

Are We Ready for the Next Pandemic? A Global Vision

Series | All-Hazards Preparedness and Response

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[This document is one of a series of discussion notes addressing fundamental questions about global health. Its purpose is to transfer scientific knowledge into the public conversation and decision-making process. The papers are based on the best information available and may be updated as new information comes to light.]

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Photograph: Maxim Malov / CDC

On July 8, 2024, a team of American and Japanese researchers published an article in *Nature* warning that the new highly pathogenic avian influenza virus H5N1 might have the potential to spread among mammals.¹ This is highly concerning news, as it significantly elevates the public health threat posed by the virus and **positions it at the forefront of potential causes of the next pandemic.**

COVID-19 caused millions of deaths and incalculable economic losses, but it also injected renewed political and social will into efforts to strengthen surveillance, alert, and response systems for future

pandemics. These efforts included the establishment of funds to support these initiatives and political actions to create effective governance structures for protecting against systemic risks of infection. **Now, more than 4 years** since the onset of this global catastrophe, the political, financial, and electoral window of opportunity to strengthen the global architecture for preparedness is closing. The question is as stark as it is inevitable: **Are we doing enough to prepare for the next pandemic?** ●

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¹ Elsfeld A.J., Biswas A., *et al.* (2024), Pathogenicity and transmissibility of bovineH5N1 influenza virus. *Nature*: <https://www.nature.com/articles/s41586-024-07766-6>

1. Pandemics throughout Human History

“Epidemics and pandemics have occurred throughout history and it seems inevitable that they will continue to occur. In addition, the risk of a new pandemic is heightened by a range of factors, and future pandemics can be expected to occur with increasingly short intervals between events.”

Infectious diseases, epidemics, and pandemics have shaped cultures and societies since the dawn of human history. **Throughout different periods, we have endured and will continue to endure** the consequences of epidemics caused by a range of pathogens. Examples are the plague, smallpox, cholera, and influenza.

The impact of these diseases is incalculable. The **Plague of Justinian**, which affected the Byzantine Empire with outbreaks in Europe, Africa, and Asia between 541 and 750, resulted in an estimated 25 to 50 million deaths (around 13%-26% of the world’s population at the time). In Constantinople alone, the plague killed 40% of the population and some researchers believe that it contributed to the fall of the Western Roman Empire.^{2,3} The Plague of Justinian was caused by the bacterium *Yersinia pestis*, the same pathogen responsible for the **Black Death** in the Middle Ages. In the 14th century, the Black Death is estimated to have killed around 50% of Europe’s population.⁴ **Smallpox** caused another devastating pandemic and its spread to the American continent claimed the lives of 90% of the indigenous population, facilitating colonization by European powers.⁵ Zoonotic influenza pandemics, originating from animals, have also had a significant impact on humanity. One of the most notorious was the “**Spanish flu**”, which occurred during World War I and claimed more lives than the war itself.⁶

Influenza pandemics caused by avian or swine flu viruses have occurred about every 20 years since the 20th century, resulting in numerous deaths and significant economic losses. More recent zoonotic epidemics include the 2003-2004 **SARS (severe acute respiratory syndrome) coronavirus** epidemic and the **MERS (Middle East respiratory syndrome) coronavirus** epidemic, which has seen several outbreaks since 2012. SARS originated from a bat virus that jumped to civets, while MERS originated from a camel virus that jumped to humans. The **Ebola virus**, presumed to have originated from bat reservoirs, has caused multiple outbreaks since its discovery in 1976, including a major epidemic in West Africa that resulted in over 11,000 deaths in three countries between 2014 and 2016. The most recent pandemic, **COVID-19**, caused by SARS-CoV-2, another coronavirus of animal origin, is estimated to have resulted in over 7 million deaths and more than 12.5 billion dollars in economic losses.^{7,8}

² Meier M. (2016), The ‘Justinianic Plague’: the economic consequences of the pandemic in the eastern Roman Empire and its cultural and religious effects, *Early Medieval Europe* 24.3: 267-292.

³ Mordechai L., Eisenberg M., et al. (2019), The Justinianic Plague: An Inconsequential Pandemic? *Proceedings of the National Academy of Sciences* 116 (51). <https://www.pnas.org/content/pnas/early/2019/11/26/1903797116.full.pdf>

⁴ Cartwright M., (2023), Black Death. World History Encyclopedia. https://www.worldhistory.org/Black_Death/

