Journal for Re Attach Therapy and Developmental Diversities
eISSN: 2589-7799
2023 August; 6 (9s): 1536-1554

From Ancient to Modern Times: A Systematic Review of Emerging Infectious Diseases and their Relevance to the COVID-19 Pandemic

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Received: 24- June -2023
Revised: 27- July -2023
Accepted: 21- August -2023

Abstract

Infectious diseases have consistently shaped human history, as evidenced by the parallels between the COVID-19 pandemic and previous outbreaks. This study aimed to identify recurring themes in the emergence and management of infectious diseases, with a focus on enhancing future preparedness and response efforts. Through an extensive systematic review of the literature, the research examined factors such as the zoonotic origins of pathogens, the complex interactions between humans and animals, the role of high population densities and urbanization, the critical importance of hygiene and public sanitation, the impact of political leadership and healthcare policies, and the effects of societal beliefs, behaviors, and perceptions on disease spread and control. The investigation revealed patterns that persist from ancient times to modern-day pandemics. One of the key findings highlighted by numerous studies is the need for comprehensive environmental measures to mitigate the risk of zoonotic diseases and manage human-animal contact. Addressing these issues is crucial for establishing robust management systems capable of minimizing the threat of infectious diseases. The study resulted in the creation of a Historical Lens Model that integrates lessons learned from historical pandemics, providing valuable guidance for dealing with current and future public health crises.

Keywords: Emerging Infectious Diseases, COVID, Contributory Factors and Relevance

Introduction

Infectious diseases have always been a part of our shared human story. From different ancient times Plague to the Middle Ages' Black Death, the 1918 "Spanish Flu" pandemic (Morens, Folkers, Fauci, 2004; NIH, 2008), and more recently, the COVID-19 pandemic have continued to emerge and reemerge in a manner that it brought global catastrophe (Institute of Medicine, 2003; Markel, 2007). According to the World Health Organization (2007), infectious diseases are responsible for 57 million global annual deaths. These historical perspectives illustrate that the current COVID pandemic is not unprecedented, as humanity has confronted pandemic events many times before (Yeomans, 2020). Despite having different causes, many infectious diseases have similar effects and management approaches. By examining the current pandemic through a historical lens, we can gain valuable insights and lessons to better understand the situation.

Emerging infectious diseases are defined as infections that have either affected a population for the first time or are rapidly increasing in the number of cases or geographical areas affected (WHO, 2010; National Institutes of Health, 2007). Developing countries with fewer resources tend to be hit the hardest by these diseases (WHO, 2008; Jones, 2008), which have significant social and economic impacts. Unfortunately, countries in Asia are often identified as the epicenter of these emerging infectious diseases (WHO, 2008; Jones, 2008). This observation explains why the Philippines has been experiencing various emerging diseases over time. Therefore, it is crucial for Filipinos to be knowledgeable and prepared to handle such diseases.

It's important to note that many of the emerging diseases are zoonotic, meaning they originate from animals and cross over to infect humans. Over the past 30 years, WHO (2014) has detected more than 30 new organisms, many of which have originated from the human-animal interface. In fact, WHO estimates that approximately 75%

of emerging infectious diseases in 2011 originated from animals. This is reminiscent of the SARS-COV-2 virus responsible for the COVID-19 pandemic, which is believed to have originated in bats and was transmitted to humans through the consumption of infected animal sources. Such transmission pathways may have played a role in other historical emerging diseases, highlighting the importance of exploring various emerging illnesses.

Aside from the nature of emerging diseases, the spread of infectious microorganisms is also influenced by various other factors. WHO (2010) has identified increasing travel, trade, and mobility of people worldwide as key drivers of the easy spread of microorganisms across international borders, resulting in the seamless movement of diseases from one population to another. Other factors contributing to emerging infections include urbanization and destruction of natural habitats, which lead to humans and animals living in close proximity; climate change and changing ecosystems; changes in reservoir hosts or intermediate insect vectors; and microbial genetic mutation. As new diseases emerge, new factors may also arise, highlighting the need for ongoing investigation and response.

The resilience of a public health system is foundational in managing and mitigating the impacts of emerging infectious diseases, as emphasized by the World Health Organization (WHO, 2010). However, existing health systems are frequently strained by outbreaks, highlighting a critical need to fortify elements such as preparedness, surveillance, risk assessment, risk communication, and laboratory capabilities, particularly at the community level. A notable gap exists in the scholarly discourse: while epidemiologists and healthcare managers frequently concentrate on immediate disease management and control, the historical analysis of infectious diseases remains relatively underexplored. Research by Markel (2007), Littman (2009), and Dunleavy (2020) substantiate that historical accounts can offer pivotal insights into long-term sociological and demographic shifts. Furthermore, studying past methodologies and responses can enable the application of successful public health interventions to contemporary and future infectious diseases (Littman, 2009; Peckham, 2020).

To address this academic shortfall, the present study employs a systematic review to investigate two pivotal research questions: RQ1 - "What are the thematic commonalities between ancient infectious diseases and COVID-19 in relation to contributory factors?" and RQ2 - "What insights can be garnered from past emerging infectious diseases to inform and enhance preparedness and response strategies for the COVID-19 pandemic and potential future pandemics?" These questions aim to bridge the existing gap by employing a historical lens to dissect emerging diseases, thereby offering a comprehensive framework for improving preparedness and response strategies. This multidimensional approach ensures that lessons learned from historical pandemics are aptly integrated into present-day public health policies and interventions.

Theoretical Framework

The study anchors on the germ theory of Koch and Pasteur (1870) and the Germ Terrain Duality Theory of Ayoade (2017). These two theories provide a discussion on the possible occurrence of emerging diseases.

Germ theory is the scientific concept that the presence and activity of microorganisms cause certain diseases, typically bacteria or viruses, commonly called germs. This theory revolutionized medicine and public health in the late 19th century, clearly understanding how diseases spread and how they could be prevented or treated (National Academy of Sciences, 2004). The major concepts of germ theory include *Microorganisms*: Germ theory is based on the idea that microorganisms, such as bacteria, viruses, and fungi, can cause infectious diseases.

Contagion: the theory proposes that diseases can spread from person to person through direct or indirect contact with infectious agents. *Pathogenicity*: Pasteur recognizes that not all microorganisms are harmful, but pathogenic ones can cause illness or disease. *Immunity*: Germ theory suggests that immunity can develop after exposure to an infectious agent, leading to resistance against future infections. *Hygiene*: lastly, the theory emphasizes the importance of good hygiene practices, such as handwashing and sterilization of medical equipment, in preventing the spread of infectious diseases. Moreover, the theory believes that disease can strike anybody and prevent illness by building defenses by avoiding and killing germs (Ayoade, 2017). However, this theory completely ignores the importance of the immune system as part of the body's defense against microorganisms.

On the other hand, Germ Terrain Duality Theory proposes that the development of infectious diseases is not solely dependent on the presence of germs but is also affected by the individual's overall health and their environment. This theory suggests that the traditional Germ Theory, which emphasizes the role of specific pathogens in causing disease, is incomplete, and the concept of the terrain, or the overall condition of the body and its surroundings, is equally important. According to the Germ Terrain Duality Theory, the body's internal environment, such as its pH balance, nutritional status, and immune system function, plays a significant role in determining whether or not a pathogen can establish an infection. External factors such as pollution, toxins, and lifestyle choices also impact the terrain and can make an individual more susceptible to infections.

