

# An Age of Emerging and Reemerging Pandemic Threats

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## Abstract

Today, we are confronted with an unprecedented crisis this world has never experienced before. Infectious diseases remain among the leading causes of death and disability worldwide. Epidemics of new and old infectious diseases periodically emerge, greatly magnifying the global burden of infections. Humans are constantly exposed to a huge diversity of viruses, though those of others mammals are of greatest importance. Persistence of SARS-CoV-2 as an endemic virus may be fueled by pockets of susceptible individuals and waning immunity after infection or vaccination, changes in the virus through antigenic drift that diminish protection and re-entries from zoonotic reservoirs. Moreover, these viruses are very genetically diverse and new genotypes, strains and species evolve rapidly. The emergence of new human viruses is a long-standing and ongoing biological process. We must anticipate the emergence and/or discovery of more new human viruses in the coming years and decades. The spillover of viruses from animals to humans is the major source of pandemic risk. Life threatening situations demand extraordinary response and more stringent measures to contain the pandemic. The first line of defence against emerging viruses is effective surveillance. Rapid detection and identification of emerging pathogen leading to the rapid introduction of preventive measures can prove highly effective in combating outbreaks of novel diseases. A coordinated, global surveillance network is essential if we are to ensure rapid detection of novel viruses. Improving the situation will require both political will and considerable investment in infrastructure, human capacity and new tools. To ensure global preparedness, newer vaccines, diagnostics and antiviral agents are being developed. Infectious diseases can be prevented at a variety of points, depending on the infectious cycle for the particular disease. Disease prevention, health promotion, strengthening public health systems, translational research, focus on drug discovery, tailored therapies by personalized precision medicine, developing newer effective and af-

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fordable vaccines are crucial to prevent and control emerging pandemics. The need of the day is to prioritize diagnostic tests and strengthen laboratory response network. Effective communication is an indispensable tool. In a world of 7.8 billion people, countries have to be in a state of emergency preparedness to tackle emerging infectious diseases. There is a need to stop pandemics before they start.

## Keywords

EID, Pandemic, Coronaviruses, Monkeypox, New Langya Virus, Henipaviruses

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## 1. Introduction

Emerging infectious diseases result from either natural processes such as the evolution of pathogens over time or as a result of human behavior and practices. Factors that have contributed to these changes are population growth, migration from rural areas to cities, international air travel, poverty, wars, and destructive ecological changes due to economic development and land use.

Many emerging diseases arise when infectious agents in animals are passed to humans. As the human population expands in number and into new geographical regions, the possibility that humans will come into close contact with animal species that are potential hosts of an infectious agent increases. When that factor is combined with increases in human density and mobility, it is easy to see that this combination poses a serious threat to human health.

Climate change is increasingly becoming a concern as a factor in the emergence of infectious diseases. As Earth's climate warms and habitats are altered, diseases can spread into new geographic areas.

Bacteria, viruses, and other microorganisms can change over time and develop a resistance to the drugs used to treat diseases caused by the pathogens. Therefore, drugs that were effective in the past are no longer useful in controlling disease.

Decline in vaccine coverage can cause a disease to re-emerge, so that even when a safe and effective vaccine exists, a growing number of people choose not to become vaccinated. This has been a particular problem with the measles vaccine.

There has been a global failure of public health systems and practice, operational coordination and transparency. Governments have been lackadaisical in their approach to face the challenges of recent pandemics. Most vulnerable groups were ignored resulting in millions of preventable deaths and adversely affecting sustainable development. A sustainable vaccination strategy, strengthening health systems and widening health services coverage, addressing the global climate crisis, a better prepared architecture driven by shared responsibility, integrating the global response to the risk of the future pandemics with appropriate and de-

finitive actions is critical for protecting populations.

Humans are constantly exposed to a huge diversity of viruses. Infectious diseases can be prevented at a variety of points, depending on the infectious cycle for the particular disease.

