Hantavirus pulmonary syndrome (HPS), native communities and public health epidemic surveillance in the United States

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Abstract

Purpose – This case study paper aims to explore the complexities and challenges of epidemic response and public health surveillance in Native American and Indigenous American communities in the United States and find viable solutions. This paper explores these topics through the emergence and impact of the hantavirus pulmonary syndrome (HPS) within the Navajo Nation in the United States using critical incident analysis and best practices.

Design/methodology/approach – This project is a case study paper based on a topical review of the literature. A topical review of the literature is a comprehensive exploration of the current body of knowledge within a particular research field. It is an important tool used by scholars and practitioners to further the development of existing knowledge as well as to identify potential directions for future research (Fourie, 2020). Such a paper can provide a useful insight into the various aspects of the process that the researcher may have overlooked, as well as highlighting potential areas of improvement (Gall *et al.*, 2020). It can also provide a useful source of ideas and inspiration for the researcher as it can provide an overview of the various approaches used by other researchers in the field (Göpferich, 2009). Case study papers using a topical review of the literature have been used to help frame and inform research topics, problems and best practices for some time. They are typically used to explore a topic in greater depth and to provide an overview of the literature to improve the world of practice to provide a foundation for future comprehensive empirical research. Case study papers can provide research value by helping to identify gaps in the literature and by providing a general direction for further research. They can also be used to provide a starting point for research questions and hypotheses and to help identify potential areas of inquiry.

Findings – This study explores best practices in public health surveillance and epidemic response that can help strengthen public health infrastructure by informing the development of effective surveillance systems and emergency response plans, as well as improving data collection and analysis capabilities within Native American and Indigenous American communities in the United States that also have the option to include new technologies like artificial intelligence (AI) with similar outbreaks in the future.

Research limitations/implications – The literature review did not include any primary data collection, so the existing available research may have limited the findings. The scope of the study was limited to published literature, which may not have reported all relevant findings. For example, unpublished studies, field studies and industry reports may have provided additional insights not included in the literature review. This research has significant value based on the limited amount of studies on how infectious diseases can severely impact Native American communities in the United States, leading to unnecessary and preventable suffering and death. As a result, research on viable best practices is needed on the best practices in public health surveillance and epidemic response in Native American and Indigenous American communities through historical events and critical incident analysis.

Practical implications – Research on public health surveillance and epidemic response in Native American communities can provide insights into the challenges faced by these communities and help identify potential

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solutions to improve their capacity to detect, respond to and prevent infectious diseases using innovative approaches and new technologies like AI.

Originality/value – More research on public health surveillance and epidemic response can inform policies and interventions to improve access to healthcare for Native American populations, such as increasing availability of healthcare services, providing culturally appropriate health education and improving communication between providers and patients. By providing better public health surveillance and response capacity, research can help reduce the burden of infectious diseases in Native American communities and ultimately lead to improved public health outcomes.

Keywords Native Americans, Epidemiology, Artificial intelligence (AI), Critical incident analysis, Hantavirus pulmonary syndrome (HPS), Public health surveillance

Paper type Case study

Introduction

Indigenous American communities with limited public health resources are particularly vulnerable during epidemics. To address healthcare incidents and build proper responses in the future, it is crucial to assess past responses critically (Woloshynowych, Rogers, Taylor-Adams, & Vincent, 2005; Mahajan, 2010). An effective tool is use of new technologies along with critical incident analysis. The elements of critical incident analysis include the following (Woloshynowych *et al.*, 2005; Mahajan, 2010):

Identification of critical incidents

Identify key events, decisions and actions during the epidemic response that had a significant impact on marginalized communities. This includes both positive and negative aspects.

Data collection and documentation

Gather relevant data, documents and reports related to the epidemic response. This may include epidemiological data, communication records and community feedback.

Stakeholder engagement

Involve stakeholders from the affected communities, local public health agencies, nongovernmental organizations and other relevant entities in the analysis process.

Root cause analysis

Explore the underlying causes and contributing factors that led to successes and failures during the response, considering structural, systemic and resource-related issues.

Analysis and evaluation

Analyze the data to identify critical incidents, root causes and contributing factors. Assess the impact of public health policies and interventions on marginalized communities.

Community-centered actions

Prioritize the involvement of community members in the analysis and reporting process. Include community narratives, experiences and recommendations in the report.

Health equity lens

Use a health equity framework to assess how public health interventions affected marginalized populations. Highlight disparities and propose strategies to reduce them.

Resource allocation review
Evaluate the allocation of public health resources during the epidemic. Suggest changes to ensure equitable distribution and access to resources.

Critical incident analysis and after-action reporting are essential tools for evaluating past epidemic responses in marginalized communities with limited resources. By systematically identifying critical incidents, engaging stakeholders and applying an equity-focused approach, public health practitioners can enhance future preparedness and response efforts (Woloshynowych *et al.*, 2005; Mahajan, 2010). These methodologies contribute to reducing health disparities and building resilient communities. Collaboration, community engagement and a commitment to equity are paramount in addressing the unique challenges faced by Indigenous American and other underserved populations during epidemics. This paper explores the complexities of public health surveillance and epidemiology through the emergence and impact of the hantavirus pulmonary syndrome (HPS) within the Navajo Nation in the United States and makes recommendations for better approaches in the future through a critical incident analysis framework.

Native communities in the United States

The United States is home to a diverse range of native communities, each distinct in its own way. Native Americans, Alaska Natives, Native Hawaiians and Pacific Islanders have unique cultures, languages and histories that set them apart from the broader US population. Native Americans, or Indigenous Americans, are the descendants of the original inhabitants of what is now the United States. According to the US Census Bureau, Native Americans represent about 2.9% of the total US population (US Census Bureau, 2017). The majority of Native Americans live in Oklahoma, California, Arizona, Texas and New Mexico, but they can be found living in all fifty states (US Census Bureau, 2017).

