Emerging Infectious Diseases and the Future of Global Animal Health Security

AUTHORS DETAIL

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Abstract

The term "emerging infectious diseases" (EIDs) refers to conditions that have only recently become prevalent in a population or are rapidly spreading to new areas or populations. An "emerging infection" can be a new infection that has never happened before or an infection that was previously unknown but has suddenly become more common. Examples of emerging infectious diseases that were not widespread prior to the 1980s and 2003 are the HIV pandemic and severe acute respiratory illness outbreaks, respectively. A "re- emerging infection," on the other hand, is an old infection that comes back. Examples of re-emerging infections include the 1918, 1957, and 1968 pandemics caused by the influenza A virus. The objectives of this book chapter are to describe emerging and re-emerging infectious diseases, analyze their main causes, look at the microorganisms that cause them, and discuss why they could become serious worldwide public health concerns.

Keywords:

Introduction

Infectious diseases represent a category of ailments instigated by pathogens, including bacteria, viruses, fungi, or parasites, which are capable of transmission from one individual to another. Notable instances of such diseases include influenza (virus), tuberculosis (bacteria), and malaria (parasite) (Verhoef et al., 2019; Zabidi et al., 2023). The domain of infectious diseases is perpetually transforming due to the emergence of novel pathogens alongside the resurgence of previously controlled infections (Cliff, 2009). For over a decade, researchers have endeavored to monitor these emerging threats, particularly in the context of global challenges such as climate change, urbanization, and heightened interactions between humans and animals (Myers & Patz, 2009). The recent COVID-19 pandemic has illustrated the rapidity with which infectious diseases can proliferate on a global scale (Baker et al., 2022). Consequently, there exists an urgent necessity for the establishment of rapid surveillance systems and responsive strategies to mitigate these threats (Peeri et al., 2020).

The epidemic events of the fourteenth century, the Spanish influenza outbreak of 1918, and, more recently, the COVID-19 pandemic serve as pertinent illustrations of persistent threats that have not been eradicated but exhibit a commonality: they remain lethally impactful. According to Mack et al., (2007)., these phenomena emphasize the need for ongoing vigilance and novel methods for individuals to mitigate the spread of infectious diseases. In light of the emergence of novel pathogens, traditional methodologies for disease intervention prove inadequate. One contributing factor to the considerable challenges encountered in combating this disease is the multitude of influences that have shaped its evolution, which encompasses environmental alterations, the escalation of international travel, and the genetic mutations of the microorganisms responsible for the illness (Levitt et al., 2016). Technological advancements such as deforestation and climate change exert profound effects on ecosystems, prompting disease-causing pathogens to seek alternative niches for propagation. The rapid interconnection of people and the rapid transportation of goods made possible by globalization contribute to the spread of infectious diseases.

Nevertheless, pathogens are not devoid of territorial affiliations; they exhibit adaptability, and evolutionary processes may, at times, undermine their vulnerability to therapeutic interventions (Wing et al., 2024).

It has been established that emerging pathogens, encompassing novel viruses, bacteria, and parasites, present formidable public health challenges due to their potential for elevated transmissibility, virulence, and resistance to current therapeutic modalities (Levitt et al., 2016). The World Health Organization (WHO) categorizes emerging infectious diseases as those that have newly surfaced within a population or those that have existed in a given environment but are currently experiencing a rapid escalation in incidence or geographic distribution (Dye, 2014). For instance, the emergence of SARS-CoV-2, the Zika virus, and antibiotic-resistant bacterial strains, such as Methicillin-resistant Staphylococcus aureus (MRSA) exemplifies this phenomenon (Janik et al., 2020). Indeed, pathogens not only pose risks to individual health but also exert considerable pressures on healthcare infrastructures and economic systems (Bloom & Cadarette, 2019).

Furthermore, zoonotic diseases represent a critical concern and exert a profound impact on human health (Rahman et al., 2020). These diseases can be transmitted from animals to humans, often facilitated by alterations in environmental conditions and human behaviors (Weiss & McMichael, 2004). Additionally, it is crucial to acknowledge that numerous risk factors, including deforestation, intensive agricultural practices, and climate change, are implicated and may amplify the probability of zoonotic spillover incidents (Tazerji et al., 2022). Several researchers have demonstrated that habitat destruction brings wildlife into closer proximity with human populations, potentially creating opportunities for pathogen transmission (Plowright et al., 2017).