## 2. Emergence of New Pathogens

The case of the coronaviruses SARS-CoV, MERS-CoV, and SARS-CoV-2, represents instances of how viruses can move from animals into humans, acquire the ability to spread from person to person and then, with great speed, reach around the globe as a result of air travel.

There are two distinct stages in the emergence of infectious diseases: the introduction of a new infection to a host population, and the establishment within and dissemination from this population.

Nearly 1400 pathogens capable of infecting humans, of which 500 are capable of human-to-human transmission, and among which fewer than 150 have the potential to cause epidemic or endemic disease; evolution drives pathogens up the pyramid.

There has been complacency about infectious diseases, partly for reasons—the antibiotic era, immunizations, improved public health measures—all of which have led to the fact that we now live longer and tend to die later of chronic diseases.

Several high impact zoonotic disease outbreaks have been linked to bat-borne viruses during the last two decades. These include SARS coronavirus, Hendra virus and Nipah virus. In addition, it has been suspected that ebola viruses and MERS coronavirus are also linked to bats. It is being increasingly accepted that bats are potential reservoirs of a large number of known and unknown viruses, many of which could spillover into animal and human populations [1].

SARS-CoV-2 the sarbecovirus behind COVID 19 emerged in the humans after cross species transmission from an animal source. Spillover of sarbecoviruses from animals to humans has resulted in outbreaks of SARS-CoV-1 and SARS-CoV-2 pandemic. Continuous efforts of researchers have resulted in the discovery of numerous animal sarbecoviruses of which majority are not capable of infecting human cells. The spike from virus, Khosta-2, could infect cells similar to human microorganisms, but is resistant to neutralization by serum from individuals who had been vaccinated for COVID-19.

Emerging diseases with their disastrous consequences might be surprising and unpredictable, but they could be foreseen.

## 3. Zoonotic Disease Outbreaks

The risk of cross-species transmission of known and unknown pathogens has emerged as a threat to human and animal populations due to a various factors, including industrialization, intensive farming, urbanization, rapid transportation and climate change.

Among the newly emerged and most deadly zoonotic viruses discovered in the past few decades, bat-borne viruses occupy a greater proportion than viruses from any other mammalian order. Several studies have now concluded that bats are exceptional in their ability to act as natural reservoir of viruses and they are able to harbour more diverse viruses per animal species. Nearly 75% of emerging infectious diseases for humans are zoonoses [2]. Transmission of highly pathogenic viruses from bats has been suspected or linked to a spectrum of potential emerging infectious diseases in humans and animals worldwide. Examples of such viruses include Marburg, Ebolavirus, Nipah, Hendra, Influenza A, Dengue, Equine Encephalitis viruses, Lyssaviruses, Madariaga and Coronaviruses, involving the now pandemic Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) [3].

Bat coronaviruses may be a more likely cause of future spillover into both human and livestock populations due to their greater genetic diversity already known in bats around the world, their large positive strand RNA genome size with a high rate of recombination, and proven spillover events in both human and animals. Understanding the immunological and physiological factors that enable bats from playing this epidemiological public health threatening role will help in the early prediction, prevention, management, and control of future coronavirus epidemics. Understanding the mechanisms by which they can inhibit virus protein-mediated modulation following viral invasion will enable the development of novel therapeutic approaches [4].

Infectious diseases will undoubtedly persist as permanent and main threats to humanity in the future, especially due to increased longevity that almost always comes at cost due to impaired immunity. One reason among many others is certainly the continuous co-evolution of pathogens with the host immunity, especially in the case of opportunistic and zoonotic pathogens, which is enabling pathogen transmission between different mammalian or animal hosts [5].

The world witnessed how COVID-19 has become a leading global cause of death within just 9 months after its discovery, and all that despite intense health warnings [6]. Establishing proper “preparedness”, is essential for both swift and appropriate actions to deal with emerging infectious disease threats.

