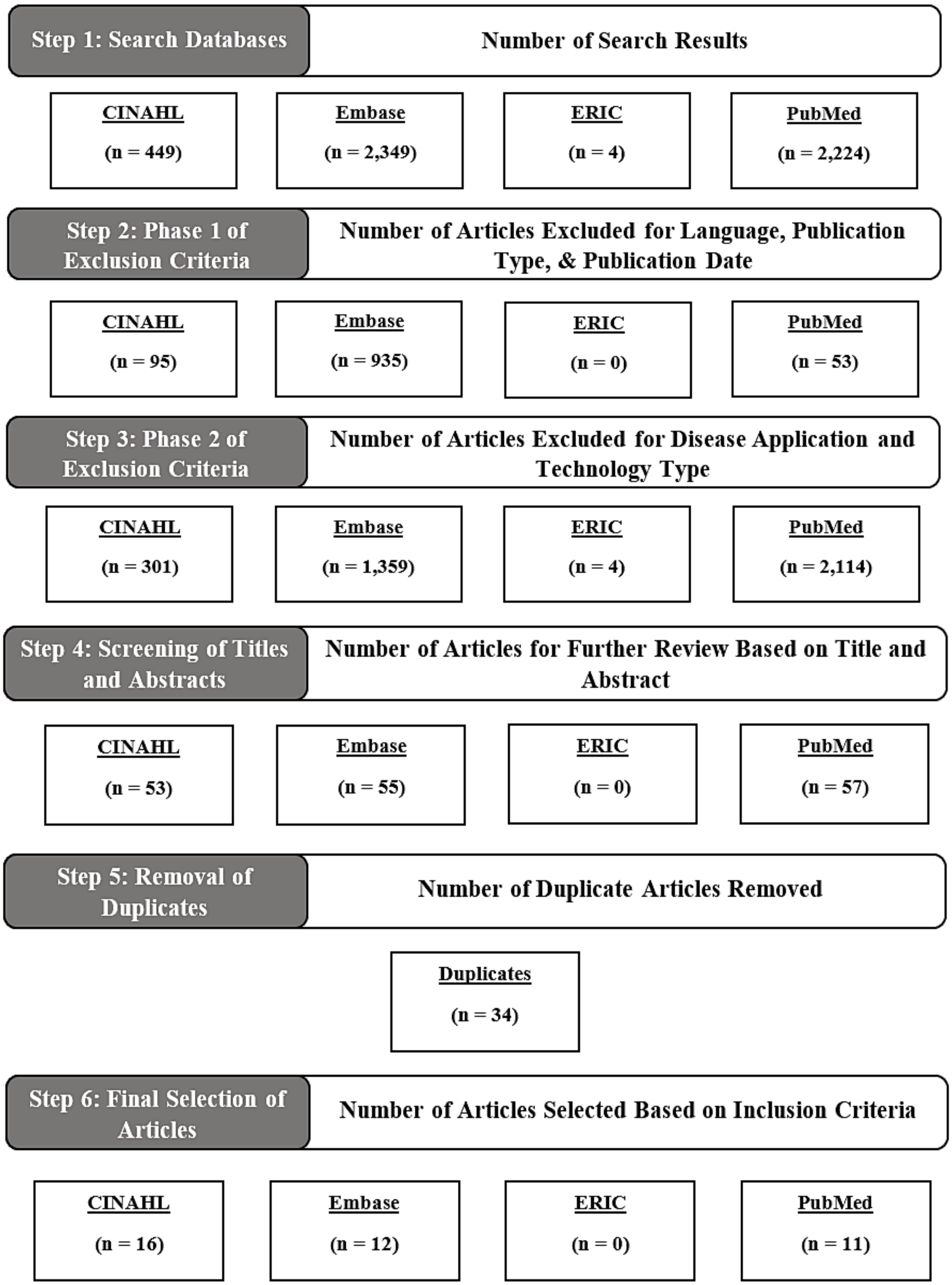
Search Results and Selection Process

For the first step in the literature search process, thousands of search results were found across the four different databases. As detailed in Appendices A, B, C, and D, multiple search strategies were utilized to find these results. A total of 449 results were associated with CINAHL, 2,349 results were associated with Embase, four results were associated with Eric, and 2,224 results were associated with PubMed, which is indicated in Figure 3. The first phase of applying the inclusion and exclusion criteria resulted in the exclusion of 95 results from CINAHL, 935 results from Embase, 0 results from Eric, and 53 results from PubMed based on the criteria of language, publication date, and publication type. The next step in the process resulted in the exclusion of 301 results from CINAHL, 1,359 results from Embase, four results from Eric, and 2,114 results from PubMed based on the inclusion and exclusion criteria related to technology type and diseases application.

Once the first two phases of applying the inclusion and exclusion criteria were completed, 53 results from CINAHL, 55 results from Embase, 0 results from ERIC, and 57 results from PubMed were further analyzed by reviewing the titles and abstracts of these articles. In the final phases of the review, 34 duplicate articles were removed and 16 articles from CINAHL, 12 articles from Embase, 0 articles from ERIC, and 11 articles from PubMed were selected for 39 total articles to be included in the final review.

Figure 3

Six-Step Literature Search and Article Selection Process with Results



Description of Studies

Information collected from the reviewed articles can be broken down based on the three different types of technology, digital and mobile applications, artificial intelligence, and geographic information systems, that served as the focus for this review. A total of nine different themes were identified across the three different types of technology. These themes were distributed evenly as each type of technology was associated with three main themes.

Digital and Mobile Applications

Though the specific details varied between the articles, three overarching themes were identified across the 11 articles related to digital and mobile applications, as indicated in Figure 4. The first theme was related to utilizing digital and mobile applications for contact tracing for COVID-19; this theme was found in five of the articles. The second theme identified was found in three articles and was associated with understanding how digital and mobile applications were utilized as a tool to detect and screen for COVID-19 and COVID-19 symptoms. Lastly, the third theme highlighted for this type of technology was the limitations of using digital and mobile applications as an emergency preparedness tool to help control and contain the pandemic. A total of four articles were associated with this theme.