2. Factors responsible for EIDs

2.1. Globalization and travel

Globalization denotes the intricate interconnectedness of economies, cultures, and populations on a global scale, exerting substantial influence across various sectors, including tourism. This phenomenon promotes the movement of individuals, ideas, and commodities, resulting in a global travel market where international tourism flourishes. The interplay between globalization and travel is complex, encompassing economic, social, and technological aspect

Economic impact globalization has redefined tourism as the premier economic sector globally, with over 1.5 billion international arrivals recorded in 2019, which constitutes 14% of the world's population (Baptista, 2023). The tourism sector reaps benefits from the diminishing of national boundaries, which fosters enhanced international trade and investment opportunities. Social and cultural dimensions globalization promotes cultural exchanges, affording travelers the opportunity to engage with a plethora of customs and values, thereby cultivating a sense of global citizenship among tourists (Dodu, 2016). Nevertheless, the distinct attributes of tourist destinations may be influenced by local economic and political circumstances, resulting in fluctuations in tourist flows (Baptista, 2023).

Technological advancements innovations in communication and transportation technologies have catalyzed the expansion of global tourism, facilitating increased accessibility to international travel (Brondoni, 2016). The emergence of digital platforms has also revolutionized the methods by which travelers organize and reserve their journeys, thereby further embedding tourism within the global economy. While globalization has markedly augmented travel opportunities, it concurrently presents challenges, such as the peril of cultural homogenization and the repercussions of global crises on tourism trends (Kellerman, 2022).

2.2. Climate change

Climate change exerts a significant impact on Aedes species, which function as primary vectors for a wide array of infectious diseases. Fluctuations in climatic variables, such as temperature, humidity, and precipitation, have a direct influence on the geographic distribution, population density, and overall viability of these mosquitoes. A thorough comprehension of these influences is essential for enhancing public health preparedness and the development of effective vector control strategies. The optimal temperature range conducive to Aedes transmission is between 26-29°C, with climatic alterations potentially promoting a poleward expansion (As global temperatures rise, climate zones and related weather patterns are expected to migrate towards higher latitudes, or closer to the poles) of their distribution. Temperature extremes may limit transmission within currently endemic regions, particularly in tropical climates (Ryan et al., 2017). Aedes species demonstrate a predilection for environments characterized by humidity levels below 70% and conditions following precipitation with rainfall amounts less than 70mm. Changes in precipitation patterns have the capacity to generate additional breeding sites, thereby increasing mosquito populations. Climate change is inducing the proliferation of Aedes species into previously temperate regions, consequently elevating the risk of vector-borne diseases in these emerging areas (Mekonnen et al., 2018). The migration of Aedes species as a result of climatic factors poses a substantial public health challenge, as these vectors possess the ability to introduce diseases into non-endemic regions (Schelling, 2008). While the focus is primarily on the adverse consequences of climate change for Aedes species, it is essential to recognize that certain areas may experience temporary declines in vector

populations due to extreme meteorological events, which can disrupt breeding cycles and habitats (Reiter and arboviral, 2020). Nevertheless, these effects are often transient when compared to the persistent threats posed by climate change (Reser & Swim, 2011).

2.3. Deforestation and land use changes

Deforestation and modifications in land utilization exert significant effects on the emergence and transmission of infectious diseases (EIDs) through the alteration of ecosystems and the enhancement of interactions between humans and disease vectors. Such ecological transformations create new habitats for disease vectors, reduce biodiversity, and increase human vulnerability to zoonotic pathogens. Deforestation results in habitat fragmentation, which intensifies interactions between humans and vectors at the boundaries of forested areas, thereby increasing the likelihood of diseases such as malaria and hantavirus (Chiang et al., 2015). The conversion of forested regions into agricultural landscapes establishes favorable breeding conditions for vectors, such as Aedes albopictus, consequently amplifying their populations and potential for disease transmission (Iwamura et al., 2023). Changes in land use instigate the decline of native species, which can disrupt ecological balances and heighten the prevalence of zoonotic diseases (White & Razgour, 2020) The decrease in biodiversity undermines natural regulatory mechanisms on vector populations, further exacerbating the risks related to disease transmission (Chiang et al., 2015). The effects of deforestation on EIDs may become apparent with a temporal lag, as alterations in population dynamics and biodiversity can persist for several decades (Daskalova et al., 2018). In contrast, some researchers argue that the adoption of sustainable land management practices could mitigate these risks by conserving biodiversity and restricting vector habitats, thereby presenting a feasible strategy to harmonize agricultural requirements with public health considerations.