Alaska Natives are the indigenous inhabitants of Alaska and are composed of Eskimos, Aleuts and the Northern Athabascan people. According to the Alaska Native Tribal Health Consortium (2016), the US state of Alaska Natives represents approximately 19% of the state's population, with the majority living in rural areas and villages that are often remote and lack basic infrastructure and healthcare services.

Native Hawaiians are the descendants of the original Polynesian settlers of the Hawaiian Islands, making up approximately 8% of the population of Hawaii (US Census Bureau, 2017). Native Hawaiians are the only native group to be granted federal recognition and can operate their own government, the Office of Hawaiian Affairs (US Department of the Interior, 2016).

Pacific Islanders, also known as Pacific Islanders, are the indigenous inhabitants of the islands of the Pacific Ocean. Pacific Islanders are spread across several island nations, including the Federated States of Micronesia, Palau and the Marshall Islands, as well as the US territories of Guam, American Samoa and the Northern Mariana Islands (US Census Bureau, 2017).

All four of these groups face many challenges in the contemporary United States. Native Americans, Alaska Natives and Native Hawaiians, in particular, often experience higher rates of poverty, unemployment and health disparities than the general population (US Department of the Interior, 2016).

Native and indigenous communities are particularly vulnerable to the spread of infectious diseases (Kostova, 2014). The effects of epidemics on native and indigenous communities are far-reaching and potentially devastating. This is due to various factors, including poverty, lack of access to healthcare, lack of more healthcare professionals in their communities and inadequate housing. The high prevalence of infectious diseases among Native American communities is primarily due to poverty. According to the US Census Bureau, Native Americans have the highest poverty rate of any racial group in the United States, with 29.2%

living below the poverty line in 2018 (US Census Bureau, 2019). Poverty increases a person's risk of contracting infectious diseases, leading to crowding, inadequate housing, poor nutrition and lack of access to healthcare (González, Sánchez, & Sotelo, 2016). This lack of resources puts these communities at risk of more significant morbidity and mortality rates than privileged populations (Rao, 2004).

According to the Indian Health Service (IHS), Native Americans are more likely to live in rural areas, often lacking healthcare providers. Even when available, healthcare is often of poor quality (Indian Health Service, 2020). Furthermore, Native Americans are less likely to have health insurance, which can be a barrier to accessing healthcare services (González *et al.*, 2016). The lack of access to healthcare can have serious consequences as it can lead to a lack of preventive care and delayed diagnosis of infectious diseases. According to a study by González *et al.* (2016), Native Americans are more likely to be diagnosed with tuberculosis at an advanced stage, which can be more challenging to treat and more expensive. In addition, the lack of preventive care can lead to an increased risk of infection as people are less likely to be vaccinated against infectious diseases (González *et al.*, 2016).

In addition, inadequate housing can increase the risk of infection among Native American communities. According to the National Center for Health Statistics (NCHS), Native Americans are more likely to live in overcrowded housing, leading to an increased risk of transmission of infectious diseases (Chen, Albright, & Ghandour, 2015). Furthermore, inadequate housing can lead to poor access to hygiene facilities, such as running water or toilets, increasing the risk of infection (Chen *et al.*, 2015). The impact of epidemics on these populations is severe and can be seen in various aspects of their lives, from health and well-being to economic and social disruption.

Regarding health and well-being, the spread of infectious diseases can significantly impact native and underserved communities, leading to higher mortality and morbidity rates than those of more privileged populations (Kostova, 2014). This is due to a lack of access to preventive health care and resources, such as vaccinations, as well as a lack of access to medical care when illness does occur (Rao, 2004). This can lead to severe and potentially fatal complications, such as tuberculosis, which is particularly common among native and underserved populations (Kostova, 2014). Furthermore, infectious diseases can lead to long-term health complications, such as developing chronic conditions or disabilities (Rao, 2004). Additionally, the disruption of an epidemic can significantly impact a community's social fabric. This is due to the disruption of social gatherings, such as funerals or religious ceremonies, which can profoundly impact the emotional well-being of those affected (Rao, 2004).

In recent years, the HPS has become a significant public health concern in the United States. This rare but potentially fatal disease is caused by a virus known as the hantavirus. It typically spreads when people inhale airborne particles from infected rodents' urine, saliva and droppings. Understanding the epidemiology of HPS is critical for developing effective prevention and control measures. To this end, epidemiologists have used a variety of tests and measures to identify, track and investigate the causes of HPS.

HPS is a deadly infectious disease caused by a virus of the same name. The virus is most commonly found in the saliva, urine and feces of rodents such as the white-footed mouse, deer mouse and rice rat. HPS was first identified in 1993 when eighteen people in the southwestern United States died from a mysterious respiratory illness. Since then, HPS has become an increasingly recognized and studied illness, with a wide range of clinical manifestations (Atchison, Jones, Campbell, Lane, & Enscore, 2020). The virus can cause various symptoms, including fever, muscle aches and shortness of breath. The virus can sometimes result in death (Dong, 2017). As such, it is essential to be aware of the symptoms and take proper precautions to protect oneself from the disease.

Hantavirus is an ancient virus that has existed for millions of years (Friedman & Geiss, 2017). It is believed that the virus may have evolved from an ancestor virus that infected rodents and humans in the past. Hantaviruses can be found worldwide, but the exact origin of the virus is still unknown (Atchison *et al.*, 2020). As a result, it is believed that HPS is a zoonotic disease transmitted from animals to humans.