Figure 4

Digital and Mobile Applications Citations and Key Concepts

Database	Citation	Key Concepts
Embase	Altmann et al., 2020	- Limitations with using digital and mobile application(s)
CINAHL	Bernard et al., 2020	- Limitations with using digital and mobile application(s)
CINAHL	Chaudhary et al., 2021	- COVID-19 contact tracing tool
Embase	Garousi & Cutting, 2021	- COVID-19 contact tracing tool - Limitations with using digital and mobile application(s)
CINAHL	Guillon & Kergall, 2020	- COVID-19 contact tracing tool
CINAHL	Heithoff et al., 2022	- COVID-19 detection and screening tool
PubMed	Lee et al., 2021	- COVID-19 detection and screening tool
Embase	Saeidnia et al., 2022	- COVID-19 detection and screening tool
PubMed	Salathé et al., 2020	- COVID-19 contact tracing tool
CINAHL	Williams et al., 2021	- Limitations with using digital and mobile application(s)
PubMed	Wymant et al., 2021	- COVID-19 contact tracing tool

Artificial Intelligence

For artificial intelligence, 14 articles were selected and reviewed for this specific technology type, as indicated in Figure 5. The first significant theme recognized from these articles was using artificial intelligence to help forecast the spread of COVID-19 cases and identify and track any trends associated with COVID-19 cases or outbreaks. This specific theme was discussed in seven of the 14 total articles. The second significant theme highlighted in this group of articles was the application of artificial intelligence to serve as a tool for COVID-19 diagnostics and symptom screening. A total of five articles discussed this idea and theme. The third notable theme, found in two articles, was understanding the limitations of utilizing artificial intelligence as an emergency preparedness resource to address COVID-19.

Figure 5

Artificial Intelligence Citations and Key Concepts

Database	Citation	Key Concepts
Embase	Abdeldayem et al., 2022	- COVID-19 forecasting - COVID-19 trends - COVID-19 case/ outbreak tracking
PubMed	Adly et al., 2020	- COVID-19 diagnostic and screening tool
Embase	Asada et al., 2021	- COVID-19 diagnostic and screening tool
CINAHL	Chen & See, 2020	- Limitations with using artificial intelligence
CINAHL	Dong et al., 2021	- COVID-19 diagnostic and screening tool
PubMed	Ibeneme et al., 2021	- Limitations with using artificial intelligence
CINAHL	Naseem et al., 2020	- COVID-19 forecasting - COVID-19 trends - COVID-19 case/ outbreak tracking
PubMed	Syrowatka et al., 2021	- COVID-19 forecasting - COVID-19 trends - COVID-19 case/ outbreak tracking
Embase	Tao et al., 2022	- COVID-19 forecasting - COVID-19 trends - COVID-19 case/ outbreak tracking
CINAHL	Tkatek et al., 2020	- COVID-19 forecasting - COVID-19 trends - COVID-19 case/ outbreak tracking
PubMed	Vaishya et al., 2020	- COVID-19 forecasting - COVID-19 trends - COVID-19 case/ outbreak tracking
CINAHL	Van Baal et al., 2022	- COVID-19 diagnostic and screening tool
Embase	Wang et al., 2021	- COVID-19 diagnostic and screening tool
CINAHL	Yu et al., 2021	- COVID-19 forecasting - COVID-19 trends - COVID-19 case/ outbreak tracking

Geographic Information Systems

Geographic information systems were discussed in 14 articles, highlighted in Figure 6. For this specific technology type, the most significant and discussed theme was using geographic information systems as a tool to aid with COVID-19 surveillance, specifically the surveillance of the spread of COVID-19 cases. In total, 10 of the 14 articles mentioned this theme. The second theme mentioned in three of the articles was the idea of applying geographic information systems to identify potential geographic and population variables that could make areas more vulnerable or suspectable to COVID-19. Lastly, the third theme represented in one of these articles related to geographic information systems were incorporating this type of technology into contact tracing strategies for COVID-19.

Figure 6

Geographic Information System(s) Citations and Key Concepts

Database	Citation	Key Concepts
Embase	Ahasan & Hossain, 2021	- COVID-19 tool for surveillance of spread
Embase	Bello et al., 2021	- COVID-19 tool for surveillance of spread
CINAHL	De Vito et al., 2021	- COVID-19 tool for surveillance of spread
Embase	Gangwar & Ray, 2021	- COVID-19 tool for surveillance of spread
CINAHL	Jesri et al., 2021	- Geographic and population vulnerabilities for COVID-19
CINAHL	Kabir et al., 2021	- COVID-19 tool for surveillance of spread
Embase	Mollalo et al., 2020	- COVID-19 tool for surveillance of spread
PubMed	Rahman et al., 2021	- Geographic and population vulnerabilities for COVID-19
PubMed	Rezaei et al., 2020	- COVID-19 tool for surveillance of spread
CINAHL	Saeed et al., 2021	- COVID-19 tool for surveillance of spread
Embase	Schmidt et al., 2021	- COVID-19 tool for surveillance of spread
PubMed	Shadeed & Alawna, 2021	- Geographic and population vulnerabilities for COVID-19
PubMed	Shariati et al., 2020	- COVID-19 tool for surveillance of spread
CINAHL	Smith & Mennis, 2020	- COVID-19 contact tracing tool

Summary of Findings

Basic background information is known about some of the rudimentary uses of technology to address the COVID-19 pandemic. Details comparing these types of technology and their specific uses as emergency preparedness tools, however, can be more thoroughly understood by summarizing the information extracted from the 39 articles selected and reviewed for this study. The first type of technology that can be summarized and understood in more robust detail is digital and mobile applications.

Digital and Mobile Applications

Contact Tracing

Contact tracing is a three-part process involving identification, assessment, and management of exposure to help individuals determine potential quarantine or isolation guidelines based on their situation. Contact tracing during the COVID-19 pandemic was essential, as the goal of utilizing this process was to prevent other individuals from being exposed and to reduce the spread of the disease (Chaudhary et al., 2021; Guillon & Kergall, 2020; Salathé et al., 2020). The process of facilitating contact tracing, however, quickly overwhelmed resources in countless countries and triggered the need for new resources to be developed. Contact tracing applications or apps were then developed to be downloaded on nearly any mobile or digital device, such as a smartphone or tablet, to help meet this need. (Chaudhary et al., 2021; Garousi & Cutting, 2021; Guillon & Kergall, 2020; Salathé et al., 2020; Wymant et al., 2021).