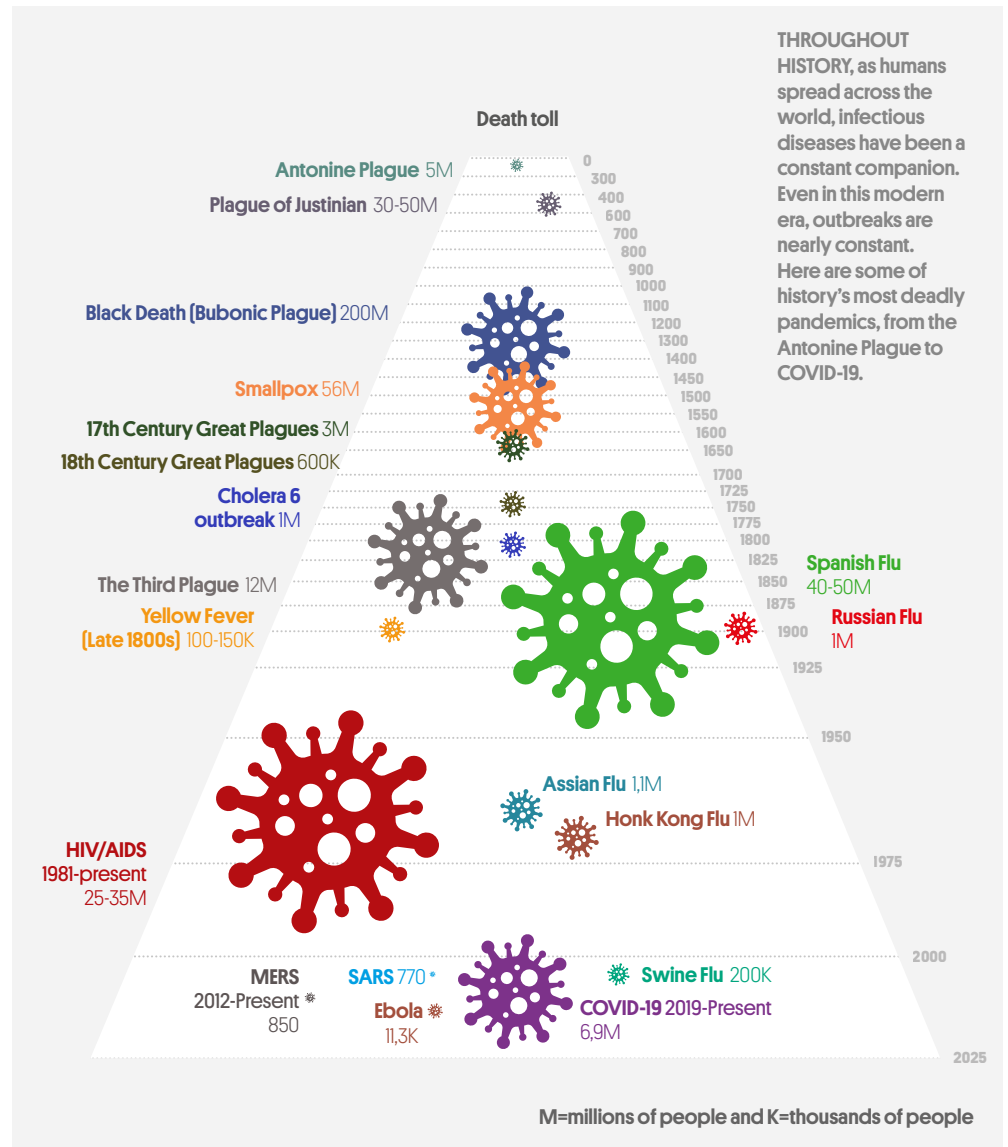
⁵ Patterson K.B., and Runge T. (2002), Smallpox and the Native American. *The American Journal of the Medical Sciences*, 323(4), 216-222. doi:10.1097/00000441-200204000-00009

⁶ National Archives and Records Administration. The deadly virus: Influenza Epidemic of 1918. <https://www.archives.gov/exhibits/influenza-epidemic/>

⁷ World Health Organization (2024). WHO COVID-19 dashboard. WHO Data. <https://data.who.int/dashboards/covid19/cases>

⁸ Reuters (2022). IMF sees cost of COVID pandemic rising beyond \$12.5 trillion estimate. <https://www.reuters.com/business/imf-sees-cost-covid-pandemic-rising-beyond-125-trillion-estimate-2022-01-20/>

Figure 1. The history of pandemics



THROUGHOUT HISTORY, as humans spread across the world, infectious diseases have been a constant companion. Even in this modern era, outbreaks are nearly constant. Here are some of history's most deadly pandemics, from the Antonine Plague to COVID-19.

Source: Adapted from LePan N. (2020), Visualizing the History of Pandemics. Visual Capitalist. <https://www.visualcapitalist.com/history-of-pandemics-deadliest/>

Epidemics and pandemics have occurred throughout history and it seems inevitable that they will continue to occur. In addition, the risk of a new pandemic is heightened by a range of factors, including environmental changes exacerbated

by the climate crisis, land use changes, interactions with wildlife, and globalization. **Future pandemics can also be expected to occur with increasingly short intervals between events** ⁹

⁹ Pandemics past, present, and future: progress and persistent risks. Arturo Casadevall J Clin Invest. 2024;134(7):e179519.