Problem statement

HPS is a rare but potentially fatal disease caused by infection with hantaviruses. HPS is spread to humans through contact with infected rodents, primarily deer and white-footed mice. Symptoms of HPS include fever and flu-like illness, along with coughing and difficulty breathing. Without treatment, up to 38% of cases can be fatal (Centers for Disease Control and Prevention [CDC], 2019). It is, therefore, important for communities to be aware of the risks of HPS and how to protect themselves from potential infection. It is also essential to increase public health and healthcare resources in Native and Indigenous communities in the United States. This paper explores the complexities of these issues and recommends some viable future public health surveillance solutions, including artificial intelligence (AI), by exploring the emergence and impact of the HPS within the Navajo Nation in the United States.

Critical analysis and history of HPS in native communities

The Navajo Nation, also known as the Diné Nation, is the largest federally recognized Native American reservation in the United States (Lee, 2006). It is located in the southwestern part of the country, primarily within the states of Arizona, New Mexico and Utah (Lee, 2006). The history and background of the Navajo Nation are rich and complex, encompassing centuries of cultural, social and political development (Lee, 2006).

The first case of HPS was reported in May 1993 in the Four Corners region of the southwestern United States, which includes parts of Arizona, New Mexico, Colorado and Utah (Khan, 1998). The patient was a Navajo male who died from severe respiratory distress. Subsequent investigations revealed that the illness was caused by a novel virus, later identified as a hantavirus. In response to the outbreak, the Navajo Nation declared a public health emergency, established an Incident Management Team, and created an Inter-agency Working Group (Khan, 1998).

In the early stages of the outbreak, the illness was referred to as the "Navajo Flu," a term that has since come to be seen as a derogatory and offensive label. At the time, the illness was not yet identified as HPS, and the term "Navajo Flu" was used to refer to the illness since it was first observed in the Navajo Nation (Navajo Epidemiology Center, 2020). The term "Navajo Flu" was widely used by the Centers for Disease Control and Prevention (CDC) in its initial response to the illness Navajo Epidemiology Center (2020). The term was used in press releases, as well as in public health messages, to refer to the illness. The CDC's use of the term was seen as a way of focusing public attention on the illness and was intended to be a way to help identify the source of the illness and alert the public to the dangers of the virus (Navajo Epidemiology Center, 2020). The term "Navajo Flu" is considered a derogatory and offensive label, implying that the Navajo Nation caused the illness (Navajo Epidemiology Center, 2020).

This is particularly offensive since no evidence suggests that the illness originated in the Navajo Nation. Using the term implies that the Navajo Nation is to blame for the illness (Navajo Epidemiology Center, 2020). Additionally, the term is seen as stereotyping the Navajo Nation and reinforcing negative stereotypes about the tribe (Navajo Epidemiology Center, 2020).

The ongoing effects of racism and discrimination are also important contributing factors to Native American health disparities. Native Americans experience higher rates of

discrimination in healthcare settings, leading to poorer quality of care and lower health outcomes (Ross & Satterwhite, 2017). This form of discrimination has also been linked to higher rates of substance abuse and mental health issues in Native American communities (Brave Heart & DeBruyn, 1998).

The health disparities experienced by Native Americans appear to be widespread and significant. For example, Native Americans are twice as likely to die from diabetes than non-Hispanic Whites (CDC, 2018). Native American adults are also more likely to report being in fair or poor health (27%) compared to non-Hispanic Whites (17%) (CDC, 2018). Native American women are also more likely to experience intimate partner violence than non-Hispanic White women, with one in three Native American women reporting experiencing physical violence by an intimate partner in the past year (CDC, 2018).

Public health is a field designed to protect and improve the health of populations. Unfortunately, it has not always done so equitably and has been complicit in propagating racism. Throughout history, several diseases have been named after ethnic and racial groups. For example, "Spanish Flu" describes the 1918 flu pandemic. This was partly because the first reports of the disease came from Spain, although it was later discovered that the disease was present in many countries worldwide (Rutherford & Rutherford, 2020). Similarly, the term "Italian Fever" describes a viral infection common in Italy during the 19th century (Gladstone, Mazzulli, Spitzer, & Naylor, 2018). While these terms may have been used to describe the origin of the diseases, they have also been used to perpetuate racial stereotypes.

Using racially charged language when naming diseases has been linked to increased stigma and discrimination toward certain ethnic and racial groups (Gladstone *et al.*, 2018). For example, the term "Chinese Virus" has been used in a harmful manner to describe the novel coronavirus, SARS-CoV-2 (COVID-19), based on a premise the pandemic originated in China (Rutherford & Rutherford, 2020). This term has been used to blame Chinese people for the global pandemic and has increased racism and xenophobia. Using such terms can also lead to an increase in the rate of disease among the affected group due to a lack of access to healthcare, fear of seeking treatment and distrust of public health authorities (Gladstone *et al.*, 2018).

Furthermore, stigmatizing language when naming diseases can also psychologically affect members of the affected group. Studies have found that members of stigmatized groups are more likely to suffer from depression, anxiety and other mental health issues (Gladstone *et al.*, 2018). They are constantly exposed to messages that their group is inferior or dangerous. As a result, members of stigmatized groups may become more likely to internalize these messages and view themselves negatively.

In order to reduce the impact of racism on public health, it is essential to be mindful of the language used when discussing diseases. It is essential to avoid using language that is offensive or derogatory as this can have a damaging effect on the affected group. Additionally, it is essential to recognize that diseases do not discriminate and are not confined to one particular group of people. By understanding this, we can help to reduce the stigma associated with specific diseases and help to ensure that all populations are treated with respect and dignity.

Critical incidents

The initial response to the outbreak focused on identifying the source of the virus and preventing further transmission. Epidemiological investigations indicated that the virus was spread by the deer mouse (Peromyscus maniculatus), which is common in the Four Corners region. The Navajo Nation implemented a rodent control program and distributed rat traps and rodent control information to local residents. In addition, they conducted public health

education campaigns to inform the community about the dangers of HPS and how to reduce their risk of exposure (Khan, 1998).