Infectious diseases stand out by far as the single major causes of childhood mortality until the age of 14 all over the world. Across all age groups, infectious disease deaths are similar to cardiovascular diseases. Efforts to improve pandemic preparedness and response for the next pandemic might benefit from greater investment in risk communication and community engagement strategies to boost the confidence that individuals have in public health guidance. Increasing health promotion for key modifiable risks is associated with a reduction of fatalities in such a scenario. Governments should invest in risk communication and community engagement strategies to boost the confidence that individuals have in government guidance in public health crises, especially in settings with historically low levels of government and interpersonal trust [7].

## 4. Disease Burden

Emerging infectious diseases (EIDs) are a significant burden on global economies and public health. Their emergence is thought to be driven largely by socio-economic, environmental and ecological factors. A study analyzed a database of 335 EID “events” (origins of EIDs) between 1940 and 2004, and demonstrate non-random global patterns. EID events are dominated by zoonoses (60.3% of EIDs); the majority of these (71.8%) originate in wildlife, and are increasing significantly over time. A study reveals that 54.3% of EID events are caused by bacteria or rickettsia, reflecting a large number of drug-resistant microbes in our database. Global resources to counter disease emergence are poorly allocated, with the majority of the scientific and surveillance effort focused on countries from where the next important EID is least likely to originate. Given the large variety of viruses in bats and their propensity to cross the species barrier, the question regarding which measures should be taken to prevent the emergence of novel virus to humans needs to be addressed with urgency, as it can become a major public health crisis, as exemplified by the COVID-19 pandemic. Viral genetics; host factors, including polymorphisms in the receptors; and ecological, environmental, and population dynamics are major parameters to consider. Another pandemic preparedness strategy is to develop drugs against conserved viral targets. One candidate is the RNA-dependent RNA polymerase, which shares structural similarity among all RNA viruses [8].

## 5. EIDs of Recent Origin

Here we will discuss most recent Emerging Infectious Diseases of public health importance.

### 5.1. Monkeypox

From 1 January through 7 August 2022, 27 814 laboratory confirmed cases of monkeypox and 11 deaths have been reported to WHO from 89 countries/territories/ areas in all six WHO Regions. The virus has hit parts of the population where people have been in close contact with each other and also travel internationally [9].

Routine immunization against smallpox stopped in the early 1970s in places like the US and UK. As smallpox vaccines can be 85% effective at preventing its related virus, monkeypox, many people born after that time are not immune anymore [9].

In a study, monkeypox manifested with a variety of dermatologic and systemic clinical findings. The simultaneous identification of cases outside areas where monkeypox has traditionally been endemic highlights the need for rapid identification and diagnosis of cases to contain further community spread [10].

The WHO declared on 23 July 2022 that the multi-country outbreak of monkeypox is a public health emergency of international concern (PHEIC). A coordinated response can stop transmission and protect vulnerable groups. Mon-

keypox is a rare disease that is rarely fatal. With the tools we have right now, we can stop transmission and bring this outbreak under control. Now, we just need to scale up our collective response [11].

In India, the outbreak was first reported on 14 July 2022 in Kerala State, suspected imported case which was confirmed hours later by the NIV. India was the tenth country to report a monkeypox case in Asia and the first in South Asia. An analysis conducted by the Indian Council of Medical Research (ICMR) and National Institute of Virology (NIV) revealed that the first two Monkeypox cases diagnosed in India which was a duo that had returned from the UAE were infected with the virus strain A.2 [12].

The current outbreak is being driven by the B.1 strain of monkeypox virus. According to the study, people with no history of sexual contact can also contract the virus. In the first case, the person had a history of similar lesions amongst his friends and contact with a suspected Monkeypox case [12].

Since the start of the monkeypox outbreak and as of 22 August 2022, 16 750 confirmed cases of monkeypox (MPX) have been reported from 29 EU/EEA countries. Two deaths have been reported by Spain in July 2022 [13]. According to WHO, cases in the Americas accounted for 60% of cases in the past month, while cases in Europe comprised about 38%. The number of monkeypox cases reported globally dropped by 21% in the mid August, 2022, reversing a month-long trend of rising infections and a possible signal the outbreak in Europe may be starting to decline [14].