While several contact tracing apps were made available worldwide, some countries developed and promoted their own apps, such as the SwissCovid app in Switzerland or the StopCovid app in France (Guillon & Kergall, 2020; Salathé et al., 2020). These contact tracing tools operated quite similarly regardless of the specific app. Through the use of Bluetooth and location software on digital and mobile devices, individuals with the downloaded app on their device would receive a notification for being a close contact if they were around another app user that indicated they tested positive (Chaudhary et al., 2021; Garousi & Cutting, 2021; Guillon & Kergall, 2020; Salathé et al., 2020). Based on the app type and the guidelines implemented in the individual's location, information about next steps, such as quarantining, would frequently be sent along with the notification of being a close contact. Having millions of individuals download and utilize digital and mobile contact tracing applications was a significant benefit in reducing the burden of COVID-19 as these tools likely helped reduce the spread of the disease and decreased the number of cases and fatalities (Chaudhary et al., 2021; Garousi & Cutting, 2021; Guillon & Kergall, 2020; Salathé et al., 2020; Wymant et al., 2021).

Detection and Screening Tools

In addition to contact tracing, another common feature and purpose of digital and mobile applications to aid with the pandemic was to detect and screen for potential COVID-19 symptoms. Detection and screening were conducted through two primary methods. First, several apps allowed individuals to self-screen for potential symptoms by answering a series of questions, such as indicating if they have a fever or cough. After this self-screening process was conducted, information would typically be provided indicating their risk level of being positive for COVID-19 and if it was recommended they should be tested (Heithoff et al., 2022; Lee et al., 2021; Saeidnia et al., 2022).

An ongoing development of a second method to detect and screen for symptoms includes utilizing biosensors, fluorescence imaging, and other smartphone features that are currently being used to help measure other biometric data, such as heart rate. Though these features are already on several different types of smartphones and other devices, an app would also need to be created. The application would help intake the individual biometric data and associate it with basic information about an individual's risk level of having COVID-19 (Heithoff et al., 2022).

Limitations with Utilization and Application

Despite the beneficial utilization of digital and mobile applications to help control and contain the COVID-19 pandemic, some limitations exist with these apps' current and future applications. First, individuals were frequently concerned about how the various contact tracing applications might violate their privacy. Since many contact tracing apps would require disclosure of personal information, including location and potential COVID-19 status, individuals were often deterred from downloading these apps as they were not comfortable sharing this information (Altmann et al., 2020; Bernard et al., 2020; Garousi & Cutting, 2021; Williams et al., 2021). Additionally, individuals often reported being concerned or skeptical of how their personal information would be stored and if it would be potentially shared with other entities. Lastly, apps developed and controlled by a country’s government were also scrutinized as individuals were concerned about surveillance that went beyond addressing COVID-19 (Altmann et al., 2020; Bernard et al., 2020; Garousi & Cutting, 2021; Williams et al., 2021).

Artificial Intelligence

Forecasting and Tracking Trends

To maintain comprehensive situational awareness for COVID-19, it was essential to track trends occurring with the disease, such as outbreaks or increases and decreases in case counts. The application and utilization of artificial intelligence were crucial in collecting this type of information (Abdeldayem et al., 2022; Naseem et al., 2020; Syrowatka et al., 2021; Tkatek et al., 2020; Vaishya et al., 2020; Yu et al., 2021). For example, since COVID-19 rapidly started to increase worldwide, the amount of information related to cases quickly became overwhelming and required the utilization of technology, such as artificial intelligence, to manage and create meaningful interpretations of the data being collected. Artificial intelligence, therefore, was able to aid in synthesizing the data to create visual representations that depicted increases and decreases in case counts and what type of trends were occurring in various regions. (Abdeldayem et al., 2022; Tkatek et al., 2020; Yu et al., 2021).

Several different hotspots and forecasting maps were also created using artificial intelligence. These maps could indicate current outbreaks of COVID-19 and forecast potential future locations that may experience outbreaks. Information from the trend, hotspot, and forecasting maps allowed public health professionals, healthcare workers, and policymakers to initiate necessary changes in COVID-19 guidelines and procedures (Abdeldayem et al., 2022; Syrowatka et al., 2021; Tkatek et al., 2020; Yu et al., 2021).

Lastly, artificial intelligence aided healthcare workers in monitoring symptoms for patients positive with COVID-19. Instead of manually tracking trends on their own, healthcare workers could utilize artificial intelligence to help track trends in patient symptoms. Artificial intelligence could then take these trends and potentially forecast future symptoms that an individual may experience based on their situation (Naseem et al., 2020; Tao et al., 2022; Vaishya et al., 2020).

Diagnostics and Symptom Screening

In addition to tracking trends in symptoms, artificial intelligence also aided healthcare workers by providing information regarding diagnostics and treatments. For example, a few situations were reported where artificial intelligence assisted with analyzing chest and lung imaging. This was accomplished by comparing the chest and lung images of a patient to a database with thousands of other related images to assist with distinguishing between issues related to COVID-19 and issues unrelated to COVID-19 (Asada et al., 2021; Dong et al., 2021; Wang et al., 2021). This process aided healthcare workers in diagnosing and establishing the appropriate treatment plans for a patient. By having a faster process of comparing various types of images and developing a treatment plan, artificial intelligence was also able to help reduce the burden on healthcare workers by allowing them to diagnose and treat patients more efficiently (Asada et al., 2021; Dong et al., 2021; Wang et al., 2021).

The application of artificial intelligence as a symptom screening tool was another method for how this type of technology helped reduce the burden of the pandemic on healthcare workers and others involved in the response. Instead of healthcare and public health workers trying to answer the countless questions from individuals about their symptoms, artificial intelligence was utilized to develop online chatbots that could answer basic questions regarding symptoms and symptom tracking. Additionally, based on the questions being asked, these chatbots were able to guide the next steps that individuals should take based on the information they provided (Adly et al., 2020; Van Baal et al., 2022).