2.4. Animal-human interface

The interface between humans and non-human animals shapes many aspects of human-animal interactions, having a significant impact on public health and animal welfare. Animal stress responses, zoonotic disease transmission, and the general health of both species are all significantly impacted by this interface, which spans a variety of contexts from agricultural settings to wildlife markets. Negative human-animal interactions can make farm animals more fearful and stressed, which will affect their ability to reproduce and general well-being. On the other hand, positive interactions may increase productivity and stress resistance although there is currently little empirical study in this area (Kumar et al., 2022). Wildlife markets serve as a pivotal human-animal interface wherein zoonotic diseases may transition to humans, as evidenced during the COVID-19 pandemic (Fauziah et al., 2024). The emergence of zoonotic diseases is frequently associated with increased human interactions with wildlife, highlighting the necessity for a One Health framework to effectively mitigate associated risks (Berrian et al., 2024).

3. Types of EIDS

3.1. Viral EIDS

Viral diseases represent infections initiate by viruses, which are micro pathogens capable of precipitating a diverse array of health complications, ranging from benign ailments to grave medical conditions. These diseases constitute a predominant source of morbidity and mortality on a global scale, impacting millions of individuals. Notable viral diseases encompass influenza, hepatitis, HIV/AIDS, in addition to emergent threats such as COVID-19 (Gangopadhayya & Bhukya, 2023).

3.1.1. COVID 19

The COVID-19 pandemic, officially declared by the World Health Organization on March 11, 2020, has significantly influenced global health, economic systems, and societal frameworks. The advent of SARS-CoV-2 resulted in extensive lockdown measures, the suspension of educational institutions, and considerable mental health repercussions, particularly among adolescents, who exhibited elevated levels of depression and obesity attributable to remote educational formats and social seclusion (Ryan, 2024). Furthermore, the inequities in healthcare accessibility and the proliferation of misinformation have complicated the overall response to the pandemic (Manesh, 2024). Over 10 million minors have experienced the loss of a primary caregiver due to the ramifications of COVID-19 (Goldstein & Goldstein, 2024). There has been a marked increase in the prevalence of severe respiratory symptoms and the onset of diabetes among individuals who have survived the infection (Prakash & Lodha, 2024). The pandemic has precipitated a global economic recession and exacerbated social inequalities (Ryan, 2024). There has been an alarming increase in incidents of domestic violence and discrimination during periods of lockdown (Ryan, 2024). The swift advancement of vaccine development and the implementation of telemedicine interventions have been notable (Goldstein & Goldstein, 2024; Manesh, 2024). There is ongoing scholarly investigation aimed at identifying effective therapeutic options and management methodologies (Rozehnal & Villars, 2023). In spite of these adversities, the

pandemic has also catalyzed technological progress within the healthcare sector, particularly in telemedicine, which has enhanced the accessibility of medical services for numerous patients. Nevertheless, the enduring consequences of COVID-19 on mental health and chronic disease manifestations continue to represent a crucial concern for forthcoming public health strategies.

3.1.2. Ebola

Ebola Virus Disease (EVD) represents a critical and often lethal pathology induced by the Ebola virus, which is predominantly disseminated from wildlife to humans and subsequently transmitted among individuals through exposure to infected biological fluids. The clinical presentation of the disease is typified by an onset of flu-like symptoms that may swiftly escalate into severe medical complications, encompassing hemorrhagic phenomena and failure of multiple organ systems (Sultana et al., 2024). Essential components of EVD encompass:

1- Transmission Natural Reservoirs: Fruit bats serve as the principal natural reservoirs for the Ebola virus (Kasarla et al., 2024).

2- Human Transmission: This transmission occurs via direct contact with bodily fluids of infected individuals, through contaminated surfaces, or as a result of the consumption of bushmeat.

3- Symptoms and Diagnosis Initial Symptoms: The initial clinical manifestations include fever, myalgia, and chills, which may be followed by gastrointestinal disturbances such as vomiting and diarrhea (Hussein et al., 2023).

4- Severe Symptoms: Advanced clinical features may include the presence of hemorrhagic rashes and significant bleeding (Sultana et al., 2024).