Since 1 January and as of 22 June 2022, 3413 laboratory confirmed cases and one death have been reported to WHO from 50 countries/territories in five WHO Regions. The majority of laboratory confirmed cases (2933/3413; 86%) were reported from the WHO European Region. Other regions reporting cases include: the African Region (73/3413, 2%), Region of the Americas (381/3413, 11%), Eastern Mediterranean Region (15/3413, <1%) and Western Pacific Region (11/3413, <1%). One death was reported in Nigeria in the second quarter of 2022. Since June, there have been over 10,000 confirmed cases in the U.S. [15].

The ongoing epidemic differs from previous outbreaks in terms of age (54.29% of individuals in their thirties), sex/gender (most cases being males), risk factors, and transmission route, with sexual transmission being highly likely. The clinical presentation is atypical and unusual, being characterized by anogenital lesions and rashes that relatively spare the face and extremities. The most prevalent sign/symptom reported was fever (in 54.29% of cases) followed by inguinal lymphadenopathy (45.71%) and exanthema (40.00%). The majority of reported cases—over 97%—are among men who have sex with men (MSM), especially those with multiple sexual partners, underscoring the need for all countries to work closely with affected communities to design and deliver effective information and services, to guard against stigma and discrimination, and to adopt measures that protect their health, human rights, and dignity [10] [16].

Human-to-human transmission can result from close contact with respiratory

secretions, skin lesions of an infected person or recently contaminated objects. Transmission via droplet respiratory particles usually requires prolonged face-to-face contact, which puts health workers, household members and other close contacts of active cases at greater risk [17].

Monkeypox was disease containment on easy mode, and yet it is looking very likely that we're going to fail to contain it. Some of the most glaring errors have been in communication, where people are getting sick because of reluctance to tell them they are at higher risk. Relentlessly tracking down the people whom the sick person has been in close contact with and encouraging them to get tested as well, is crucial.

According to a study in the *New England Journal of Medicine*, 98 percent of documented cases were found in gay or bisexual men. While the disease isn't a sexually transmitted infection like syphilis, which spreads nearly exclusively through sex, monkeypox transmission requires close physical contact, and sex appears to be a major opportunity for the virus—95 percent of the transmissions documented in the study occurred during sexual relations. The best way to serve the population of men who have sex with men is by getting them truthful information, high-quality health care, and priority vaccine access, public health agencies are too often failing to communicate clearly about this. Effective immunity can be obtained with the use of the smallpox vaccine; additionally, some antivirals, such as tecovirimat and brincidofovir, have efficacy against the virus. So far, few major neurological complications, including two cases of encephalitis, have been reported during this outbreak. Biological samples, including CSF, should be collected for viral and immune studies [18].

Endemic monkeypox is generally self-limited, with clade-dependent case fatality rates of 1 to 10%. Monkeypox virus is an orthopoxvirus that is in the same genus as variola (causative agent of smallpox) and vaccinia viruses (the virus used in smallpox vaccine). Most cases of monkeypox have occurred in Central and West Africa. However, an ongoing outbreak associated with person-to-person transmission was first reported in May 2022 and has involved thousands of individuals in dozens of nonendemic countries [19].

The draft sequence of the virus responsible for the rapidly growing monkeypox outbreak shows it is most closely related to strains detected in the UK, Singapore and Israel in 2018 and 2019. The monkeypox virus is much larger – around 200,000 DNA letters long compared with 30,000 RNA letters for the coronavirus and for now at least not nearly as intensively studied [20]. Mass vaccination is not yet needed, and targeted vaccination strategies with vaccines from the smallpox stockpile, as well as other public health measures such as quarantine and isolation, can contain the outbreaks. As the spread of the virus indicates we will need rapid and strong containment measures including targeted vaccination with the smallpox vaccine, to contain the clusters [21].