Limitations with Utilization and Application

Though there were several beneficial applications of artificial intelligence to address COVID-19, there were also numerous limitations associated with this type of technology. First, one of the most significant drawbacks of implementing artificial intelligence as a response tool was the complex nature of this technology. While artificial intelligence may be simple to utilize after it is developed, individuals, such as healthcare workers who do not have an extensive background or knowledge base in technology, would likely struggle to create and implement an artificial intelligence system that works for their facility. Therefore, the complicated nature of establishing an artificial intelligence system was identified as a barrier to implementing this technology to help control and contain the pandemic (Chen & See, 2020).

Lastly, another notable limitation identified with artificial intelligence was the lack of resources available in lower-income areas to implement this technology. Not only would facilities need to have the personnel to develop or set up the artificial intelligence system, but they would also need other resources, such as updated computers and reliable internet access. Therefore, lower-income regions and countries would not be able to benefit from the services provided by artificial intelligence as they likely would not have access to all the necessary resources (Ibeneme et al., 2021).

Geographic Information Systems

Surveillance Tool

Like artificial intelligence, geographic information systems tools and mapping also played a vital role in controlling and containing the COVID-19 pandemic through situational surveillance. While artificial intelligence and geographic information systems technologies likely worked in tandem, one distinct feature of geographic information systems was its capability to identify more specific situational details (Bello et al., 2021; Rezaei et al., 2020; Schmidt et al., 2021). For example, geographic information systems could provide almost real-time data associated with trends in COVID-19 cases. Collecting this type of information was critical to a wide range of individuals involved in the pandemic response as changes could quickly be made to policies and procedures if concerning trends were being demonstrated in the data described by geographic information system tools (Bello et al., 2021; Rezaei et al., 2020; Schmidt et al., 2021).

Geographic information systems tools also provided precise details about the locations of cases and potential outbreaks. Instead of simply looking at trends on a state or country-wide basis, geographic information systems provided more precise details about COVID-19 trends in counties, cities, and even specific communities. Several countries and regions around the world were able to utilize this technology to gather data for specific streets or small neighborhoods (Ahasan & Hossain, 2021; De Vito et al., 2021; Gangwar & Ray, 2021; Kabir et al., 2021; Mollalo et al., 2020; Saeed et al., 2021; Shariati et al., 2020). Having more detailed information regarding COVID-19 surveillance and trend tracking allowed for more targeted approaches not just to contain potential outbreaks but also to forecast areas that could potentially become future outbreak locations (Ahasan & Hossain, 2021; De Vito et al., 2021; Gangwar & Ray, 2021; Kabir et al., 2021; Mollalo et al., 2020; Saeed et al., 2021; Shariati et al., 2020).

Identification of Geographic and Population Vulnerabilities

While the more detailed information provided by geographic information systems tools was beneficial for effective and efficient COVID-19 response efforts, it also aided with the development of preparedness and mitigation strategies by highlighting geographic and population-specific vulnerabilities. These vulnerabilities included recognizing rural communities with limited access to health care facilities and lower-income communities with limited resources to treat individuals (Jesri et al., 2021; Rahman et al., 2021; Shadeed & Alawna, 2021). This geographic information systems technology application was utilized in several countries or territories worldwide, including Palestine, Iran, and Bangladesh. For example, in Bangladesh, these applications were able to identify the number of healthcare workers and their locations in specific regions in the country as two significant vulnerabilities contributing to the incidence of COVID-19. By identifying these vulnerabilities through the utilization of geographic information systems tools, correlations could then be recognized for why specific communities were experiencing an outbreak and what types of strategies could be implemented to prevent similar types of communities from also experiencing outbreaks (Jesri et al., 2021; Rahman et al., 2021; Shadeed & Alawna, 2021).

Contact Tracing

The final utilization and application of geographic information systems as a technology to help control and contain the COVID-19 pandemic was to aid with contact tracing. Though digital and mobile applications were crucial in facilitating contact tracing efforts, geographic information systems were also essential in assisting this process. Since geographic information systems can identify population and area-specific information, individuals with contact tracing related applications on their digital devices could be notified on a large scale if they were in close contact with an individual that tested positive (Smith & Mennis, 2020). Additionally, geographic information systems could also surveil individuals' locations to help determine potential areas associated with widespread outbreaks, such as different types of events. Though geographic information systems must be utilized in conjunction with digital or mobile applications to facilitate contact tracing, reliable technology-based contact tracing could not be accomplished without geographic information systems tools and capabilities (Smith & Mennis, 2020).

Chapter 5: Discussion

Summary

After utilizing various search strategies and a six-step selecting process, 39 articles across four databases, 16 articles from CINAHL, 12 articles from Embase, 0 articles from ERIC, and 11 articles from PubMed, were included in the final review for this study. Numerous articles from each database were associated with the three types of technology, digital and mobile application, artificial intelligence, and geographic information systems, that were the focus of this literature review. For each of the different types of technology, three main themes were identified based on the information described in the respective articles.

For the technology type digital of digital and mobile applications, the first theme identified was how this technology type was utilized as a tool for contact tracing during the COVID-19 pandemic. Contact tracing using this technology type was accomplished through a variety of methods, including tracking individuals’ locations and notifying them if they were near an individual that tested positive (Chaudhary et al., 2021; Garousi & Cutting, 2021; Guillon & Kergall, 2020; Salathé et al., 2020). The second theme identified for digital and mobile applications was how this technology could be utilized as a tool to detect and screen for COVID-19 and COVID-19 symptoms. Like contact tracing, this technology was also utilized in several ways, including allowing individuals to simply self-screen using the applications (Heithoff et al., 2022; Lee et al., 2021; Saeidnia et al., 2022). Lastly, the third theme for digital and mobile applications were the limitations associated with using this type of technology, which included privacy concerns and how sensitive information might be utilized for other purposes (Altmann et al., 2020; Bernard et al., 2020; Garousi & Cutting, 2021; Williams et al., 2021).