5- Treatment and Prevention Supportive Care: Therapeutic interventions primarily emphasize rehydration and management of symptomatic manifestations (Nash et al., 2023).

6- Vaccination: Various vaccines have been engineered with the objective of mitigating outbreaks (Kasarla et al., 2024).

Notwithstanding progress in the comprehension of EVD, numerous obstacles persist in the effective management of outbreaks, particularly within resource-constrained environments. Ongoing investigative efforts are crucial to enhance treatment methodologies and preventative strategies against this formidable disease (Nash et al., 2023).

3.2. Bacterial EIDs

Bacterial pathologies are infections induced by bacteria, which are unicellular microorganisms capable of precipitating a diverse array of health complications in humans (Verhoef & Snippe, 2019). These diseases may be propagated through various transmission pathways, including direct physical contact, consumption of contaminated food and water, and inhalation of airborne particulates. Comprehending the characteristics of bacterial diseases is imperative for public health, as they can profoundly influence morbidity and mortality statistics (Martínez & Baquero, 2002).

3.2.1. Tuberculosis

Tuberculosis (TB) constitutes a significant concern for global public health, impacting approximately 10 million individuals each year and leading to approximately 1.5 million fatalities, predominantly attributed to Mycobacterium tuberculosis. The disease presents in two distinct forms: latent tuberculosis, characterized by the absence of symptoms, and active tuberculosis, which may be classified as pulmonary (80%) or extra-pulmonary (20%) (Thwaites, 2024). The demonstrative cycle for inactive TB includes lymphocyte reactivity appraisals, while the analysis of dynamic TB requires the discovery of the bacterium through microscopy or sub-atomic techniques (Villa et al., 2023). The helpful routine for idle TB by and large involves isoniazid and rifampicin, though the treatment of dynamic TB requires a routine of numerous pharmacological specialists managed over a base length of six months (Thwaites, 2024). Notwithstanding advancements in treatment, TB continues to rank among the leading causes of mortality, particularly within the population of individuals living with HIV (Villa et al., 2023). Nevertheless, the persistent issue of multi-drug-resistant TB exacerbates the complexities associated with treatment endeavors, thereby necessitating innovative strategies and international collaboration to effectively address and ultimately eradicate this age-old affliction (Li et al., 2024).

3.2.2. Methicillin-resistant Staphylococcus aureus (MRSA)

Methicillin-resistant Staphylococcus aureus (MRSA) represents a considerable public health challenge attributable to its resistance to β-lactam antibiotics, primarily mediated by the mecA gene. MRSA can be categorized into healthcare-associated (HA-MRSA) and community-associated (CA-MRSA) strains, with the latter increasingly impacting individuals without prior health complications (Thakkar et al., 2023; Wierzchowska, 2023). The pathogen demonstrates significant clonal diversity and virulence determinants, which contribute to the onset of severe clinical manifestations such as skin and soft tissue infections, bacteremia, and toxic shock syndrome (Shoaib et al., 2023). The proficient management of MRSA infections necessitates

ongoing surveillance and the implementation of alternative antibiotic regimens, especially as resistance patterns are subject to continual evolution (Mannheim et al., 2024). The ensuing points summarize critical aspects of MRSA:

1- Epidemiology and Transmission: MRSA exhibits widespread prevalence in both healthcare and community settings, with a notable escalation in CA-MRSA occurrences (Thakkar et al., 2023). Genetic analyses reveal the intricate connections between human and livestock strains, thereby highlighting the potential for zoonotic transmission (Akinduti et al., 2024).

2- Clinical Manifestations: MRSA infections can present as minor cutaneous infections or escalate to severe conditions, including necrotizing pneumonia (Shoaib et al., 2023. The elevated rates of resistance complicate therapeutic interventions, prompting the investigation of alternative treatment strategies (Wierzchowska, 2023).

3- Treatment and Prevention: Traditional therapeutic modalities encompass vancomycin; however, the increasing trends of resistance necessitate the investigation of innovative antibiotic agents (Shoaib et al., 2023). Enhanced hygiene protocols and stringent surveillance measures are essential for the efficient containment of MRSA spread (Thakkar et al., 2023).

In spite of the significant challenges posed by MRSA, persistent research initiatives and improved infection control measures have the potential to mitigate its impact on public health. Nevertheless, the emergence of new resistant strains continues to threaten effective therapeutic alternatives, emphasizing the critical need for vigilance in both clinical and community settings.