This theory has important implications for the prevention and treatment of infectious diseases. Instead of solely focusing on eliminating pathogens, it highlights the importance of maintaining a healthy internal and external environment to support the body's natural defenses against infections. This includes measures such as improving nutrition, reducing exposure to toxins and pollutants, and promoting healthy lifestyle habits like exercise and stress management (Ayoade, 2017).

While the Germ Terrain Duality Theory provides important insights into the role of host susceptibility and environmental factors in the development of infectious diseases, some critics argue that it may overlook the importance of specific pathogens in causing disease and the need to control their spread. To address this limitation, combining the Germ Theory and Germ Terrain Duality Theory can provide a more comprehensive understanding of the complex factors contributing to the development and spread of infectious diseases. By considering the interplay of causative agents, hosts, and the environment, this approach is similar to the concept of the epidemiological triad, which includes host, vector, and environment. To control disease outbreaks, it is necessary to alter or break the three corners of the triad, which can be achieved through various health management strategies. Figure 1 illustrates the interplay of the different variables in this study, highlighting the importance of considering both germ theory and germ terrain duality theory in understanding and managing infectious diseases.

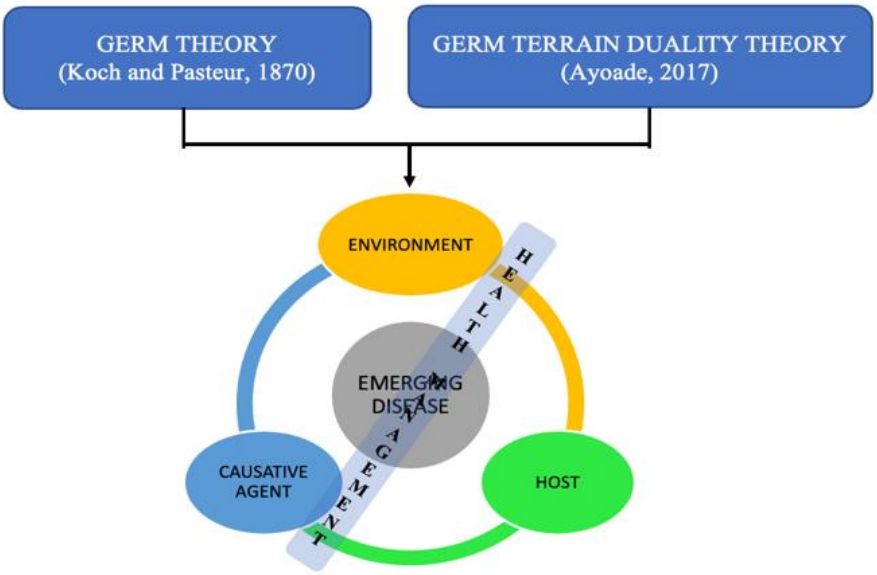

Figure 1 shows the interplay of variables used in the study

Methodology

This research employed a systematic review methodology, rigorously adhering to the standards delineated by the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. As part of this systematic review, the structured PICO (Population, Intervention, Comparison, Outcome) framework was utilized. This framework assisted in refining our research questions, optimizing search strategies,

and ensuring an exhaustive evaluation of pertinent literature. The integration of both PRISMA and PICO guaranteed transparency, consistency, and methodological rigor throughout the review.

Literature search process

The study adhered to the guidelines set forth by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). The researchers formulated a search string based on the PICO framework, which comprises four components: P, representing the individual or group of people affected by emerging diseases; I, representing the health management and practices conducted as the intervention being studied; C, representing the comparison of these practices between ancient and current times; and O, representing the investigation of how these practices contribute to the control of emerging diseases. Keywords used such as "Emerging diseases," AND "Relevance to COVID-19," AND "Causes/ Causative Factors, NOT "non-communicable/ non-emerging diseases." A combination of keywords was used to refine the search results and identify relevant studies for this investigation. The screening process involved using inclusion and exclusion criteria to identify eligible literature. These criteria were applied consistently throughout the screening process to ensure the inclusion of only pertinent studies.

The PRISMA search protocol identified a total of 356 related studies retrieved from three online data sources, of which 76 are from ProQuest, 120 are from Google Scholar, and 160 are from PubMed. After removing duplicates and studies irrelevant to the research topic, 208 studies remained. However, due to the unavailability of full text and failure to meet inclusion and exclusion criteria, 144 studies were excluded, leaving 18 eligible sources. The eligible sources included 1 study from ProQuest, 5 from Google Scholar, and 12 from PubMed.

The identified citations were compiled in a Word document file and manually synthesized using Excel. The literature obtained through the electronic databases, snowball, and hand-searching undergoes a two-stage screening process. The first stage involves reviewing the titles and abstracts of the retrieved literature to assess eligibility with the minimum inclusion criteria set in this study. Further, in the second stage, the full texts of the included articles were reviewed and evaluated using Cochrane methods (Higgins, et. al., 2019)

Eligibility Criteria

The study established clear inclusion and exclusion criteria to ensure a comprehensive and relevant selection of literature for the study. The inclusion criteria were set to include a). Full-text peer-reviewed articles on major infectious diseases throughout the world. Including investigation of evolving societal enablers, barriers, and management practices to thwart and control the spread of infectious diseases; b). Research papers that are written in full English text; c). Articles that discussed major epidemiologic events/diseases from the Athenian plague to the present; d). Research articles were published in peer-reviewed journals in English; e). Textbooks that were peer-reviewed and published; and f). Abstract represented in scientific community conferences, congress reports, dissertations, case studies, and other gray literature.

In December 2022, the researchers conducted a comprehensive electronic database search to identify relevant literature and studies on emerging diseases. The search encompassed a broad range of emerging diseases, including those that have existed since ancient times, such as the Plague, and modern diseases like Avian influenza, Smallpox, Yellow fever, SARS, MERS, Legionella, Ebola, Anthrax, and others. Data from these sources were extracted and included in the study to facilitate a comprehensive understanding of emerging diseases and their implications for public health. The inclusion of literature from different time periods allowed for a thorough examination of the evolution and impact of emerging diseases on society over time.

On the other hand, the exclusion criteria include: a). Articles that focus solely on non-infectious, non-emerging diseases; b). non-English language papers; c). Book chapter reviews published in secondary, non-empirical studies; f). Commentaries, review documents, letters, discussion papers, and posters; and g). articles with no full text available.