There appears to have been a recent change in the epidemiologic characteristics of monkeypox in Africa, where cases are now occurring in new geographic

areas, perhaps facilitated by climate change and deforestation leading to changes in the environmental interface between humans and the animal reservoir (or reservoirs) [22].

Lessons learned during the responses to AIDS and Covid-19 should help us to marshal a more efficient and effective response to monkeypox, and the response to monkeypox should, in turn, help to inform our response to the inevitable next emerging or reemerging infectious disease of pandemic potential [23].

Appropriate measures should be taken: physical distancing between people infected with monkeypox and domestic pets; proper waste management to prevent the disease from being transmitted from infected humans to susceptible animals at home [24].

The world needs to move cohesively and quickly to close knowledge gaps and to contain the outbreak. Without widely available treatment or prophylaxis, rapid case identification is vital to containment. To enable reliable evaluations of interventions, further research (randomized trials) is crucial.

## 5.2. Coronaviruses

Severe acute respiratory syndrome coronavirus (SARS-CoV) and Middle East Respiratory Syndrome coronavirus (MERS-CoV) are two highly transmissible and pathogenic viruses that emerged in humans at the beginning of the 21st century. Both viruses likely originated in bats, and genetically diverse coronaviruses that are related to SARS-CoV and MERS-CoV were discovered in bats worldwide. We highlight the diversity and potential of spillover of bat-borne coronaviruses, as evidenced by the recent spillover of swine acute diarrhoea syndrome coronavirus (SADS-CoV) to pigs [25].

Persistence of SARS-CoV-2 as an endemic virus may be fueled by pockets of susceptible individuals and waning immunity after infection or vaccination, changes in the virus through antigenic drift that diminish protection and re-entries from zoonotic reservoirs. Moreover, these viruses are very genetically diverse and new genotypes, strains and species evolve rapidly.

SARS-CoV most likely originated in bats through sequential recombination of bat SARSr-CoVs. Recombination likely occurred in bats before SARS-CoV was introduced into Guangdong province through infected civets or other infected mammals from Yunnan. The introduced SARS-CoV underwent rapid mutations in *S* and *orf8* and successfully spread in market civets. After several independent spillovers to humans, some of the strains underwent further mutations in *S* and became epidemic during the SARS outbreak in 2002–2003. However, a recent serological investigation revealed the presence of antibodies against the SARSr-CoV nucleocapsid in humans living around a bat cave but who had not shown clinical signs of disease, suggesting that the virus can infect humans through frequent contact [26].

Coronavirus disease 2019 (caused by SARS-CoV-2), has had a catastrophic effect on the world's demographics resulting in over 6 million deaths worldwide

as of March 2022, emerging as the most consequential global health crisis since the era of the influenza pandemic of 1918. COVID-19 has ravaged many countries worldwide and has overwhelmed many healthcare systems. The pandemic has also resulted in the loss of livelihoods due to prolonged shutdowns, which have had a rippling effect on the global economy.

Based on the recent epidemiological update by the WHO, as of December 11, 2021, five SARS-CoV-2 VOCs have been identified since the beginning of the pandemic:

*Alpha (B.1.1.7)*: first variant of concern described in the United Kingdom (UK) in late December 2020

*Beta (B.1.351)*: first reported in South Africa in December 2020

*Gamma (P.1)*: first reported in Brazil in early January 2021

*Delta (B.1.617.2)*: first reported in India in December 2020

*Omicron (B.1.1.529)*: first reported in South Africa in November 2021

Despite robust global mass vaccination efforts including vaccine boosters, the emergence of these new SARS-CoV-2 variants threatens to overturn the significant progress made so far in limiting the spread of this viral illness [27].