For the technology type of artificial intelligence, 14 articles were selected for review. The first theme identified from the selected articles was the utilization of technology as a tool to help forecast and track trends related to COVID-19 cases. This application served a variety of purposes, including aiding public health, healthcare, and policymakers in making necessary changes in response efforts to adequately address the needs of populations being more heavily impacted by the pandemic (Abdeldayem et al., 2022; Syrowatka et al., 2021; Tkatek et al., 2020; Yu et al., 2021). The second theme identified in the reviewed articles was using artificial intelligence to aid with diagnostic, treatment, and symptom screening measures for positive patients. This was accomplished by using artificial intelligence to compare chest and lung images to a database of similar types of images to determine if issues were or were not related to COVID-19 (Asada et al., 2021; Dong et al., 2021; Wang et al., 2021). Lastly, the final theme associated with artificial intelligence was limitations, especially regarding lack of access due to limited experienced personnel and resources (Chen & See, 2020; Ibeneme et al., 2021).

Lastly, for the technology type of geographic information systems, 14 articles were reviewed. The first theme of this technology type was utilizing geographic information systems to aid with COVID-19 surveillance. This most notable theme was accomplished by collecting almost real-time data that allowed individuals responding to the pandemic to adjust their response strategies appropriately (Bello et al., 2021; Rezaei et al., 2020; Schmidt et al., 2021). The second notable theme within these articles was using geographic information systems to help identify geographic and population-specific vulnerabilities, which provided crucial information regarding which communities or types of communities may require unique COVID-19 preparedness and response efforts (Jesri et al., 2021; Rahman et al., 2021; Shadeed & Alawna, 2021). Lastly, the third notable theme associated with this technology type was using geographic information system tools to aid with contact tracing by assisting with the technology developed for digital and mobile applications to notify a large scale of individuals simultaneously if they were a close contact (Smith & Mennis, 2020).

Public Health Implications

In addition to understanding how digital and mobile applications, artificial intelligence, and geographic information systems were applied to address the COVID-19 pandemic, it is also crucial to recognize the public health implications of these types of technology for this specific disaster and potential future events. First, each of the three types of technology played a clear role in helping reduce the spread of COVID-19 through contact tracing or identifying hotspots that needed to be contained (Chaudhary et al., 2021; Garousi & Cutting, 2021; Guillon & Kergall, 2020; Salathé et al., 2020; Wymant et al., 2021). These strategies reduced the burden of the pandemic on healthcare and public health workers who were mainly in charge of facilitating contact tracing and developing COVID-19 safety guidelines and policies. Therefore, technology played a significant role in accelerating necessary tactics that would have taken a significant amount of time to be completed by a single public health worker (Chaudhary et al., 2021; Garousi & Cutting, 2021; Guillon & Kergall, 2020; Salathé et al., 2020; Wymant et al., 2021).

Another public health implication associated with the findings from this review is recognizing and identifying geographic and population-based vulnerabilities for various types of communities using artificial intelligence and geographic information system tools. This is a crucial component to highlight for public health as the field's focus is mainly on how to address issues from a population or systematic level (Jesri et al., 2021; Rahman et al., 2021; Shadeed & Alawna, 2021). For example, these two types of technology aided with identifying components that were contributing to the pandemic disproportionately impacting certain types of communities, such as lower-income neighborhoods. In addition to using technology to adjust response actions, this same type of technology application could also aid with preparedness and mitigation efforts in order to help recognize how and what types of communities may be more vulnerable to various types of disasters (Jesri et al., 2021; Rahman et al., 2021; Shadeed & Alawna, 2021).

Lastly, the third public health implication for the findings of this review is recognizing how technology could be utilized to enhance the efforts made by public health leaders and policymakers to advocate for all individuals more effectively and efficiently, especially those at higher risks of being more negatively impacted by disasters. For example, artificial intelligence and geographic information systems were vital in providing visual representations for areas experiencing outbreaks or high numbers of COVID-19 cases. A similar application of these types of technology could be utilized for a wide variety of public health issues to aid with the interpretation of complicated sets of data (Jesri et al., 2021; Rahman et al., 2021; Shadeed & Alawna, 2021; Syrowatka et al., 2021; Yu et al., 2021).

This would not only provide a more comprehensive understanding of public health problems for those directly working in public health but could allow for more effective advocacy efforts by simplifying issues to policymakers and members of the public. For example, having a hotspot map demonstrating issues with access to mental health services could lead to more effective efforts to address those gaps. Despite having beneficial applications for the COVID-19 pandemic, utilizing and applying digital and mobile applications, artificial intelligence, and geographic information systems for other public health issues would undoubtedly have a positive impact and yield positive results (Jesri et al., 2021; Rahman et al., 2021; Shadeed & Alawna, 2021; Syrowatka et al., 2021; Yu et al., 2021).

Strengths, Limitations, and Gaps in Evidence

Several strengths can be associated with this literature review and the analyzed articles. The first notable strength was the diversity in the articles regarding technology type and application. For example, numerous articles related to digital and mobile applications, artificial intelligence, and geographic information systems discussed how these technology types were utilized to address COVID-19 in multiple countries. This is a strength as it demonstrates a more comprehensive analysis and understanding of the application of technology for various types of situations with COVID-19 and in numerous types of cultural and political climates.

Another significant strength associated with this literature review and the associated articles was the consistency in the information discussed in each analyzed article. For most of the main themes highlighted for the three technology types, multiple articles were available to support or supplement the idea or concept consistently. This can be considered a strength as it demonstrates that the discussed ideas are not outliers and were consistently found in various situations or settings.

Despite these two crucial strengths, there are three limitations with the articles incorporated into this literature review that should be identified as they could contribute to a gap in the evidence. First, since COVID-19 is a relatively new disease that only started impacting the world two years ago and is still evolving, it may be premature to fully understand how technology has been utilized to address the pandemic. Critical applications of the three types of technology discussed for this review could still occur or change based on how the pandemic progresses. Therefore, this limitation could contribute to a gap in evidence since the COVID-19 pandemic is still significantly impacting countries worldwide, and how technology is being applied to address these situations could change.

Another notable limitation related to this literature review and the associated articles is also related to the timing of COVID-19. Since it has only been two years since the start of this disaster, many studies related to the application of technology to address the pandemic could still be in progress. Therefore, the available information regarding the topic for this review could be limited, which could prevent the findings of this study from being truly comprehensive. This limitation also leads to a gap in evidence as widespread or significant uses of digital and mobile applications, artificial intelligence, and geographic information systems could not yet be published in the literature.