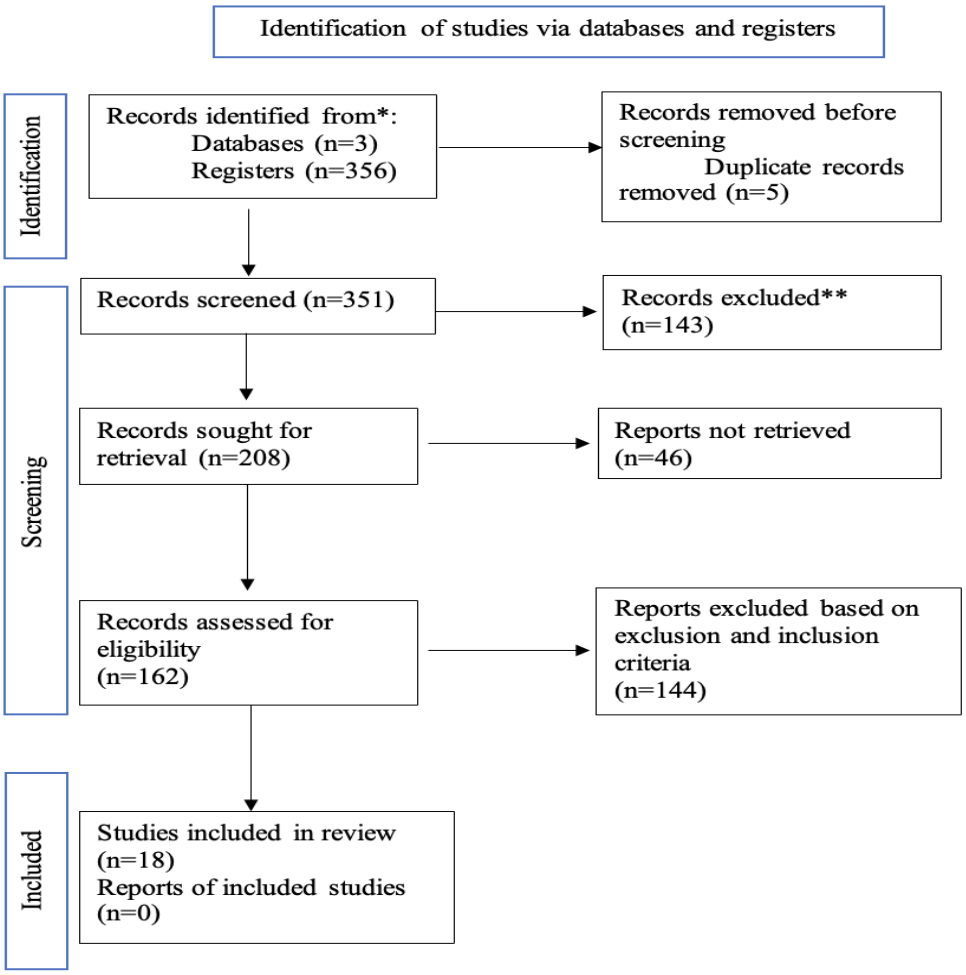

Figure 2. PRISMA flowchart for the Selected Articles

Risk of Bias Across Studies

To reduce the risk of bias, the researchers utilized the Bolens, Wever, & Voet (2017) review procedure, which involves conducting separate literature reviews. Two writers reviewed the titles, abstracts, and full manuscripts of the identified papers against the study's inclusion and exclusion criteria to select relevant articles. In cases where uncertainty arose, the third author independently evaluated the compiled sources. The writers then discussed and deliberated the selection of peer-reviewed journals until a consensus was reached. This rigorous review process helps to ensure that the selected articles meet the study's criteria and reduces the possibility of introducing bias into the analysis.

Overview of Systematic Review Studies

The paper provides an overview of the research methodologies utilized in the selected studies, as shown in Figure 3. Out of the eighteen (18) selected studies, four (n=4) utilized qualitative research methods, while four (4) others used mixed qualitative and quantitative approaches. Three (n=3) studies each employed mixed method case studies and thematic reviews. Two (n=2) studies were systematic reviews, and one (n=1) each utilized descriptive research and descriptive correlational research methodologies. This distribution of research methods demonstrates the varied approaches utilized in the literature on emerging diseases and reflects the need for a diverse range of methodologies to comprehensively understand the topic.

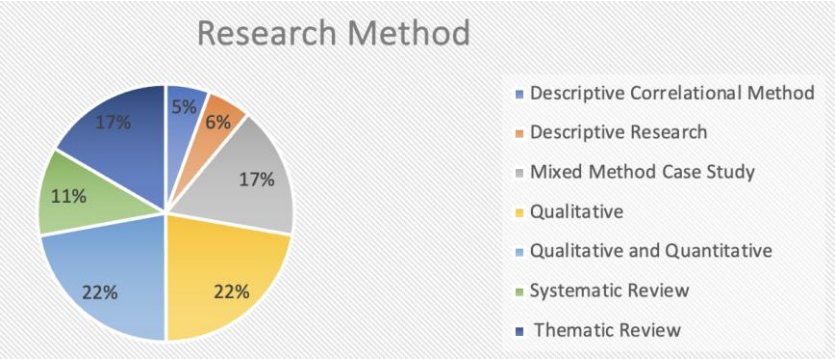

Figure 3. Distribution of selected ID studies by research method

Figure 4 displays the distribution of studies according to their country of origin. The majority of studies (n=4) were conducted in the United States of America. Four (4) countries contributed two (2) studies each, namely Brazil (n=2), Switzerland (n=2), the United Kingdom (n=2), and South Africa (n=2). The remaining six (6) countries provided a single study each: India (n=1), Canada (n=1), Norway (n=1), Indonesia (n=1), the Philippines (n=1), and Ukraine (n=1). The higher number of studies from the USA is due to the presence of the Centers for Disease Control and Prevention (CDC), while Switzerland is the headquarters of the World Health Organization, which explains the contribution of two studies.

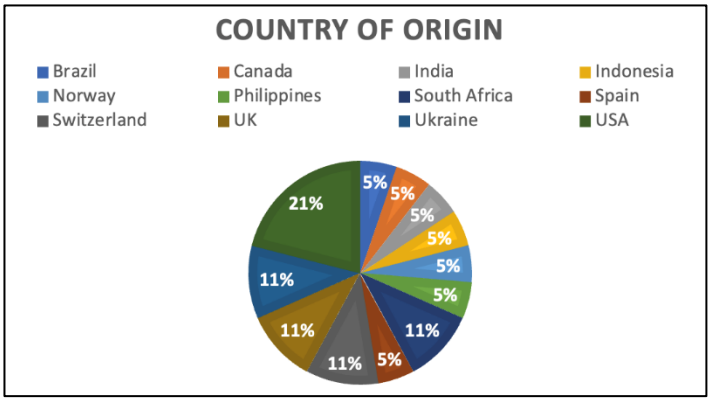

Figure 4. Distribution of selected ID studies by country of origin

Results and Discussions

Human societies have faced various emerging infectious diseases throughout history. These diseases have significantly impacted affected societies, and various efforts have been made to combat, alleviate, or prevent their emergence. The analysis does not differentiate between different modes of infection. Instead, it focuses on how society interacts with infectious diseases in terms of their contributory factors, effects, and ways to improve, prevent, and prepare for them. These ideas help us comprehend the diverse perspectives of society in dealing with infectious diseases.

Contributory Factors of Ancient Infectious Diseases and COVID-19

Emerging infectious diseases (EIDs) have created significant problems throughout history, affecting civilizations, economies, and international health policies. Novel infections and their effects continue to have an impact on the world despite notable advances in medical research and technology. In this systematic study, essential factors named as themes come into play as reflected in Table 1—human-animal interactions, trade & travel, population density, dynamics and urbanization, hygiene & sanitation, political leadership, and human beliefs, behavior & perceptions. These themes illustrate similarities between infectious diseases in the past and the present.