Infectious diseases will undoubtedly persist as permanent and main threats to humanity in the future, especially due to increased longevity that almost always comes at cost due to impaired immunity. One reason among many others is certainly the continuous co-evolution of pathogens with the host immunity, especially in the case of opportunistic and zoonotic pathogens, which is enabling pathogen transmission between different mammalian or animal hosts. Global surveillance programs of water-borne pathogens, vector-borne diseases and zoonotic spillovers at the animal-human interface are of prime importance to rapidly detect the emergence of infectious threats. Novel technologies for rapid diagnostic testing, contact tracing, drug repurposing, biomarkers of disease severity as well as new platforms for the development and production of vaccines are needed for an effective response in case of pandemics [28].

### 5.3. Henipaviruses

Henipaviruses, of which Nipah and Hendra are the most infamous, belong to the Paramyxoviridae family of viruses, and have sparked a number of deadly spillovers into humans and epidemics across South East and Central Asia and to a lesser extent Australia over the past 25 years. Characteristics of Nipah virus that increase its risk of becoming a global pandemic include: humans are already susceptible; many strains are capable of limited person-to-person transmission; as an RNA virus, it has an exceptionally high rate of mutation; and that if a human-adapted strain were to infect communities in South Asia, high population densities and global interconnectedness would rapidly spread the infection. Normally carried by Fruit bats, these viruses can carry a high mortality rate in humans, and human-to-human transmission of Nipah has been demonstrated [29].

Last year, researchers announced the discovery of a A Novel Variant of the

Hendra Virus in Australia, and it is a fair assumption there are other as yet undiscovered variants in the wild. And while bats are presumed to be the primary reservoir host for Henipaviruses, they may not be the only ones. Researchers described a phylogenetically distinct henipavirus, dubbed Langya henipavirus (LayV), which they isolated from the throats of 35 fever patients who reported recent animal exposure [27].

Starting with Ebola in 1976, and followed by HIV in the early 1980s, we've seen a procession of emerging zoonotic disease threats which now includes avian flu, Nipah, and COVID. Instead of a "golden age", we've entered an age of emerging and reemerging pandemic threats, one where an obscure virus from a far off land can spark a global crisis with little or no warning. Fifty years ago, it seemed as if we had entered the golden age of medicine, and were on the verge of conquering infectious diseases [30].

The genus Henipavirus (family Paramyxoviridae) currently comprises seven viruses, four of which have demonstrated prior evidence of zoonotic capacity.

Characterization of novel henipaviruses and documentation of their pathogenic and zoonotic potential are essential to predicting and preventing the emergence of future zoonoses that cause pandemics [31]. Henipavirus infections are characterized by their systemic nature, with evidence of infection in multiple organ systems.

#### **5.4. New Langya Virus**

An international team of scientists identified a new virus that was likely to have been transmitted to humans after it first infected animals, in another potential zoonotic spillover less than three years into the coronavirus pandemic. Genetic sequencing of the Langya virus subsequently showed that the pathogen is part of the henipavirus family, which has five other known viruses. Two are considered highly virulent and are associated with high case-fatality ratios, according to the U.S. Centers for Disease Control and Prevention. During sentinel surveillance of febrile patients with a recent history of animal exposure in eastern China, a phylogenetically distinct henipavirus, named Langya henipavirus (LayV), was identified in a throat swab sample from one patient by means of metagenomic analysis and subsequent virus isolation. The genome of LayV is composed of 18,402 nucleotides with a genome organization that is identical to that of other henipaviruses. LayV is most phylogenetically related to Mojiang henipavirus, which was discovered in southern China. In a study, a newly identified henipavirus of probable animal origin was associated with febrile illness, a finding that warrants further investigation to better understand associated human illness [32].

### **6. "One Health" Approach**

Some 70 percent of emerging infectious diseases in humans are of zoonotic origin and nearly 1.7 million undiscovered viruses may exist in mammals and birds. The Hendra and Nipah viruses, two henipaviruses with high mortality rates, can

be contracted through close contact with sick horses, pigs and bats. Scientists who study zoonotic diseases had warned even before the coronavirus pandemic that practices such as unregulated wildlife trade, deforestation and urbanization have brought people closer to animals, thereby increasing the odds of viral spillovers [33].