The third notable limitation of the articles incorporated into this literature review was the lack of evidence supporting the effectiveness of the three types of technology highlighted in this study. While some studies provided quantitative information about how effective the technology was in addressing the COVID-19 pandemic, several of the other articles only had limited information to support the usage of digital and mobile applications, artificial intelligence, and geographic information systems as an effective strategy. A lack of quantitative supportive information is a gap in evidence that should be considered as a focal point for future studies associated with these technology types and the topic of this review.

Conclusion

This systematic literature review focused on three types of technology, digital and mobile applications, artificial intelligence, and geographic information systems, to understand how they served as emergency preparedness tools and resources to help control and contain the COVID-19 pandemic. Geographic information systems, for example, aided with identifying geographic and population-specific vulnerabilities and supported digital, large-scale contacting tracing efforts (Rahman et al., 2021; Shadeed & Alawna, 2021; Smith & Mennis, 2020). Additionally, artificial intelligence was also an available resource to facilitate forecasting and tracking trends with COVID-19 cases; it also aided healthcare workers with diagnostics and treatment strategies for positive patients (Dong et al., 2021; Naseem et al., 2020; Tkatek et al., 2020; Van Baal et al., 2022). Lastly, digital and mobile applications were able to assist with the pandemic by serving as contact tracing tools and as resources to help detect and screen for COVID-19 and COVID-19 symptoms (Heithoff et al., 2022; Saeidnia et al., 2022; Salathé et al., 2020; Wymant et al., 2021). Unfortunately, while these types of technology had several beneficial purposes, limitations were present within these tools, including potential privacy violations and a lack of available resources for implementation.

The COVID-19 pandemic has resulted in countless negative impacts worldwide, including physical and mental health damages, lives lost, and economic disruption (Carvalho et al., 2021; Gavin et al., 2020; He et al., 2020; Udalova, 2021). Fortunately, despite these terrible impacts, novel tools and strategies were still created and implemented to aid with the pandemic response. Though the situation is still ongoing, and these resources will likely continue to develop, digital and mobile applications, artificial intelligence, and geographic information systems have demonstrated to be valuable and beneficial emergency preparedness resources and tools to help control and contain the COVID-19 pandemic.

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Appendix A

Database: CINAHL		
Concept	**Keyword(s)**	**Alternate Terms**
Technology	- Mobile and digital applications	-N/A
	- Artificial intelligence	-Intelligence, artificial
	-Geographic information system mapping	-Geographic information systems
COVID-19	- COVID-19	-SARS-CoV-2
Emergency Preparedness	- Prevention -Control	-N/A

Search Strategy	**# of Search Results**	**# of Articles Excluded for Language, Publication Date, Publication Type**
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2")	104	21
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Digital Phone Application*”)	0	--
(Emergency Preparedness) AND (COVID-19 OR SARS-CoV-2) AND (Digital Phone Applications)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Digital Application*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Mobile Application*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Mobile Phone Application*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Phone Application*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Phone App*”)	0	--
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Phone App*”)	8	1
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Digital Phone App*”)	0	--
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Mobile Phone App*”)	5	0
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Digital App*”)	7	2
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Mobile App*”)	106	28

(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (Intelligence, Artificial*)	0	--
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”)	58	17
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Intelligence, Artificial*”)	0	--
(“Control”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”)	74	19
(“Control”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Intelligence, Artificial*”)	0	--
(“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”) AND (Track*) AND (Outbreak*)	6	0
(“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”) AND (Monitor*) AND (Outbreak*)	12	1
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information Systems Map*” OR “GIS Map*”)	0	--
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information Systems Map*” OR “GIS Map*”)	2	0
(“Control”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information Systems Map*” OR “GIS Map*”)	2	0
(“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information Systems Map*” OR “GIS Map*”) AND (Track*) AND (Outbreak*)	0	--
(“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information Systems Map*” OR “GIS Map*”) AND (Monitor*) AND (Outbreak*)	0	--
(“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information Systems Map*” OR “GIS Map*”) AND (Monitor*) AND (Outbreak*)	0	--
(“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information Systems Map*” OR “GIS Map*”)	2	0
(“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information System*”)	46	5
(“COVID-19” OR “SARS-CoV-2") AND (“GIS”)	17	1
Totals	**449**	**95**

Appendix B

Database: EMBASE		
Concept	**Keyword(s)**	**Alternate Terms**
Technology	- Mobile and digital applications	-Mobile health applications
	- Artificial intelligence	-N/A
	-Geographic information system mapping	-Geographic information systems
COVID-19	- COVID-19	-SARS-CoV-2 - Coronavirus disease 2019
Emergency Preparedness	- Prevention -Control	-N/A

Search Strategy	**# of Search Results**	**# of Articles Excluded for Language, Publication Date, Publication Type**
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”)	343	104
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Digital Phone Application*”)	0	--
(Emergency Preparedness) AND (COVID-19 OR SARS-CoV-2 OR Coronavirus Disease 2019) AND (Digital Phone Applications)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Digital Application*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Mobile Application*”)	1	1
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Mobile Phone Application*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Phone Application*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Mobile Health App*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Phone App*”)	0	--
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Phone App*”)	23	8

(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Digital Phone App*”)	0	--
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Mobile Phone App*”)	16	4
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Digital App*”)	14	6
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Mobile App*”)	353	159
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Mobile Health App*”)	57	21
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Artificial Intelligence*”)	5	3
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Artificial Intelligence*”)	440	247
(“Control”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Artificial Intelligence*”)	606	266
(“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Artificial Intelligence*”) AND (Track*) AND (Outbreak*)	9	5
(“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Artificial Intelligence*”) AND (Monitor*) AND (Outbreak*)	49	24
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Geographic Information Systems Map*” OR “GIS Map*”)	0	--
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Geographic Information Systems Map*” OR “GIS Map*”)	2	0
(“Control”) AND (“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Geographic Information Systems Map*” OR “GIS Map*”)	3	0
(“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Geographic Information Systems Map*” OR “GIS Map*”) AND (Track*) AND (Outbreak*)	0	--
(“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Geographic Information Systems Map*” OR “GIS Map*”) AND (Monitor*) AND (Outbreak*)	0	--
(“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Geographic Information Systems Map*” OR “GIS Map*”) AND (Monitor*) AND (Outbreak*)	0	--
(“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Geographic Information Systems Map*” OR “GIS Map*”)	8	2