Table 1

Similitude in ancient and modern emerging infectious diseases

Contributory Factors		Theme
Ancient Emerging Diseases	COVID	
• Bubonic plague spread from rodents and spread to humans through the bite of infected fleas (Harbeck et al., 2013, Stenseth et al., 2008 Gage & Kosoy, 2005); • H1N1 influenza A virus responsible for the 1918 Spanish flu pandemic is thought to have emerged from an avian host (Taubenberger & Morens, 2006).	• Originated in bats and may have been transmitted to humans through an intermediate host, such as pangolins (Andersen et al., 2020, Zhang et al., 2020). • Wet markets and the wildlife trade potential sources of zoonotic diseases (Karesh et al., 2012; Zhou et al., 2020).	Human-Animal Interactions
• Return of Athens soldiers after war (Littman, 2009, Morens, Folkers Fauci, 2008) • Multiple independent importations (Morens, Folkers Fauci, 2008) • Commerce and intense trade between Europe and Asia and plague tended to arrive by ship (Ferreira, 2014).	• Strong trade and travel links spreads COVID (Huang et al., 2020; WHO, 2020). • Air travel (Chinazzi et al., 2020; Bogoch et al., 2020); Cruise ships (Moriarty et al., 2020; Kakimoto et al., 2020)	Trade and travel
• Crowded areas during plagues (Carmichael, 2014; Littman, 2009), inadequate housing,overcrowding, (Kelaidis, 2020; Horgan, 2019; Morens, Folkers Fauci, 2008) • Quarters of the poor are densely crowded (Morrill, 2016, Fischer, 2017) Living in close proximity (Gage, 2012)	• Population density and urbanization (Hamidi et al., 2020; Sy et al., 2020) • Crowded buses, trains, and subways, especially with insufficient ventilation, and people are not wearing masks (Hu et al., 2020). • Low-income and marginalized populations (Ahmed et al., 2020)	Population Density, dynamics, and urbanization
• Poor ventilation (Littman, 2009), inadequate sanitation, (Kelaidis, 2020) • Accumulation of human and animal waste (Cohn, 2008), Inadequate sanitation infrastructure (Byrne, 2004). • Limited knowledge on personal hygiene and the transmission of infectious diseases (Cohn, 2008). • Rodent infestations (Gage & Kosoy, 2005), improper handling and disposal of the dead (Cohn, 2008)	• Infrequent handwashing (World Health Organization, 2020); • Poor surface cleaning and disinfection; Sharing personal items (Centers for Disease Control and Prevention, 2020). • Inadequate ventilation (Morawska et al., 2020)	Hygiene and sanitation
• Poor economic, social, and political foundation (Bruun, 2006; Sitaraman, 20111) • Political tension (De Witte, 2020) • Government's failed health policies (Fischer, 2017)	• Delayed response (Hale et al., 2020) • Conflicting messages from political leaders and health authorities (Gollwitzer et al., 2020). • The politicization of public health measures (Gostin et al., 2016). • Insufficient funding and resources for healthcare systems, testing, and	Political Leadership and public health policies

	contact tracing (Legido-Quigley et al., 2020). • Inequitable vaccine distribution (Wouters et al., 2021).	
• Lack of attention to important public-health and safety measures (Kelaidis, 2020; Morens, Folkers Fauci, 2008; Horgan, 2019) • People during the plague attributed the disease to supernatural causes, divine punishment, or the alignment of the planets (Cohn, 2002). • Resistance of people due to religious objections, distrust of medical practitioners, or concerns about the procedure's safety (Stern & Markel, 2005).	• Non-wearing of mask (Chu et al., 2020) • Complacency in public health guidelines: mask-wearing, hand hygiene, and social distancing (Bavel et al., 2020). • Ignoring physical distancing recommendations (Centers for Disease Control and Prevention, 2020); Not adhering to self-isolation and quarantine guidelines (Hellewell et al., 2020) • COVID-19 misinformation and conspiracy theories (Pennycook & Rand, 2020); Lack of trust in authorities and institutions (van der Linden, 2021). • Individualism and prioritizing personal freedom (Bavel et al., 2020); Social stigma and discrimination (Bagcchi, 2020).	Human beliefs, behaviors, and perceptions

*Human-Animal Interactions**:***

A recurring theme in the emergence of EIDs is the critical role of human-animal interfaces. Zoonotic diseases, caused by pathogens that spill over from animals to humans, have been responsible for numerous historical pandemics. For instance, the Plague of Justinian, attributed to Yersinia pestis, is believed to have originated from rodents (Harbeck et al., 2013, Stenseth et al., 2008 Gage & Kosoy, 2005). Similarly, the H1N1 influenza virus responsible for the Spanish Flu in 1918 had an avian origin (Taubenberger et al., 2005).

In modern times, the continued expansion of human populations into wildlife habitats, the intensification of animal agriculture, and the growth of the wildlife trade have further increased the opportunities for zoonotic diseases to emerge. For example, the emergence of the highly pathogenic H5N1 avian influenza virus was linked to human-animal interactions in live bird markets, where the virus could spread among birds and occasionally infect humans (Sims et al., 2005). The severe acute respiratory syndrome (SARS) outbreak in 2002-2003, caused by a coronavirus, was traced back to wildlife markets in China, where the virus is believed to have jumped from bats to civets and then to humans (Guan et al., 2003). Similarly, the ongoing COVID-19 pandemic, caused by the SARS-CoV-2 virus, is thought to have a zoonotic origin, with evidence pointing to bats as the potential reservoir and an intermediate host, potentially a pangolin, facilitating the transmission to humans (Anderson et al., 2020; Zhang et al., 2020). The exact route of transmission remains under investigation. Still, it is likely that human-animal interactions in wildlife markets or other settings played a crucial role in the emergence of the virus.

Therefore, human-animal interactions have been a common contributing factor in the emergence and spread of infectious diseases throughout history, from ancient to modern times. As human populations continue to grow and encroach on wildlife habitats, the risk of zoonotic diseases emerging will likely persist.

Trade and travel:

Trade and travel have been significant contributing factors in the spread of infectious diseases throughout history, from ancient times to the modern era, including the COVID-19 pandemic. The movement of people, goods, and animals across borders and continents facilitates the transmission of pathogens, leading to the emergence of new diseases or the re-emergence of existing ones.

In ancient times, the expansion of trade routes and increased travel contributed to the spread of various diseases. For example, the repatriation of soldiers' post-conflict during the Plague of Athens and the Antonine Plague facilitated the introduction of diseases into disparate regions (Littman, 2009; Morens, Folkers, & Fauci, 2008). Morens et al. (2008) further delineated multiple independent importations as a contributing factor to the accelerated transmission of illnesses between nations. Similarly, the commercial and migratory activities within the Silk Road, a nexus linking Asia, Europe, and Africa, are posited to have been instrumental in the dissemination of the bubonic plague (Yersinia pestis) throughout the 14th century, culminating in the catastrophic pandemic known as the Black Death (Benedictow, 2004). Further, Ferreira (2014) emphasized that commerce and intense trade between countries escalate the spread of plague by ship.

The interconnected nature of today's global economy has facilitated the rapid spread of COVID-19. As people travel for business, tourism, or migration, they may unknowingly carry pathogens with them (Petersen et al., 2020). The SARS-CoV-2 virus quickly spread worldwide, with the first cases outside China reported in countries with strong trade and travel links, such as Japan, South Korea, and the United States (Huang et al., 2020; WHO, 2020). Another factor is the international trade in goods. While the risk of transmission through contaminated surfaces is considered low, the movement of goods and people involved in trade can facilitate the spread of the virus.

Additionally, disruptions in global supply chains due to the pandemic have had significant economic and social impacts, further highlighting the interdependence of countries and the influence of trade on public health (Nicola et al., 2020). Air and sea travel further escalate this scenario. With millions of people traveling by air daily, the potential for the international dissemination of pathogens has increased dramatically (Chinazzi et al., 2020). Airport hubs and densely populated cities with frequent air connections have been particularly vulnerable to the spread of the virus (Bogoch et al., 2020). Sea travel through Cruise ships emerged as hotspots for COVID-19 transmission early in the pandemic, with several high-profile outbreaks occurring onboard (Moriarty et al., 2020). The close living quarters, shared facilities, and high contact rates among passengers and crew created an environment conducive to the spread of the virus (Kakimoto et al., 2020).