As Earth's human population hurtles toward 8 billion, no one thinks human-animal interaction is going to decrease. The key is reducing the risk of a devastating spillover, scientists say and not by killing bats. But they acknowledge that cultural and economic pressures make change difficult.

Many researchers say the coronavirus pandemic underscores the need for a more holistic "one health" approach, which views human, animal and environmental health as interconnected. There needs to be a cultural shift from a community level up about how we treat animals, our understanding of the dangers and biosecurity risks that we're exposing ourselves to. Leaving ecosystems intact, not destroying them [34].

## 7. Climate Crisis

Out of several documented pandemics, the 1918 pandemic was by far the worst. The Asian flu of 1957 was not much fun, to put it mildly, but nothing was ever like 1918 [29]. The 1918 influenza pandemic was the deadliest pandemic of the Twentieth Century. The number of deaths was estimated to be at least 50 million worldwide with about 675,000 occurring in the United States. Mortality was high in people younger than 5 years old, 20 - 40 years old, and 65 years and older. The high mortality in healthy people, including those in the 20 - 40 year age group, was a unique feature of this pandemic [35].

Since 1980 new human pathogen species have been discovered at an average rate of over 3 per year. Overall, no more than 50 to 100 species are specialist human pathogens. The 87 new species of human pathogen are associated with public health problems of hugely variable magnitudes [30].

A more efficient strategy to address future emerging diseases is to combine rigorous analyses of the fine-scale ecological and demographic changes within hotspot regions (the risk factors) with state-of-the-art molecular approaches to viral discovery. Techniques such as pyrosequencing and mass tag polymerase chain reaction will rapidly decrease the expense and logistical challenges involved in identifying new viral groups, and if applied to key groups of wildlife species within hotspot regions, will provide the most cost-effective way to proactively address the EID challenge [30].

## 8. Emergency Preparedness

There has been a global failure of public health systems and practice, operational coordination and transparency. Governments have been lackadaisical in its approach to face the challenges of recent pandemics. Most vulnerable groups were ignored resulting in millions of preventable deaths and adversely affecting sus-

tainable development. A sustainable vaccination strategy, strengthening health systems and widening health services coverage, addressing the global climate crisis, a better prepared architecture driven by shared responsibility, integrating the global response to the risk of the future pandemics with appropriate and definitive actions is critical for protecting populations.

The first line of defense against any emerging pathogen is its rapid detection and identification. Surveillance needs to be global, especially considering the unprecedented rates of international travel and trade that can allow new infectious diseases, to spread around the world over time scales of days or weeks. Pathogen emergence is an international problem. Estimating the transmission potential of a new pathogen within the human population can only be achieved by closely monitoring initial outbreaks.

It is extremely likely that we will encounter new species of human pathogen in the near future. The scientific and logistic capacity to rapidly detect and evaluate the threat that new pathogens present and to intervene quickly and effectively wherever necessary, is urgently needed.

The constant spillover of viruses from natural hosts to humans and other animals is largely due to human activities, including modern agricultural practices and urbanization. Therefore, the most effective way to prevent viral zoonosis is to maintain the barriers between natural reservoirs and human society, in mind of the “one health” concept. Three practical actions to minimize the impact of future pandemics include: better surveillance of pathogen spillover and development of global databases of virus genomics and serology, better management of wildlife trade, and substantial reduction of deforestation. These primary pandemic prevention actions cost less than 1/20th the value of lives lost each year to emerging viral zoonoses and have substantial cobenefits [36].

There are 219 virus species that are known to be able to infect humans. There is still a substantial pool of undiscovered human virus species, although an apparent slow-down in the rate of discovery of species from different families may indicate bounds to the potential range of diversity. A few possible predictors of species jumps can be identified, including the use of phylogenetically conserved cell receptors. It seems almost inevitable that new human viruses will continue to emerge, mainly from other mammals and birds, for the foreseeable future. An effective global surveillance system for novel viruses is needed [37].