3.3. Fungal diseases

Fungal pathologies are a broad category of fungal-induced illnesses that can affect plants, animals, and people (Anand & Rajeshkumar, 2022). These conditions, which can be superficial, subcutaneous, or systemic, pose serious health risks, especially to those with weakened immune systems. The increasing prevalence of these diseases, particularly during the COVID-19 pandemic, highlights the urgent need for improved surveillance and treatment strategies (Ibrahim, 2020).

3.3.1. *Candida auris*

Candida auris (*C. auris*) addresses a thriving multidrug-safe parasitic microorganism that presents impressive hindrances to medical services frameworks on a worldwide scale. It has the ability to colonize the integumentary framework and different substantial areas asymptomatically; notwithstanding, it can likewise impel serious obtrusive contaminations related with raised death rates, especially in immunocompromised population (Tsitou et al., 2024). An exhaustive comprehension of the elements encompassing *C. auris* is basic for the plan of successful contamination control and preventive methodologies. Fundamental parts include:

1- Disease and Colonization Elements: *C. auris* can possibly progress from a condition of colonization to one of contamination, with risk factors like constant kidney sickness (OR 45.070) and expanded vasopressor use (OR 68.994) perceived as critical donors (Park et al., 2024). The microbe's ability to persevere in outrageous conditions, alongside its particular morphological qualities, essentially upgrade its flexibility (Tsitou et al., 2024).

2- Antifungal Opposition: *C. auris* exhibits protection from various antifungal classes, in this way entangling the scene of treatment choices. The need for cutting edge sub-atomic diagnostics emerges from the insufficiencies of customary distinguishing proof strategies (Tsitou et al., 2024).

3- Safe Reaction: The natural resistant reaction is vital in the guard against *C. auris* diseases, with continuous examinations concerning the instruments of invulnerable communications and acknowledgment processes (Holt and Nett, 2024).

Despite the unsettling expansion in *C. auris* cases, certain investigations demonstrate that improved disease control conventions and uplifted mindfulness might effectively diminish its spread. By and by, the microorganism's innate versatility and opposition instruments constantly challenge general wellbeing drives (Tsitou et al., 2024).

3.3.2. *Aspergillus*

With over 250 different species, the genus *Aspergillus* is a very varied group of fungi that can have significant clinical effects, particularly for people with weakened immune systems. Despite being rare, *Aspergillus* endocarditis is a serious illness that usually presents with persistent fever and embolic complications. To achieve effective treatment outcomes, an integrative approach involving both antifungal therapy and surgical procedures is necessary (Gopal et al., 2024). The seven subgenera that make up this genus have traditionally been identified using morphological categorisation methods (Kidd et al., 2022). Pan-genomic studies are essential to understand the population dynamics and ecological adaptations of *Aspergillus fumigatus*, a major pathogen whose genetic heterogeneity influences its virulence and resistance to antifungal agents. Furthermore, new developments in CRISPR/Cas9 technology have made it possible to precisely target genes in different *Aspergillus* species, which has advanced research efforts and potential treatment approaches (Chang, 2023). Despite the advancements in our understanding of *Aspergillus*, significant challenges remain in diagnosing and treating infections, primarily due to the organism's ability to evade detection in conventional blood culture techniques and the increasing incidence of antifungal resistance, which makes clinical treatment procedures even more challenging.

4. Conclusion

In conclusion, emerging infectious diseases pose a significant threat to global stability and public health. We must be ready to respond quickly and effectively as the world faces the emergence of new pathogens and unexpected outbreaks. High morbidity and mortality, as well as health and socioeconomic crises, may result from these diseases. Early detection, epidemiological surveillance, strengthening healthcare systems, and implementing preventative measures are key components in responding to emerging infectious diseases. We have witnessed how COVID-19 has affected millions of people worldwide, overwhelming healthcare systems, imposing mobility restrictions, and having a significant impact on the global economy. In addition, public education and awareness, effective vaccine and treatment development, and scientific research all play a crucial role in preventing these outbreaks. In addition, in order to jointly address these threats, international cooperation and collaboration must be strengthened. To exchange information, resources, and best practices, governments, international organizations, healthcare professionals, and society as a whole must collaborate. Key components to address and mitigate the effects of these diseases include investments in research, international cooperation, preparedness, strengthening healthcare systems, and public education and awareness.

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