Definitely, the trade and travel have been common contributing factors in the spread of infectious diseases from ancient times to the present, including the COVID-19 pandemic. The interconnectedness of the modern world through globalization has amplified the potential for the rapid dissemination of pathogens.

Population Density, Dynamics & Urbanization

High population densities and urban environments can facilitate the rapid transmission of pathogens due to increased human interactions. In contrast, population dynamics, such as migration, can contribute to the spread of diseases across regions. Overcrowded living conditions exacerbated historical pandemics, Plague and Black Death (Carmichael, 2014; Littman, 2009).

Similarly, the rapid transmission of COVID-19 can be attributed to high population density in contemporary cities, compounded by extensive global travel (Kraemer et al., 2020). This factor underscores the importance of effective urban planning and public health policies to minimize the impact of EIDs in densely populated areas. Crowded urban environments provided ideal conditions for rats and fleas to thrive, facilitating the rapid spread of the disease (Gage, 2012). Moreover, inadequate housing was also documented (Kelaidis, 2020; Horgan, 2019; Morens, Folkers Fauci, 2008) facilitating faster spread of diseases. This scenario is further aggravated by having poorly densely crowded quarters of the poor (Fischer, 2017, Morrill, 2016, Gage, 2012).

During the COVID-19 pandemic, population density and urbanization have also been identified as factors influencing the transmission of the virus. Studies have shown that areas with densely populated cities experienced more rapid and widespread transmission of SARS-CoV-2 due to increased human interactions and contact (Rocklöv & Sjödin, 2020). With their complex transportation networks and large public gatherings, urban

environments facilitated the rapid spread of the virus within and between cities (Hamidi et al., 2020; Sy et. al., 2020). Another factor is the presence of public transportation. Urban areas often rely heavily on public transportation systems, which have been implicated in the transmission of COVID-19. Crowded buses, trains, and subways can facilitate the spread of the virus among passengers, especially if there is insufficient ventilation, and people are not wearing masks (Hu et al., 2020). Implementing public health measures, such as reducing passenger capacity, promoting mask-wearing, and improving ventilation, can help mitigate this risk (Tirachini & Cats, 2020).

Subsequently, socioeconomic factors associated with population dynamics & urbanization contributed to increase cases. Specifically, socioeconomic disparities influence the spread and impact of COVID-19. Low-income and marginalized populations living in densely populated urban areas may face challenges accessing healthcare, adhering to social distancing guidelines, or working remotely (Ahmed et al., 2020). These factors can contribute to increased transmission and poorer health outcomes in these communities (Adhikari et al., 2020). These studies highlight the importance of considering population density and urbanization in the context of infectious disease transmission, particularly for COVID-19.

Hygiene and Sanitation

Hygiene and sanitation have consistently been crucial determinants in the transmission of infectious diseases, as evidenced by historical outbreaks such as the Plague and more recently, the COVID-19 pandemic. Substandard hygiene practices and insufficient sanitation can spread and exacerbate pathogens within human populations. The 14th-century Black Death pandemic, a particularly devastating manifestation of the Plague, exemplified the significant influence of deficient hygiene and sanitation on disease transmission. The etiological agent of bubonic plague, Yersinia pestis, was conveyed to humans through bites from infected fleas that infested rats in close proximity to human habitation (Benedictow, 2004).

Inadequate waste management and sanitation in urban environments fostered optimal rat and flea proliferation conditions, thus expediting disease dissemination (Cohn, 2008). The thriving of flea-infested rats, which served as primary vectors for the Yersinia pestis bacterium, was exacerbated by unsanitary living conditions, poor waste management, and insufficient public health interventions (Gage & Kosoy, 2005). Furthermore, the contamination of water sources by human and animal waste, a result of deficient sanitation infrastructure, heightened the risk of waterborne diseases and may have contributed to the plague's spread (Byrne, 2004).

Limited knowledge regarding the significance of personal hygiene in preventing the transmission of infectious diseases during ancient times contributed to the rapid propagation of such diseases. Consequently, infrequent bathing and handwashing were common practices, potentially facilitating the spread of the plague (Cohn, 2008). Lastly, the improper handling and disposal of the deceased, including mass burials and the absence of protective measures for individuals handling corpses, may have further contributed to the transmission of the infection (Cohn, 2008).

Conversely, during the COVID-19 pandemic, hygiene and sanitation have also been identified as crucial factors in controlling the spread of the virus. One of the hygiene problems documented is inadequate hand hygiene. Frequent handwashing with soap and water or using alcohol-based hand sanitizers can help minimize the transmission risk (CDC, 2020). However, not all individuals consistently adhere to these hand hygiene recommendations, which can increase the risk of spreading the virus by touching contaminated surfaces and subsequently touching their face, nose, or mouth (Bavel, et. al., 2020; Djalante, et. al., 2020).

Sanitation problems can also contribute to the spread of COVID-19. Inadequate waste management and cleaning practices in public spaces, such as transportation hubs, healthcare facilities, and commercial areas, can result in contaminated surfaces that increase the risk of indirect transmission (Kampf, et. al, 2020; Ong, et. al, 2020). Maintaining clean and disinfected public spaces is crucial for controlling the spread of the virus. The provision of clean water and sanitation facilities, particularly in densely populated urban areas, is essential for supporting hygiene practices and preventing the spread of COVID-19 (WHO, 2020; UNICEF, 2020). Limited access to clean water and sanitation can hinder the adoption of proper handwashing and other hygiene measures, increasing the risk of transmission (Prüss-Ustün, et. al., 2016). Therefore, hygiene and sanitation problems,

including inadequate hand hygiene, improper use of PPE, poor waste management, and limited access to clean water and sanitation facilities, can contribute to the spread of COVID-19.

Political Leadership and Public Health Policies

Political leadership and public health policies have been crucial in shaping the trajectory of infectious diseases throughout history, including ancient and modern emerging diseases. These factors can influence the effectiveness of public health measures, resource allocation, and the dissemination of accurate information. Political leadership and public health policies varied across different regions during the Plague, particularly the Black Death pandemic in the 14th century. Some cities and states implemented strict measures, such as quarantines and travel restrictions, to control the spread of the disease (Carmichael, 2014). For example, the local government established a quarantine island in Venice to isolate travelers and suspected plague carriers (Cohn, 2010). In contrast, other regions failed to implement effective public health policies, exacerbating the spread of the Plague (Benedictow, 2004). Specifically, poor economic, social, and political foundations were documented in the Antonine Plague (Bruun, 2006; Sitaraman, 20111), and political tension during the Black Plague as leaders grappled with widespread social, economic, and religious upheaval. The uncertainty and instability of the era contributed to increased tensions between various factions and power centers. (De Witte, 2020).

Relatedly, Fischer (2017) documented the government's failed health policies during the great plague of London. The government's health policies during the outbreak can be seen as inadequate or ineffective due to several reasons: Lack of understanding: The scientific understanding of the nature of the disease and its transmission was limited during the 17th century. The prevailing theory was the miasma theory, positing that the disease spread through "bad air." This lack of understanding led to ineffective health policies, as the government focused on addressing symptoms and environmental factors rather than the root cause of the plague (Porter, 1999). Another is the poor public health infrastructure: London's public health infrastructure was underdeveloped, with poor sanitation, overcrowded living conditions, and inadequate waste management (Wall, 1993). These factors contributed to the rapid spread of the plague and hampered the effectiveness of government policies.