(“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“Geographic Information System*”)	171	37
(“COVID-19” OR “SARS-CoV-2" OR “Coronavirus Disease 2019”) AND (“GIS”)	249	48
Totals	**2,349**	**935**

Appendix C

Database: ERIC		
Concept	**Keyword(s)**	**Alternate Terms**
Technology	- Mobile and digital applications	-Mobile health applications
	- Artificial intelligence	-N/A
	-Geographic information system mapping	-Geographic information systems
COVID-19	- COVID-19	-SARS-CoV-2
Emergency Preparedness	- Prevention -Control	-N/A

Search Strategy	# of Search Results	# of Articles Excluded for Language, Publication Date, Publication Type
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2")	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Digital Phone Application*”)	0	--
(Emergency Preparedness) AND (COVID-19 OR SARS-CoV-2) AND (Digital Phone Applications)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Digital Application*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Mobile Application*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2”) AND (“Mobile Phone Application*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Phone Application*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Mobile Health App*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Phone App*”)	0	--
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Phone App*”)	0	--
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Digital Phone App*”)	0	--
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Mobile Phone App*”)	0	--
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Digital App*”)	0	--

(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Mobile App*”)	0	--
(“Prevent*”) AND (“COVID-19” OR “SARS-CoV-2”) AND (“Mobile Health App*”)	0	--
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2”) AND (“Mobile Health App*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”)	0	--
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”)	0	--
(“Control”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”)	1	0
(“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”) AND (Track*) AND (Outbreak*)	0	--
(“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”) AND (Track*)	0	--
(“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”) AND (Outbreak*)	0	--
(“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”) AND (Monitor*) AND (Outbreak*)	0	--
(“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”) AND (Monitor*)	0	--
(“COVID-19”) AND (“Artificial Intelligence*”) AND (Monitor*)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information Systems Map*” OR “GIS Map*”)	0	--
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information Systems Map*” OR “GIS Map*”)	0	--
(“Control”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information Systems Map*” OR “GIS Map*”)	0	--
(“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information Systems Map*” OR “GIS Map*”) AND (Track*) AND (Outbreak*)	0	--
(“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information Systems Map*” OR “GIS Map*”) AND (Monitor*) AND (Outbreak*)	0	--
(“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information Systems Map*” OR “GIS Map*”) AND (Monitor*) AND (Outbreak*)	0	--
(“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information Systems Map*” OR “GIS Map*”)	0	--
(“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information System*”)	2	0
(“COVID-19” OR “SARS-CoV-2") AND (“GIS”)	1	0
Totals	**4**	**0**

Appendix D

Database: PubMed		
Concept	**Keyword(s)**	**Alternate Terms**
Technology	- Mobile and digital applications	-Mobile health application - Smartphone applications
	- Artificial intelligence	- Computational Intelligence
	-Geographic information system mapping	-Geographic information systems
COVID-19	- COVID-19	-SARS-CoV-2
Emergency Preparedness	- Prevention -Control	-N/A

Search Strategy	**# of Search Results**	**# of Articles Excluded for Language, Publication Date, Publication Type**
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2")	372	5
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Digital Phone Application*”)	1	0
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Digital Application*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Mobile Application*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2”) AND (“Mobile Phone Application*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Phone Application*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Mobile Health App*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Phone App*”)	0	--
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Smart Phone App*”)	0	--
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Phone App*”)	23	0
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Digital Phone App*”)	31	0
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Mobile Phone App*”)	18	0

(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Digital App*”)	13	1
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Mobile App*”)	246	5
(“Prevent*”) AND (“COVID-19” OR “SARS-CoV-2”) AND (“Mobile Health App*”)	14	5
(“Prevent*”) AND (“COVID-19” OR “SARS-CoV-2”) AND (“Smart Phone App*)	2	0
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”)	5	5
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”)	308	4
(“Control”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”)	476	6
(“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”) AND (Track*) AND (Outbreak*)	17	17
(“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”) AND (Monitor*) AND (Outbreak*)	47	0
(“COVID-19” OR “SARS-CoV-2") AND (“Artificial Intelligence*”) AND (Monitor*)	250	4
(“COVID-19” OR “SARS-CoV-2") AND (“Computational Intelligence*”) AND (Monitor*)	3	0
(“Emergency Preparedness”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information Systems Map*” OR “GIS Map*”)	0	--
(“Prevention”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Geographic* Information System* Map*” OR “GIS Map*”)	3	0
(“Control”) AND (“COVID-19” OR “SARS-CoV-2") AND (“Geographic Information Systems Map*” OR “GIS Map*”)	3	0
(“COVID-19” OR “SARS-CoV-2") AND (“Geographic* Information System* Map*” OR “GIS Map*”) AND (Track*) AND (Outbreak*)	1	0
(“COVID-19” OR “SARS-CoV-2") AND (“Geographic* Information System* Map*” OR “GIS Map*”) AND (Monitor*) AND (Outbreak*)	0	--
(“COVID-19” OR “SARS-CoV-2") AND (“Geographic* Information System* Map*” OR “GIS Map*”) AND (Monitor*) AND (Outbreak*)	0	--
(“COVID-19” OR “SARS-CoV-2") AND (“Geographic* Information* System* Map*” OR “GIS Map*”)	9	0
(“COVID-19” OR “SARS-CoV-2") AND (“Geographic* Information* System*”)	169	1
(“COVID-19” OR “SARS-CoV-2") AND (“GIS”)	213	0
Totals	**2,224**	**53**

Biography and Curriculum Vitae

Alyssa Spartz is a Master of Public Health student with the University of Nebraska Medical Center (UNMC) with a concentration in emergency preparedness. She earned a bachelor’s degree in psychology and a bachelor’s degree in emergency management from the University of Nebraska at Omaha. Alyssa also currently serves as a Graduate Research Assistant for the Office of Health Security and the Department of Emergency Management at UNMC. Through this position, she has aided with the facilitation of the UNMC Incident Command during several incidents and has been an active contributor to the University’s response to the COVID-19 pandemic. In addition to her roles as a student and a Graduate Research Assistant, Alyssa also holds numerous student leadership positions, including the President of the College of Public Health (COPH) Student Association, a COPH Senator within the Student Senate, and as Student Senate Health and Wellness Liaison.