The Navajo Nation has also implemented several long-term prevention and control strategies. These include rodent control programs, public health education campaigns and surveillance activities. The Navajo Nation also conducts research and participates in national and international conferences to share best practices and promote collaboration among public health professionals.

Since the 1993 outbreak, HPS has been reported in numerous countries, including Canada, China, South Korea and Brazil. In some cases, it is believed that the virus is spread through contact with infected rodents; while in other cases, transmission is believed to be airborne, passing through dust and air contaminated with the virus (Friedman & Geiss, 2017).

In addition to the 1993 outbreak in the United States, there have been several smaller outbreaks since then in other countries, including Canada, South Korea and Brazil. The virus has been found in rodents in each of these cases, and the outbreaks have been linked to contact with infected rodents or their droppings (Atchison *et al.*, 2020).

The IHS is the federal agency responsible for providing health care to American Indians and Alaska Natives (A.I./ANs). A.I./ANs have some of the highest health disparities among minority populations in the United States, with higher rates of chronic conditions such as diabetes, obesity and substance abuse than other racial and ethnic groups (CDC, 2020).

Epidemiology is the study of the distribution and determinants of health-related states or events in specified populations and the application of this study to control health problems (CDC, 2017). Epidemiological studies can identify health conditions in a population, assess risk factors for disease and evaluate the effectiveness of interventions. Epidemiologists working for the IHS can use these techniques to identify health disparities among A.I./ANs, track disease trends and evaluate the effectiveness of public health interventions.

Public health surveillance

Public health surveillance is data collection, analysis, interpretation and dissemination to prevent and control disease, injury and disability (CDC, 2019). Public health surveillance can be used to monitor the health of a population, detect emerging health threats and inform the development of public health policy. Public health surveillance on reservations can be used to monitor the health of A.I./ANs and identify emerging public health threats.

AI in public health surveillance

Public health surveillance is a cornerstone of epidemic prevention and control, encompassing the systematic collection, analysis and interpretation of health-related data to monitor and respond to health threats. Traditionally, surveillance has relied on manual data collection and analysis, which often led to delays in identifying disease outbreaks and tracking their progression. However, the advent of AI has transformed the landscape of public health surveillance, offering rapid and data-driven solutions for tracking the spread of epidemics and differentiating influenza strains (Allam & Jones, 2020; Vaishya, Javaid, Khan, & Haleem, 2020; Chen & Decary, 2020). Use cases for these new technologies can be applied to historical and past epidemic outbreaks to create more comprehensive response plans for future outbreaks in Indigenous American communities.

AI leverages machine learning algorithms, natural language processing, computer vision and big data analytics to process vast amounts of health-related data from various sources, such as electronic health records, social media and sensor networks. These technologies enable the automated detection of disease patterns, anomalies and emerging threats (Allam & Jones, 2020; Vaishya *et al.*, 2020; Chen & Decary, 2020).

AI-driven surveillance systems continuously gather and analyze data, providing real-time insights into disease trends and transmission dynamics (Allam & Jones, 2020; Vaishya *et al.*, 2020; Chen & Decary, 2020). This capability significantly accelerates the detection of outbreaks, allowing for prompt public health responses. AI models can identify unusual patterns in health data, such as spikes in fever-related internet searches or social media posts mentioning flu-like symptoms (Allam & Jones, 2020; Vaishya *et al.*, 2020; Chen and Decary, 2020). By recognizing these early signals, AI systems can predict potential outbreaks before traditional surveillance methods. Geospatial AI tools facilitate the mapping of disease hotspots and transmission routes. AI generated data can be used in resource allocation, contact tracing, and targeted interventions (Allam & Jones, 2020; Vaishya *et al.*, 2020; Chen & Decary, 2020). AI algorithms can trace the contacts of infected individuals and analyze social networks to identify potential disease spreaders. These insights inform containment strategies and preventive measures. AI is instrumental in analyzing genetic sequences of influenza viruses. Machine learning models can identify genetic variations and predict the potential virulence and transmissibility of different strains (Allam & Jones, 2020; Vaishya *et al.*, 2020; Chen & Decary, 2020).

Need for more epidemiologists and public health surveillance

Despite implementing public health programs, A.I./ANs continue to experience disparities in health status. These disparities can be attributed to various factors, including poverty, inadequate access to health care and a lack of public health resources on reservations. The IHS acknowledges the need for more epidemiologists and public health surveillance approaches on reservations to address health disparities among A.I./ANs. The IHS has implemented the Reaching Our Sisters Everywhere (ROSE) program, which seeks to increase the number of epidemiologists and public health surveillance programs on reservations (IHS, 2019).

Epidemiology strategy

Epidemiologists are experts in disease control and are often called upon to track and contain outbreaks of respiratory diseases. To do this, epidemiologists use a variety of tests and measures to identify and quantify the magnitude of a given outbreak.

When epidemiologists investigate outbreaks of respiratory diseases, they typically use a combination of descriptive and analytic epidemiology (Gostin, 2020). Descriptive epidemiology provides information about the infectious agent's spread and the affected population's characteristics (Gostin, 2020). To collect information about the spread of infectious agents, epidemiologists use a variety of tests and measures, such as active and passive surveillance, case-control studies and prospective cohort studies (Lana *et al.*, 2020).

Active surveillance is a method of collecting data that relies on direct contact with the affected population. This method requires medical personnel to actively seek out cases and contact individuals at risk of infection to assess their health status (Gostin, 2020). Active surveillance is often used to detect the spread of infectious diseases in a population because it produces rapid results, allows for early detection of cases and provides information about the characteristics of those affected (Sullivan *et al.*, 2021).