Then there were ineffective quarantine measures. Although the government did impose quarantines and restrictions on movement, these measures were often inadequately enforced or only partially effective. The lack of a centralized and coordinated response made it difficult for the government to effectively implement and monitor these measures (Fischer, 2017). Another Factor is the limited resources. The government's resources were stretched thin during the outbreak, as it was already dealing with the ongoing war with the Dutch Republic (the Second Anglo-Dutch War). This limited the resources available for public health measures and made it difficult for the government to respond effectively to the crisis (Wilson, 2016). Another factor is the slow response. The government's initial response to the plague was slow, as it was reluctant to acknowledge the severity of the outbreak. This delay in implementing measures to combat the disease likely contributed to its rapid spread and the high death toll (Moote, et. al. 2004). Lastly, the inequality in policy implementation burdens the poor sector. The government's health policies often disproportionately affected the poor, as wealthier individuals could afford to flee the city, leaving the most vulnerable behind. This may have exacerbated the spread of the disease in poorer neighborhoods and further strained the government's ability to respond effectively (Fischer, 2017).

During the COVID-19 pandemic, the importance of political leadership and public health policies has been widely recognized. Countries with strong political leadership, clear public health policies, and efficient implementation have been more successful in controlling the spread of the virus and mitigating its impact (Horton, 2020). For example, countries like South Korea, Taiwan, and New Zealand have been praised for their proactive and coordinated responses (Cheng et al., 2020; Hale et al., 2020). On the other hand, countries with weak political leadership, unclear public health policies, or delayed responses (Hale et al.,2020) have experienced more significant challenges in managing the outbreak (Legido-Quigley et al., 2020). Conflicting messages from political leaders and health authorities have caused confusion and mistrust among the public during the COVID pandemic (Gollwitzer et al., 2020). Another is the politicization of public health measures. Public health measures, such as mask-wearing and lockdowns, have sometimes been politicized, leading to divisions and resistance to following these recommendations. This politicization undermines the effectiveness of the measures and prolongs the pandemic (Gostin et al., 2016).

During the pandemic, inadequate resource allocation was also reported. Insufficient funding and resources for healthcare systems, testing, and contact tracing have hampered the ability to effectively manage the pandemic. A lack of resources can lead to overwhelmed healthcare systems and increased transmission (Legido-Quigley et al., 2020). Further, fragmented and uncoordinated policies, such as the absence of a unified, coordinated approach to managing the pandemic, both within countries and internationally, have led to a patchwork of policies that may not effectively contain the virus (Rosenberg et al., 2020). Lastly, inequitable vaccine distribution was highlighted. Inequitable distribution of COVID-19 vaccines, particularly between high-income and low-income countries, has slowed global vaccination efforts and prolonged the pandemic. Ensuring equitable access to vaccines is crucial for achieving worldwide herd immunity and controlling the virus (Wouters et al., 2021).

Human Beliefs, Behaviour, and Perceptions

Human beliefs, behavior, and perception play a significant role in spreading and managing infectious diseases. Cultural, religious, and social factors shape how individuals and communities respond to these diseases and their adherence to public health measures. During the Plague, specifically the Black Death pandemic in the 14th century, various beliefs and misconceptions about the disease's origin and transmission influenced people's behavior and response to the outbreak. Religious beliefs often attributed the Plague to divine punishment or supernatural forces, leading to fatalism and limited adherence to public health measures (Cohn, 2008). Additionally, the Plague was often associated with marginalized groups, leading to the persecution and stigmatization of these communities (Cohn, 2007). Another factor is the lack of attention to important public-health and safety measures of people (Kelaidis, 2020; Morens, Folkers Fauci, 2008; Horgan, 2019). These beliefs and perceptions contributed to the spread of the disease and hindered effective public health interventions.

In the COVID-19 pandemic, human beliefs, behavior, and perception have also played a significant role in shaping the trajectory of the outbreak. Misinformation and conspiracy theories about the virus's origin, transmission, and treatment have fueled public confusion, mistrust, and non-compliance with public health measures (Roozenbeek et al., 2020). For example, early misconceptions about the virus being primarily a risk for older adults and those with underlying health conditions led many younger individuals to underestimate their vulnerability and adopt a more relaxed approach to preventive measures (Seale et al., 2020).

Furthermore, some individuals may underestimate the severity of the virus or perceive themselves as not at risk, leading to complacency in adhering to public health guidelines, such as mask-wearing, hand hygiene, and social distancing (Bavel et al., 2020). The proliferation of COVID-19 misinformation and conspiracy theories has also played a significant role. The dissemination of false information and conspiracy theories about the virus, its origins, and the effectiveness of preventive measures undermines trust in public health advice, prompting some people to ignore or resist safety recommendations (Pennycook & Rand, 2020). One notable area of resistance is in terms of vaccination. Vaccine hesitancy or refusal can impede efforts to achieve widespread immunity and prolong the pandemic. Factors contributing to this resistance include concerns about vaccine safety, efficacy, and mistrust in the government and pharmaceutical companies (Murphy et al., 2021).

Moreover, a lack of trust in authorities and institutions has been observed. Distrust in government, public health institutions, and experts can result in skepticism about the pandemic's seriousness and reluctance to comply with guidelines or recommendations (van der Linden, 2021). Individualism and prioritizing personal freedom have also emerged as significant factors. Some individuals may value their personal freedom and autonomy over collective responsibility, leading to resistance to public health measures such as mask mandates, lockdowns, and social distancing (Bavel et al., 2020). Finally, social stigma and discrimination play a role. People who have contracted the virus, healthcare workers, or individuals from specific ethnic backgrounds may face social stigma and discrimination, contributing to hesitancy in seeking medical care or reporting symptoms, further exacerbating the virus's spread (Bagcchi, 2020).

Insights from past emerging infectious diseases

Understanding the factors that contributed to the spread of past emerging infectious diseases can offer valuable insights for preparedness and response strategies for the COVID-19 pandemic and potential future pandemics. This section discusses vital factors from past experiences and their implications for COVID-19.

A. Zoonotic origin and Human-animal interactions

The emergence of infectious diseases, such as COVID-19, is significantly influenced by zoonotic origins and human-animal interactions. One key aspect of addressing this is through enhancing the surveillance and monitoring of zoonotic diseases. Since most emerging infectious diseases stem from animals, it is vital to improve the tracking and monitoring of zoonotic diseases and their potential transmission to human populations (Jones et al., 2008). Early identification of zoonotic pathogens allows for prompt implementation of public health measures and targeted interventions, thereby averting the onset of new pandemics (Karesh et al., 2012). Furthermore, understanding the ecological drivers of disease emergence, such as land-use changes, agriculture, and wildlife trade, can inform policies to reduce the risk of future pandemics (Daszak et al., 2020). For instance, regulating wildlife trade and adopting sustainable land-use practices can minimize human-animal interactions that enable disease spillover events (Rohr et al., 2019).

Empowering communities in areas prone to zoonotic disease emergence can facilitate early detection and reporting of potential outbreaks (Meslin et al., 2017). Local communities can play a critical role in monitoring and reporting atypical disease patterns in animals, allowing authorities to initiate swift response measures. Capacity building and international collaboration are also essential. Improving national and global capabilities to address zoonotic disease threats is crucial for pandemic preparedness (Gostin & Katz, 2016). This includes investing in laboratory infrastructure, workforce development, and epidemiological surveillance systems. International collaboration and information sharing can expedite the detection and response to emerging zoonotic diseases (Morens et al., 2020).