Alyssa Spartz

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EDUCATION

Master of Public Health
University of Nebraska Medical Center | Aug 2020 - May 2022 (Anticipated)
Concentration: Emergency Preparedness

Bachelor of Science Degree in Emergency Management
Bachelor of Science Degree in Psychology
University of Nebraska Omaha | Aug 2015 - May 2020
Minors: Public Health, Nonprofit Management, and Sociology
Recipient of the first Community Engaged Scholars Transcript Designation

PROFESSIONAL EXPERIENCE

Graduate Research Assistant

University of Nebraska Medical Center (Aug 2020 - Present)
Office of Health Security & Department of Emergency Management

- Organized and facilitated training demonstrating a new interactive disaster management site for UNMC's Incident Command Team
- Coordinated and centralized communication between several individuals and departments to create guidance and procedures related to COVID-19
- Culminated information from numerous sources to initiate a document repository for new and developing COVID-19 data
- Served in multiple advisory roles, including planning positions, on UNMC's Incident Command Team to implement programming and strategically plan for program improvements
- Developed informational graphics to educate and guide individuals in various aspects of emergency planning and response

Graduate Student Intern

Nebraska Area Health Education Center (May 2021 – Aug 2021)

- Researched state and regional level healthcare workforce needs and generated a multi-sectional report
- Formulated a new design and template for a statewide and organizational needs assessment
- Partnered with multiple statewide offices to gather information utilized to establish an overview of healthcare workforce needs in multiple regions of Nebraska
- Examined peer-reviewed articles and sources to understand essential and effective components for a needs assessment

Undergraduate Student Intern

University of Nebraska Medical Center (May 2019 – Aug 2020)
Department of Emergency Management

- Served as a member of the planning section on UNMC's Incident Command Team during multiple emergency response initiatives
- Designed emergency operations center position-specific checklists for UNMC's Incident Command Team based on peer-reviewed articles and sources
- Orchestrated personnel training on how to use the capabilities of the emergency response programming and software, "Knowledge Center"
- Scheduled and facilitated meetings for a 60-person team on a quarterly basis and a 15-person team on a monthly basis

Nebraska Flood Recovery Serviceship Intern

Washington County Extension Office (May 2019 – Aug 2019)

- Orchestrated the recovery and refurbishment of two offices damaged by flood water at the Washington County Fairgrounds
- Managed the selecting and purchasing of replacement materials to furnish two damaged office locations

Maverick Food Pantry Student Manager

University of Nebraska Omaha (May 2017 – Oct 2019)

- Established and implemented programming to distribute food to individuals suffering from food insecurity on the UNO campus
- Formulated and secured a balanced inventory of multiple types of items to maintain month-long periods of operation for the pantry
- Coordinated multiple donation drives to raise funds associated with supporting the operations and services provided by the pantry
- Created a partnership with College of Saint Mary's to provide food and other products to food insecure students on their respective campus

LEADERSHIP ROLES & ACTIVITIES

President — UNMC College of Public Health Student Association (Aug 2021 - Present)

- Designed agendas and facilitated bi-weekly meetings with a team of seven individuals
- Fostered an inclusive and positive environment for other officers of the College of Public Health Student Association to discuss ideas and strategies
- Culminated partnerships with other UNMC student organizations to encourage engagement and collaboration with other colleges and departments

College of Public Health Senator & Health and Wellness Liaison — UNMC Student Senate (Aug 2021 - Present)

- Advocated for the inclusion of student perspectives and opinions in policy changes regarding COVID-19 and tuition fees
- Formulated and established programming for a leadership training series targeting student organization officers and student leaders
- Developed an anonymous system to monitor student concerns related to changing COVID-19 guidelines and policies in addition to general health and wellness concerns
- Engineered and implemented mental wellness checks on a bi-weekly basis to a team of 35 individuals to generate an accepting environment of mental well being

SKILLS & TECHNICAL KNOWLEDGE

- Microsoft Word (7 years)
- Microsoft Excel (7 years)
- Microsoft PowerPoint (7 years)
- Canva (5 years)
- Zotero (5 years)
- Zoom (2 years)
- Microsoft OneDrive (2 years)
- Microsoft Outlook (2 years)
- Microsoft Teams (2 years)
- Microsoft SharePoint (1 year)
- Exceptional written and communication skills (5 years)
- Project coordination knowledge (5 years)
- Knowledge of public health principles (2 years)

HONORS & AWARDS

Nebraska Step Forward Awards
Disaster Volunteer Honoree (2019)

University of Nebraska Medical Center
UNMC Student Leadership Award and Scholarship (2022)
Student Impact Award for the College of Public Health (2021)

Nebraska Step Forward Awards
Dean's Award: College of Public Affairs and Community Service (2020)
Undergraduate Major Award: School of Public Administration (2020)
Community Engaged Scholar Transcript Designation (2020)
University Honors Program Outstanding Leadership Award (2019)
Funding for Undergraduate Scholarly Experience Grant Recipient (2019)

PRESENTATION EXPERIENCE

National Collegiate Honors Council Conference
New Orleans, Louisiana (Nov 2019)
Title: "Disruptive Service Learning: Service Projects as Capstones and Credit"

Upper Midwest Regional Honors Conference
University of Wisconsin-Stout (Apr 2019)
Title: "Let's Give 'em Pumpkin to Talk About: Mishaps and Missteps of Student Engagement"

Edventures Peer to Peer: Challenging Extremism
Washington, D.C. (Jan 2016)
Title: "The Refugee Perspective"

COMMUNITY SERVICE

- Designed a system for the UNMC Student Response Team to assist volunteers with contact tracing (2022)
- Assisted Douglas County Health Department with vaccination efforts for COVID-19 (2021)
- Supported emergency housing facilities during Nebraska flood recovery efforts (2019)
- Organized, hosted, and recruited donors for blood drives through the American Red Cross (2016-2019)
- Demonstrated tornado safety practices for local Boy Scouts (2019)
- Educated elementary school students about the importance of emergency preparedness (2019)