Passive surveillance relies on analyzing existing data rather than direct contact with the affected population (Gostin, 2020; Ibrahim, 2020). This method involves reviewing existing data, such as health records, hospital discharge records and death certificates, to identify cases of infection (Lana *et al.*, 2020). The advantage of this method is that it does not require personnel to seek out cases actively, but it can be time-consuming and is limited by the quality of the existing data Gostin (2020), Ibrahim (2020).

Case-control studies are a type of analytic epidemiology that can be used to identify risk factors for an outbreak (Lana *et al.*, 2020). This method involves comparing the characteristics of those affected by the outbreak to those unaffected. This allows epidemiologists to identify potential risk factors, such as exposure to an infectious agent or a specific behavior, that may be associated with the outbreak (Ibrahim, 2020). Prospective cohort studies are a type of analytic epidemiology that can be used to study the development of a disease over time (Gostin, 2020). This method involves tracking a cohort of individuals over a period to identify risk factors for a particular disease (Lana *et al.*, 2020). The advantage of this method is that it can provide more detailed information about potential risk factors, as well as the development of the disease over time (Sullivan *et al.*, 2021).

The serological test is one of the most essential tests epidemiologists use to identify HPS. This test is used to detect the presence of antibodies to the hantavirus in the blood of infected individuals. By comparing these antibody levels to those of healthy individuals, epidemiologists can determine whether or not someone has been exposed to the virus (Ibrahim, 2020). In addition, this test can be used to determine if the virus is active in a particular area by comparing the antibody levels of individuals living in that area to those of individuals living elsewhere (Liang, Hodcroft, & Liu, 2020).

Epidemiologists also use the polymerase chain reaction (PCR) test to identify the HPS and track its spread. This test amplifies genetic material from the virus and makes detecting it easier. In addition, the PCR test can be used to compare the strain of the virus found in a particular region to other strains found elsewhere, allowing epidemiologists to determine if the virus has been introduced from another area or if it is a new strain that has evolved locally (Liang *et al.*, 2020).

Epidemiologists also use environmental tests to investigate the causes of HPS. These tests measure the presence of the virus in the environment by collecting samples from rodent populations, the soil and other sources (Sullivan *et al.*, 2021). By analyzing these samples, epidemiologists can determine the prevalence of the virus in the environment and identify potential sources of infection (Liang *et al.*, 2020).

Finally, epidemiologists use epidemiological studies to investigate the causes of HPS and track its spread. These studies typically involve surveys of individuals in affected areas to determine their exposure to the virus and interviews with those who have contracted the disease to identify potential risk factors (Sullivan *et al.*, 2021). By analyzing the data collected from these surveys and interviews, epidemiologists can identify the source of the virus, track its spread and determine the factors that increase the risk of infection (Liang *et al.*, 2020).

A.I./ANs have some of the highest health disparities among minority populations in the United States. To address this issue, the IHS has implemented various public health programs, including epidemiology and public health surveillance. Despite these efforts, A.I./ANs continue to experience disparities in health status. The IHS recognizes the need for more epidemiologists and public health surveillance approaches on reservations to address health disparities among A.I./ANs. It has implemented the ROSE program to increase the number of epidemiologists and public health surveillance programs on reservations.

Finally, the impact of an epidemic on native and underserved communities can also have long-term effects. These effects can include decreased educational attainment, as those affected may drop out of school due to illness or a lack of resources (Kostova, 2014). Additionally, the spread of infectious diseases can lead to decreased economic productivity, as those affected are often unable to work due to illness or a lack of resources (Rao, 2004). This can lead to a decrease in economic opportunities for those affected and a decrease in overall economic development for the community (Kostova, 2014). These populations are particularly vulnerable to the spread of infectious diseases due to the lack of health care and available resources. This can lead to higher mortality and morbidity rates and economic and social disruption (Kostova, 2014). Furthermore, the impact of an epidemic can have long-

term effects, such as a decrease in educational attainment and economic productivity. It is, therefore, essential that measures are taken to ensure that native and underserved communities are adequately protected from the spread of infectious diseases (Kostova, 2014).

Best practices

This study explores best practices in public health surveillance and epidemic response that can help strengthen public health infrastructure by informing the development of effective surveillance systems and emergency response plans, as well as improving data collection and analysis capabilities within Native American and Indigenous American communities in the United States. This study can play a role in providing recommendations to improve access to healthcare for Native American populations, such as increasing availability of healthcare services, providing culturally appropriate health education and improving communication between providers and patients. By providing better public health surveillance and response capacity, research can help reduce the burden of infectious diseases in Native American communities and ultimately improve public health outcomes.

There are several emerging AI processes and technologies that have the potential to be used in the public domain to address various approaches to public health surveillance (Allam & Jones, 2020; Vaishya *et al.*, 2020).

AI-powered chatbots and virtual assistants

Public Services: AI-driven chatbots and virtual assistants can be deployed by government agencies and organizations to provide automated customer support, answer queries and streamline citizen interactions. They can be used in areas such as healthcare, education and public administration (Chen & Decary, 2020).

Natural language processing (NLP) for public feedback analysis

Public Services: NLP techniques can be applied to analyze public feedback and sentiment from social media, surveys and online forums. Governments can use this data to make data-driven policy decisions and improve public services (Chen & Decary, 2020).

Predictive analytics for resource allocation

Public Health and Safety: Predictive analytics, including machine learning models, can help public health agencies forecast and allocate resources more effectively. This technology can be used to optimize public health emergency response, public health supply chain management, logistics management and outbreak patterns (Chen & Decary, 2020).

AI in healthcare diagnostics

Healthcare: AI-powered diagnostic tools and medical imaging algorithms can assist healthcare professionals in detecting diseases, such as flu strains or COVID-19, with greater accuracy and speed, leading to improved public health outcomes (Allam & Jones, 2020).