By recognizing the impact of zoonotic origins and human-animal interactions on the emergence of infectious diseases like COVID-19, we can devise more effective preparedness and response strategies for potential future pandemics. Achieving this goal necessitates interdisciplinary collaboration, robust surveillance systems, informed policymaking, and continuous investment in public health infrastructure.

B. Trade and travel

Trade and travel have historically played pivotal roles in the dissemination of infectious diseases, including the COVID-19 pandemic. Enforcing efficient screening and quarantine procedures at airports, seaports, and land borders is essential for identifying and preventing the import of infectious diseases (Clifford et al., 2021). Strengthening border control measures, such as temperature monitoring, health declarations, and targeted testing of travelers from high-risk regions, can help detect and isolate infected individuals (Chinazzi et al., 2020). Moreover, proactive and accurate information sharing among nations regarding emerging infectious diseases can facilitate the prompt implementation of travel restrictions and public health measures, potentially curbing the spread of future pandemics (Nuzzo et al., 2019). These measures should be consistently applied even when COVID-19 incidence is low.

Additionally, the global trade of goods can contribute to the spread of infectious diseases either directly through contaminated products or indirectly through increased human interactions (Keogh-Brown & Smith, 2008). Enhancing surveillance and inspection protocols for imported goods can help avert the introduction of pathogens through trade. Furthermore, enforcing safe handling guidelines for goods and endorsing proper hygiene practices among international trade workers can mitigate disease transmission risks (Gostin et al., 2014).

During the COVID-19 pandemic, the importance of preserving essential trade and supply chains while safeguarding public health has become increasingly evident (Evenett, 2020). Creating and executing strategies to maintain the flow of essential goods and services during pandemics can minimize disruptions to economies and societies while simultaneously protecting public health. This encompasses developing contingency plans for vital supply chains, investing in local production capabilities, and fostering regional cooperation to ensure the availability of essential goods and services during health emergencies (Van Asselt & Vos, 2008). Strengthening international collaboration and coordination is indispensable for tackling the challenges posed by trade and travel in the context of emerging infectious diseases. Through cooperative efforts, countries can devise harmonized strategies for surveillance, border control, and trade regulations that facilitate the early detection and containment of infectious diseases while minimizing pandemics' economic and social ramifications (Fidler, 2010).

C. Population density and urbanization

Population density and urbanization have been significant factors in the spread and impact of infectious diseases, including COVID-19. To address this, targeted public health measures can be implemented in densely populated urban areas, such as increasing testing capacity, encouraging remote work, and imposing stricter social distancing and mask-wearing guidelines. Moreover, urbanization can lead to an increased demand for resources, such as housing, water, and sanitation services. Inadequate access to these resources can exacerbate the spread of infectious diseases in urban settings (Ezeh et al., 2017). Investments should be made in improving urban infrastructure, including water and sanitation systems, waste management, and housing, to enhance preparedness and response strategies. This can help reduce disease transmission by promoting hygienic practices and reducing overcrowding (Corburn et al., 2020). Furthermore, urban planning can play a crucial role in mitigating the impact of infectious diseases in densely populated areas. By incorporating principles of healthy urban planning, cities can be designed to minimize disease transmission risks and promote overall population health. This includes ensuring adequate green spaces, promoting non-motorized transportation options, and designing buildings with adequate ventilation (Gupta et al., 2020).

Public health systems need to be strengthened to cope with the challenges posed by population density and urbanization. This includes enhancing surveillance systems for early detection and monitoring of infectious diseases, training healthcare workers to respond to outbreaks, and ensuring that healthcare facilities are well-equipped to handle surges in demand (Kruk et al., 2018). Finally, community engagement and public education play a crucial role in preparedness and response strategies. Raising awareness of infectious diseases and promoting behavioral changes, such as hand hygiene and vaccination, can help reduce disease transmission in densely populated urban areas (Lewnard & Lo, 2020).

D. Hygiene and sanitation

Hygiene and sanitation play a crucial role in limiting the spread of infectious diseases, including the COVID-19 pandemic. One way to improve hygiene and sanitation is by promoting hand hygiene practices. Frequent and proper handwashing can break the chain of transmission for many infectious diseases, including COVID-19 (Aiello et al., 2008). Public health campaigns should emphasize the importance of handwashing with soap and water or using hand sanitizers with at least 60% alcohol content when soap and water are not available (CDC, 2020).

Another crucial aspect of hygiene and sanitation is the management of public spaces. Ensuring proper cleaning and disinfection procedures in public spaces such as transportation hubs, healthcare facilities, and commercial areas can minimize the risk of indirect transmission through contaminated surfaces (Adams et al., 2020). This may include regular cleaning of high-touch surfaces, providing hand sanitizing stations, and promoting physical distancing in crowded areas. Improved sanitation facilities and access to clean water, particularly in densely populated urban areas and informal settlements, can also support hygiene practices and reduce the spread of infectious diseases (Ezeh et al., 2017). Providing adequate sanitation infrastructure, such as public restrooms and waste management systems, can minimize the risk of fecal-oral transmission of pathogens (Prüss-Ustün et al., 2016).

In healthcare settings, infection prevention and control measures should be strengthened to prevent the spread of pathogens among patients, healthcare workers, and visitors (Allegranzi et al., 2011). This may include appropriate hand hygiene practices, personal protective equipment (PPE) use, and environmental cleaning and disinfection. Education and community engagement are essential in promoting hygiene and sanitation practices (Curtis et al., 2009). Raising public awareness of the importance of personal and environmental hygiene can foster behavioral change and improve adherence to public health recommendations.

E. Political leadership and public health policies

Political leadership and public health policies are essential in addressing infectious disease outbreaks such as COVID-19, and they can substantially influence preparedness and response strategies. One comprehensive approach involves clear communication and transparency. Effective political leadership requires open and transparent communication with the public regarding risks, preventive measures, and response plans for infectious

diseases (Quah & Hin-Peng, 2004). Providing accurate information and debunking misinformation can foster public trust and compliance with health guidelines (Pennycook & Rand, 2020). Another vital aspect is evidence-based decision-making. Political leaders should base public health policies on scientific evidence and expert opinions, ensuring that interventions are efficient and appropriately targeted (Brownson et al., 2009).

Moreover, coordinating responses across sectors is crucial. Political leaders should orchestrate public health responses among various sectors, including healthcare, education, and transportation, to ensure a holistic approach to managing infectious disease outbreaks (Frenk & Moon, 2013). Allocating resources and investing in public health is also critical. Sufficient funding for public health infrastructure, research, and workforce development is vital for pandemic preparedness and response. Political leaders play a central role in determining priorities and allocating resources to address public health challenges (Gostin & Katz, 2016).

International collaboration is another key factor. Since infectious diseases do not adhere to borders, political leaders should actively participate in international cooperation efforts to share information, resources, and expertise. Such collaboration can bolster global capacity to detect, prevent, and respond to emerging infectious diseases (Morens et al., 2020). Adaptive policymaking is also essential, as political leaders should be prepared to modify public health policies and interventions based on new evidence and evolving circumstances (Gostin et al., 2014). Additionally, considering equity is crucial. Pandemics often disproportionately affect vulnerable populations, including low-income communities and ethnic minorities. Political leadership should prioritize equity in public health policies to ensure interventions effectively reach those most in need (Marmot et al., 2020).