## 9. Primary Prevention of Pandemics

Globally, about one billion cases of illness and millions of death occur every year from zoonoses. Some 60% of emerging infectious diseases that are reported globally are zoonoses. Over 30 new human pathogens have been detected in the last three decades, 75% of which have originated in animals. Viruses are the cause of diseases that pose a serious threat to public health. Marburg, coronaviruses: Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome Coronavirus 1 (SARS-CoV-1), Human Immunodeficiency Virus (HIV),

Hendra, Nipah virus (NiV) and those responsible for Crimean-Congo hemorrhagic fever, Lassa fever, Ebola, Influenza A virus subtype H1N1, Asian highly pathogenic avian influenza (HPAI) A(H5N1) virus or Rift Valley Fever (RVF) caused numerous epidemics in recent years. These epidemics were characterized by high morbidity and mortality, mainly in developing countries in Asia, Africa, and South America [38] [39].

Epidemics are happening more often, getting larger and spreading further. Based on the Earth's current population of nearly 8 billion people, they estimate that we can expect about 3.3 million deaths per year from zoonotic epidemics. Viral discovery is the cornerstone of this suite of preventive interventions. New epidemics will invariably emerge. Improving healthcare for underserved communities that border tropical forests would help detect infectious disease outbreaks and curtail them before they can spread. The investments in conservation and health systems that focus on spillover risk are investments in pandemic prevention, prevention could save trillions of dollars and millions of lives [40].

New and better systems for detecting and monitoring potential health threats when the first person becomes sick as well as enforcing the protection of habitats for wild animals will help shift to a more preventative model to keep people healthy. Prevention is better than cure. Identification of emerging pathogen leading to the rapid introduction of preventive measures can prove highly effective in combating outbreaks of novel diseases. Surveillance for novel pathogens, however, does present some particular challenges. The current inadequacies in healthcare delivery systems and access to new biomedical interventions must be addressed. The necessity of global cooperation for pandemic control is crucial.

The risk for pandemics increases as humans continue to expand into wildlife habitats, increasing the contact between animals and humans along with the risk of diseases that can move from one species to another. Three practical actions to minimize the impact of future pandemics have been suggested: better surveillance of pathogen spillover and development of global databases of virus genomics and serology, better management of wildlife trade, and substantial reduction of deforestation. These primary pandemic prevention actions cost less than 1/20th the value of lives lost each year to emerging viral zoonoses and have substantial cobenefits. Scientific inquiry, policy actions, and financial and organizational resources needed to forestall the next pandemic and estimate that primary pandemic prevention actions are remarkably inexpensive compared to the many lives emerging viral zoonoses take or the direct economic damage they cause [40].

By acting now with urgency, we can avert the unfolding global crisis of drug-resistance, protecting our health today and for generations to come.

## 10. Conclusion

Infectious diseases remain among the leading causes of death and disability worldwide. Epidemics of new and old infectious diseases periodically emerge,

greatly magnifying the global burden of infections. Raising awareness of risk factors and educating people about the measures they can take to reduce exposure to the virus is the main prevention strategy for emerging pathogens. Surveillance and rapid identification of new cases is critical for outbreak containment. Infectious diseases can be prevented at a variety of points, depending on the infectious cycle for the particular disease. Integrated surveillance coupled with evidence-based epidemiologic data can help formulate better public health policies and increase preparedness to meet the future challenges presented by emerging/re-emerging infectious diseases. We should aim at translating scientific discoveries into affordable, globally accessible public health solutions to face the challenges of Emergent Infection on a priority basis. The need of the day is to prioritize diagnostic tests and strengthen laboratory response network. Greater investment in antibiotic research and development, both as a tool to control novel disease outbreaks, but also to treat known pathogens developing resistance to currently available treatments is important. Effective communication is an indispensable tool. In a world of 7.8 billion people, countries have to be in a state of emergency preparedness to tackle emerging infectious diseases. Primary prevention of zoonotic pandemics is an inescapable necessity.

### Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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