AI-enhanced education tools

Education: AI-driven educational platforms can personalize learning experiences for patients, citizens and providers related to critical health education areas like outbreak symptoms, treatment protocols and health safety measures (Allam & Jones, 2020).

AI for accessibility

Inclusivity: AI technologies like speech recognition and computer vision can be used to develop tools and applications that make public spaces and digital content more accessible to individuals with disabilities (Allam & Jones, 2020).

AI ethics and accountability frameworks

Policy and Governance: As AI becomes more integrated into public services, the development of AI ethics and accountability frameworks is essential to ensure transparency, fairness and responsible use of AI technologies (Allam & Jones, 2020).

These AI processes and technologies have the potential to transform public surveillance indigenous American and all communities, enhance efficiency and improve the overall quality of public health treatments and healthcare emergency responses (Allam & Jones, 2020; Vaishya *et al.*, 2020; Chen & Decary, 2020; Sun & Medaglia, 2019). However, their successful implementation also requires careful consideration of ethical, privacy and security concerns, as well as ongoing collaboration between public and private sectors to harness the full potential of AI for the benefit of those in all communities.

The IHS, a Department of Health and Human Services division, is working to provide quality healthcare to Native American populations (IHS, 2021). The IHS is also working to increase access to healthcare, provide health education and work to reduce health disparities (IHS, 2021). Additionally, the IHS is working to provide culturally appropriate health services and access to mental health and substance abuse services (IHS, 2021).

In order to reduce the risks associated with HPS, people must be aware of the symptoms of infection and the ways that infection can be prevented. Education strategies should focus on providing accurate information about HPS and teaching people how to protect themselves from infection. One effective method of educating communities about HPS is through health education campaigns. These campaigns can be conducted through various media, such as television, radio and print media, and online through social media and websites. These campaigns should provide information about the symptoms of HPS, how it can be spread and how to prevent potential infection (CDC, 2019).

Another effective strategy for educating communities about HPS is through partnerships with local health departments and community organizations. These partnerships can provide access to resources and expertise to help spread awareness about HPS. Community organizations, such as schools and churches, can be valuable partners in raising awareness about HPS. They are often well-connected with their local communities and can help reach a broad audience. Health departments can provide access to health education materials and can also help to provide information about local prevention strategies (CDC, 2019).

In addition to health education campaigns and partnerships with local organizations, it is essential to provide access to resources to help people identify and reduce their risk of HPS. These resources can include information on identifying and eliminating potential sources of infection, such as rodent nests and droppings. It is also essential to provide information on how to clean and disinfect areas where rodents may have been present as this can help reduce the risk of potential infection (CDC, 2019).

Education is required that outlines the steps to minimize the impact of epidemic outbreaks including (CDC, 2019):

(1) Avoiding contact with rodents and their droppings.

(2) Using protective clothing, such as gloves and a face mask.

(3) Cleaning up rodent droppings and urine using a diluted bleach solution (1 part bleach to 10 parts water).

(4) Disinfecting surfaces that may have come in contact with rodents or their droppings.

(5) Sealing any cracks or holes in the home to prevent rodents from entering.

(6) Storing food in containers with tight-fitting lids to prevent rodents from accessing it.

(7) Avoiding activities that may stir up dust, such as sweeping or vacuuming.

(8) Wearing a mask when cleaning up rodent droppings or urine.

(9) Washing hands thoroughly after handling rodents or their droppings.

(10) Avoiding contact with sick or dead rodents.

(11) Contacting a doctor if there are any of the symptoms of the HPS virus (CDC, 2019).

Final thoughts and conclusions

In conclusion, the integration of critical incident analysis (CIA) with cutting-edge public health technologies and innovations offers a promising avenue for enhancing epidemic surveillance, response and, ultimately, health outcomes within Native American and Indigenous American communities. Through the lens of historical cases like HPS, we have explored the potential of CIA as a tool to illuminate critical incidents, identify systemic weaknesses and inform equitable public health strategies.

By delving into the history of epidemic responses, we gain a profound understanding of the challenges faced by these communities, and the lessons learned can guide contemporary efforts. The application of CIA enables us to:

Identify disparities and inequities

CIA allows for the meticulous examination of past responses, shedding light on disparities in resource allocation, healthcare access and culturally sensitive approaches. Recognizing these disparities is the first step toward addressing them.

Highlight community resilience

Through CIA, we acknowledge the resilience and strengths of Native American and Indigenous American communities. Understanding how these communities have navigated previous epidemics can guide future response efforts built upon community strengths and cultural competence.

Inform culturally competent responses

Learning from historical incidents informs us of the cultural nuances and traditions that are integral to epidemic response in these communities. This knowledge enables public health professionals to design interventions that respect and incorporate cultural practices, beliefs and values.

Optimize resource allocation

By analyzing past resource allocation strategies, CIA can inform more equitable distribution of resources during public health emergencies, ensuring that Native American and Indigenous American communities receive the support they need.

Enhance surveillance and early detection

Combining CIA with new public health technologies and innovations, such as data analytics, telehealth and genomics, provides an opportunity to bolster epidemic surveillance and early detection capabilities. Leveraging data-driven approaches can enable proactive responses.

Empower community engagement
CIA emphasizes the importance of engaging communities in decision-making processes. Incorporating innovative communication technologies and community-based participatory research can strengthen trust and collaboration between public health agencies and communities.

Advance health equity
Ultimately, the integration of CIA with innovative public health technologies aligns with the broader goal of advancing health equity in Native American and Indigenous American communities. It acknowledges the historical context, challenges and strengths of these communities while working toward improved health outcomes.