F. Human beliefs, behavior, and perception

Adherence to public health measures is vital for controlling infectious disease outbreaks, and human beliefs, behavior, and perception significantly influence preparedness and response strategies for the COVID-19 pandemic and other potential pandemics. Effective risk communication strategies can bridge the divide between expert opinions and public perception, increasing adherence to guidelines (Fischhoff et al., 2011). Clear, consistent, and transparent messaging from reliable sources can help alleviate public anxiety and foster informed decision-making (Slovic, 2000). Furthermore, addressing misinformation is essential. Misinformation and conspiracy theories can erode public trust in health authorities and negatively affect preventive measure adoption (Van Bavel et al., 2020). Developing strategies to identify, counter, and prevent misinformation spread is vital for managing public perceptions and behaviors during pandemics (Lewandowsky et al., 2012). Public health campaigns should confront common misconceptions and provide accurate information to encourage adherence to recommended guidelines (Nyhan & Reifler, 2015).

Promoting preventive behaviors is also a valuable approach. Understanding factors that influence preventive behavior adoption, such as handwashing, mask-wearing, and social distancing, can help create targeted interventions to promote adherence (Bavel et al., 2020). Public health campaigns should underscore the advantages of these behaviors and offer practical guidance on implementation (Michie et al., 2011). Additionally, utilizing social influence and peer pressure can foster widespread adoption of preventive measures (Cialdini & Goldstein, 2004).

Vaccine acceptance and addressing hesitancy are also vital. Vaccine acceptance is critical for controlling pandemics. Tackling vaccine hesitancy by providing transparent information about vaccine safety, efficacy, and benefits is crucial for widespread immunization (Larson et al., 2014). Engaging with community leaders, religious organizations, and social media influencers can help establish trust and promote vaccine uptake (MacDonald, 2015). Moreover, culturally sensitive interventions should be considered. Acknowledging the impact of cultural, social, and religious factors on public perception and behavior is vital for developing effective and culturally sensitive public health interventions (Airhihenbuwa et al., 1995). Collaborating with community leaders and organizations can help customize interventions to address diverse populations' unique needs and ensure culturally appropriate and well-received public health messages (Kreuter et al., 2003).

The Historical Lens Model: An Exploration of Infectious Disease Dynamics

The culminating insights of this research have led to the development of the Historical Lens Model, an avant-garde instrument crafted to delve deep into the origins and propagation mechanisms of infectious diseases. By

meticulously dissecting previous epidemics, this model unveils consistent patterns and determinants that, if not addressed, may set the stage for forthcoming pandemics akin to COVID-19.

This model revealed that there was frequent emergence of zoonotic diseases, which are borne from pathogens transitioning from animals to humans. This transition is typically fueled by persistent and intensified human-animal interactions. Persistent and unrestrained interactions between animal and human species can provoke these agents to morph, transitioning from mere zoonotic precursors to full-scale zoonotic infections that endanger human populations..

Nevertheless, the introduction of a zoonotic infection within human populations isn't a guaranteed precursor to an epidemic. There exist specific societal and environmental accelerants that can either propel or mitigate the spread of these infections. Our model shines a spotlight on five pivotal accelerants that have shaped disease dynamics across both historical and modern landscapes:

a. Trade and Travel: The movement of both commodities and individuals has historically served as a formidable vector for disease, dismantling geographical constraints.

b. Population Dynamics: Dense populations, escalating urbanization, and suboptimal urban planning intensify the transmission rate, complicating containment measures.

c. Hygiene & Sanitation: The sanitary practices upheld by a community, paired with their overall hygiene consciousness, are paramount in disease control.

d. Political Leadership & Public Health Policies: The trajectory of a disease is heavily influenced by the promptness, efficacy, and foresight of political directives and public health interventions.

e. Human Beliefs, Behaviors, & Perceptions: The tapestry of cultural, societal, and personal beliefs, often with historical underpinnings, can either fortify or undermine public health endeavors.

Envision the Historical Lens Model as a time-traveling telescope. While metaphorical in nature, it offers an immersive journey into the annals of time, revealing the intricate interplay of factors that have fostered pandemics like COVID-19. By fusing historical wisdom with present-day knowledge, the model paints a holistic picture, transcending mere pathogens to incorporate a dynamic interplay of societal and environmental determinants. At its core, this model serves as an invaluable compendium for policymakers and health professionals. By internalizing yesteryear's lessons, we can architect robust countermeasures, preemptively neutralizing the emergence and resurgence of infectious diseases, thus bolstering global health security.

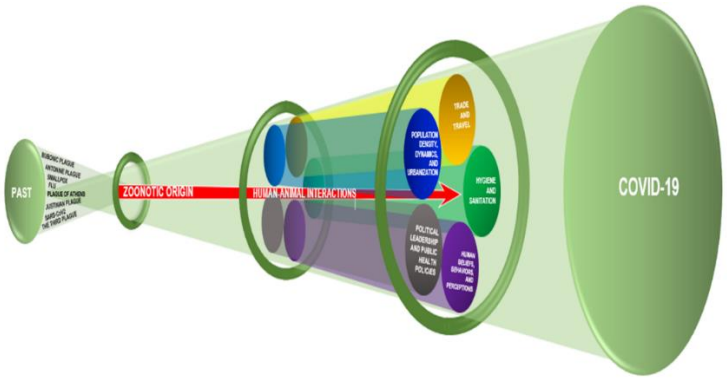

Figure 2: Historical Lens Model

Conclusion

This study concludes that emerging diseases exhibit cyclical patterns with significant links to modern ways of living and human behaviors. A critical finding is a pattern related to the tendency of infectious diseases to thrive in conditions arising from human-animal interactions, travel & trade, population density, dynamics, & urbanization, hygiene & sanitation, political leadership, and human beliefs, behavior, and perceptions. These factors are inherent in contemporary human societies, making it challenging to enact significant changes.

Given the difficulty in modifying these societal norms, the study concludes that the primary focus should be strengthening and adapting existing health management systems to better cope with such conditions. By identifying the recurring patterns and factors that contribute to the emergence and spread of infectious diseases, we can address the gaps in our preparedness and response strategies.

Recommendations

In light of the global challenges posed by diseases like COVID-19, this study serves as a timely reminder of the lessons from our past. By heeding these lessons, the DOH, HEIs, and DENR can work collaboratively to ensure a healthier, safer future for all.

1. Department of Health (DOH): As the primary health agency, the DOH can leverage the insights from the study to bolster its current and future infectious disease response strategies. By understanding historical patterns and causative factors, the department can devise more targeted prevention and intervention measures, anticipate challenges, and optimize resource allocation.
2. Higher Education Institutions (HEIs): Universities and colleges, particularly those with medical, public health, veterinary, and environmental science faculties, can incorporate findings from this study into their curricula. The model offers a multi-faceted understanding of infectious diseases, making it an invaluable tool for interdisciplinary education. Moreover, HEIs can encourage further research based on the insights from this study, promoting an academic culture that is forward-thinking yet deeply rooted in historical context.
3. Department of Environment and Natural Resources (DENR): Given the zoonotic nature of many emerging diseases, the DENR can benefit from the study by gaining insights into the ecological aspects of disease emergence. The study can guide the DENR in creating policies related to wildlife conservation, habitat preservation, and sustainable human-animal interaction, ultimately reducing the risk of zoonotic disease transmission.

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