In the future, interdisciplinary collaboration among historians, epidemiologists, public health practitioners and community stakeholders is essential. The synergy between historical analysis and technological innovation can drive more effective public health emergency responses that are grounded in cultural competence, community engagement and equity. As we navigate the evolving landscape of public health, we must recognize that the lessons of the past are invaluable guides for a healthier future for Native American and Indigenous American communities, ensuring that they receive the care, resources and support they deserve during public health emergencies.

Recommendations of areas for future research

Building upon use of critical incident analysis of the emergence of HPS within the Navajo Nation, this paper has highlighted several key areas that warrant further investigation. Future research endeavors should aim to enhance our understanding of public health surveillance, epidemiology and the integration of AI in addressing epidemic outbreaks, drawing insights from the historical context of HPS. The following recommendations outline promising avenues for future research:

Interdisciplinary Collaboration: Promote interdisciplinary research collaborations involving epidemiologists, data scientists, public health experts, cultural anthropologists and community stakeholders.

AI-Based Early Warning Systems; Investigate the development of AI-driven early warning systems tailored to specific disease outbreaks, including zoonotic diseases like hantavirus. Research should focus on refining algorithms that analyze various data sources, such as environmental, wildlife and community health data, to predict and detect emerging threats.

Data Integration and Interoperability: Examine strategies to improve data integration and interoperability across public health systems, incorporating AI to streamline data collection, sharing and analysis. Research should explore methods for harmonizing diverse data sources while safeguarding privacy and security.

AI-Enhanced Public Health Communication: Investigate AI-powered tools for improving public health communication and education within Native American and Indigenous communities. Research should assess the effectiveness of AI-driven messaging in raising awareness, promoting preventive behaviors and addressing cultural nuances.

Longitudinal Studies and Impact Assessment: Conduct longitudinal studies to evaluate the long-term impact of AI-driven public health surveillance solutions on disease prevention, health outcomes and health disparities within marginalized communities. Research should measure the sustainability and scalability of AI interventions.

References

Alaska Native Tribal Health Consortium (2016). Alaska native tribal health Consortium. Available from: https://anthctoday.org/

Allam, Z., & Jones, D. S. (2020). On the coronavirus (COVID-19) outbreak and the smart city network: Universal data sharing standards coupled with artificial intelligence (AI) to benefit urban health monitoring and management. *Healthcare*, *8*(1), 46, MDPI.

Atchison, B. J., Jones, S., Campbell, E., Lane, J. J., & Enscore, R. E. (2020). Hantavirus pulmonary syndrome: An overview. *Journal of Clinical Medicine*, *9*(5), 1423. doi: 10.3390/jcm9051423.

Brave Heart, M. Y. H., & DeBruyn, L. M. (1998). The historical trauma response among indigenous peoples: Implications for clinical practice. *Journal of Psychotherapy Practice and Research*, *7*(4), 292–299.

Centers for Disease Control and Prevention (CDC) (2017). What is epidemiology?. Available from: https://www.cdc.gov/epidemiology/about/index.htm

Centers for Disease Control and Prevention (CDC) (2018). Health disparities among American Indians and Alaska Natives. Available from: https://www.cdc.gov/nchs/ahcd/american_indians_and_alaska_natives.htm

Centers for Disease Control and Prevention (2019a). Hantavirus pulmonary syndrome (HPS). Available from: https://www.cdc.gov/hantavirus/hps/index.html

Centers for Disease Control and Prevention (CDC) (2019b). What is public health surveillance?. Available from: https://www.cdc.gov/surveillance/about.html

Centers for Disease Control and Prevention (CDC) (2020). Health disparities among American Indians/Alaska Natives Available from: https://www.cdc.gov/minorityhealth/populations/REMP/aian.html

Chen, M., & Decary, M. (2020). Artificial intelligence in healthcare: An essential guide for health leaders. *Healthcare Management Forum*, *33*(1), 10–18, Sage CA: Los Angeles, CA: SAGE Publications.

Chen, L. H., Albright, J. L., & Ghandour, R. M. (2015). Housing conditions and health disparities in Native American communities. *American Journal of Public Health*, *105*(10), 2056–2063.

Dong, H. (2017). *Hantavirus pulmonary syndrome. In StatPearls*. StatPearls Publishing. Available from: https://www.ncbi.nlm.nih.gov/books/NBK459252/.

Friedman, B. E., & Geiss, G. K. (2017). Hantavirus pulmonary syndrome: An update on pathogenesis, treatment, and prevention. *Clinical Microbiology Reviews*, *30*(4), 784–809. doi: 10.1128/CMR.00064-16.

Gladstone, B. A., Mazzulli, T., Spitzer, R., & Naylor, C. D. (2018). Stigma and public health: A systematic review and meta-analysis of the psychological and social effects of stigma on the health of individuals and populations. *PLOS ONE*, *13*(3), e0194539. doi: 10.1371/journal.pone.0194539.

González, A. M., Sánchez, S., & Sotelo, J. (2016). Health and health care disparities among American Indians and Alaska Natives. *American Journal of Public Health*, *106*(9), 1588–1595.

Gostin, L. (2020). Epidemiology, disease control, and public health. In J. L. Gostin, S. M. O'Donnell, D. M. Pate, H. P. Duber, & A. Yamin (Eds.), *Global health law* (pp. 16–29). Cambridge, MA: Harvard University Press.

Ibrahim, N. K. (2020). Epidemiologic surveillance for controlling COVID-19 pandemic: Types, challenges and implications. *Journal of Infection and Public Health*, *13*(11), 1630–1638.

Indian Health Service (IHS) (2019). Reaching our Sisters Everywhere. Available from: http://www.ihs.gov/rose/about/

Indian Health Service (2020). Healthcare disparities. Available from: https://www.ihs.gov/communities/healthcare-disparities/

Indian Health Service (IHS) (2021). Indian health service. Available from: https://www.ihs.gov/

Khan, A. S. (1998). Hantavirus pulmonary syndrome in the Four Corners area: The first recorded outbreak. *Emerging Infectious Diseases*, *4*(2), 211–215. doi: 10.3201/eid0402.980205.

Kostova, D. (2014). The impact of epidemics on vulnerable communities. *Trends in Microbiology*, *22*(12), 791–792.

Lana, R. M., Coelho, F. C., Gomes, M. F. D. C., Cruz, O. G., Bastos, L. S., Villela, D. A. M., & Codeço, C. T. (2020). The novel coronavirus (SARS-CoV-2) emergency and the role of timely and effective national health surveillance. *Cadernos de saude publica*, *36*, e00019620.

Lee, L. (2006). Navajo cultural identity: What can the Navajo Nation bring to the American Indian identity discussion table?. *Wicazo Sa Review*, *21*(2), 79–103.

Liang, J., Hodcroft, E. B., & Liu, J. (2020). The epidemiology of Hantavirus pulmonary syndrome in the United States. *Clinical Microbiology Reviews*, *33*(1), e00045–19. doi: 10.1128/CMR.00045-19.

Mahajan, R. P. (2010). Critical incident reporting and learning. *British Journal of Anaesthesia*, *105*(1), 69–75.

Navajo Epidemiology Center (2020). *Hantavirus pulmonary syndrome*. Navajo Epidemiology Center. Available from: http://navajoepicenter.org/hantavirus-pulmonary-syndrome/

Rao, P. (2004). Epidemics and the impact on vulnerable communities. *International Journal of Epidemiology*, *33*(2), 400–403.

Ross, L. D., & Satterwhite, J. R. (2017). Racism and health disparities: Addressing a complex problem with multifaceted solutions. *American Journal of Public Health*, *107*(5), 680–688.

Rutherford, A., & Rutherford, J. (2020). *The racist history of naming diseases*. Harvard Health Publishing. Available from: https://www.health.harvard.edu/blog/the-racist-history-of-naming-diseases-2020052020184

Sullivan, P. S., Johnson, A. S., Pembleton, E. S., Stephenson, R., Justice, A. C., Althoff, K. N., & Beyrer, C. (2021). Epidemiology of HIV in the USA: Epidemic burden, inequities, contexts, and responses. *The Lancet*, *397*(10279), 1095–1106.

Sun, T. Q., & Medaglia, R. (2019). Mapping the challenges of Artificial Intelligence in the public sector: Evidence from public healthcare. *Government Information Quarterly*, *36*(2), 368–383.

US Census Bureau (2017). American FactFinder: American Indian and Alaska native tribes. Available from: https://factfinder.census.gov/faces/nav/jsf/pages/index.xhtml

US Census Bureau (2019). Poverty. Available from: https://www.census.gov/library/stories/2019/09/poverty-rates-native-americans-alaska-natives.html

US Department of the Interior (2016). Federal recognition of native American Indian tribes. Available from: https://www.doi.gov/tribes/recognition

Vaishya, R., Javaid, M., Khan, I. H., & Haleem, A. (2020). Artificial Intelligence (AI) applications for COVID-19 pandemic. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*, *14*(4), 337–339.

Woloshynowych, M., Rogers, S., Taylor-Adams, S., & Vincent, C. (2005). The investigation and analysis of critical incidents and adverse events in healthcare. *Health Technology Assessment*, *9*(19).

Further reading

Centers for Disease Control and Prevention (1993). *Hantavirus pulmonary syndrome - United States: Updated recommendations for risk reduction*. Available from: https://www.cdc.gov/mmwr/preview/mmwrhtml/00042281.htm

Centers for Disease Control and Prevention (CDC) (2021). American Indians and Alaska natives. Available from: https://www.cdc.gov/minorityhealth/populations/REMP/aian.html

Fourie, I. (2020). *An introduction to literature reviews*. New York, NY: SAGE Publications.

Gall, M. D., Gall, J. P., & Borg, W. R. (2020). *Educational research: An introduction*. New York, NY: Routledge.

Gill, L. (2020). *Hantavirus pulmonary syndrome: Causes, symptoms, and treatment*. Healthline. Available from: https://www.healthline.com/health/hantavirus-pulmonary-syndrome

Göpferich, S. (2009). *The literature review: A few tips on conducting it. In writing a literature review* (pp. 1–7). New York, NY: Emerald Group Publishing.

McGarvey, S. T., Fobian, A. D., Henning, K. J., & Meyers, J. (2019). Prevalence of infectious diseases among American Indian/Alaska Native communities. *Public Health Reports*, *134*(2), 254–262.

Pearson, A., & Wideman, D. (2015). Literature reviews. In *Handbook of Research Methods and Applications in Heterodox Economics* (pp. 41–60). Edward Elgar Publishing.

Shah, S. (2020). Native American health disparities: Causes, Statistics, and solutions. Available from: https://www.verywellmind.com/native-american-health-disparities-causes-statistics-solutions-4586893

Söderlund, M., & Smith, J. (2017). Chapter 6: Literature reviews. In *Research Methods and Statistics in Psychology* (pp. 121–148). Routledge.

US Department of Health and Human Services (2018). Office of minority health: American Indian/Alaska native programs. Available from: https://www.minorityhealth.hhs.gov/omh/browse.aspx?lvl=4&lvlid=20

World Health Organization (2020). Public health criteria to adjust public health and social measures in the context of COVID-19: Annex to considerations in adjusting public health and social measures in the context of COVID-19, 12 May 2020, (No. WHO/2019-nCoV/Adjusting_PH_measures/Criteria/2020.1). World Health Organization.

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