2. The Risk of Pandemics is Growing

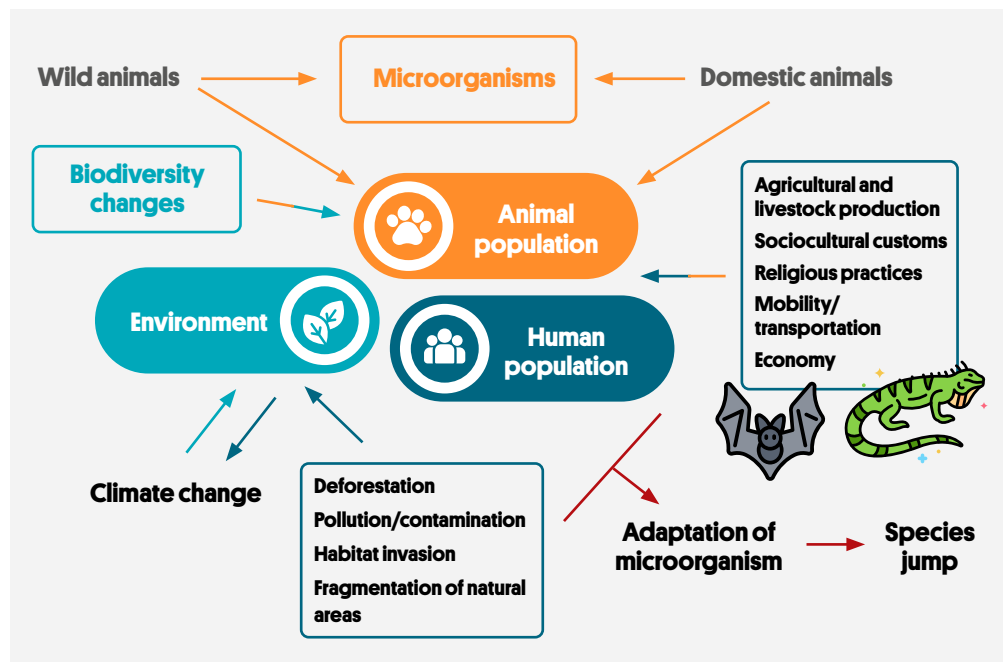
“The more contact between humans and animals, the greater the chances of a pathogen adapting to enable human-to-human transmission.”

The risk of a new pandemic is linked to the **frequency of contact with animal pathogens** capable of crossing the species barrier and the likelihood of these pathogens adapting to humans. The more contact between humans and animals, the greater the chances of a pathogen adapting to enable human-to-human transmission.

Emerging infectious diseases are diseases that appear in a population for the first time or whose incidence or geographic range increases rapidly. Since 1940, 60% of emerging infectious diseases have been **zoonotic**, meaning they originated in animals.¹⁰ Several factors increase the risk of animal diseases spreading to humans (*see Figure 2*).

Figure 2. How do zoonotic diseases emerge?

The graph illustrates how various interactions between humans, animals, and the environment can lead microorganisms typically found in animals to cross over to humans. This process can be understood within the One Health approach.



Source: Adapted from Federico Mayor Zaragoza, Fernando Fariñas Guerrero and Santiago Vega García. ONE HEALTH: Cambio climático, contaminación ambiental y el impacto sobre la salud humana y animal. Zaragoza (España). Amazing Books, 2019.

¹⁰ Jones K.E., Patel, N., et al. (2008), Global trends in emerging infectious diseases. *Nature*. 2008; 451:990-994. [Global trends in emerging infectious diseases.](#)

The risk of zoonotic spillovers can be understood within the **One Health approach**, which recognizes that human, animal, and environmental health are closely interconnected. Wild and domestic animals have their own **microbiota**, a community of microorganisms that may or may not cause disease in their host. Both microorganisms and animal hosts are affected by **environmental** conditions, which can alter **biodiversity**. Climate change and other human-driven changes, such as deforestation, pollution, habitat invasion, and territorial fragmentation, are having a drastic impact on the environment. The likelihood of contact between human and animal populations is influenced by numerous factors, including agricultural and livestock production, sociocultural customs, religious practices, conflicts, mobility, transportation, and the economy. These factors increase the risk of human exposure to novel pathogens, which may successfully adapt, leading to a **species jump** or **spillover** and an emerging zoonotic disease.

The likelihood of a pathogen spillover from wildlife or domestic animals is increased by several **predictive factors** related to different activities and conditions that can help identify high-risk areas^{1,11}

- **Population density.** The risk of emerging infectious diseases originating in wildlife (potential reservoirs) or domestic animals is greater in densely populated areas.
- **Population growth.** Zoonotic diseases are more likely to occur in growing populations.
- **Environmental changes.** Numerous environmental factors increase the risk of zoonotic diseases. These include the climate crisis (which disrupts ecosystems and alters the presence of vectors that can transmit disease), deforestation, new agricultural or land use practices, and territorial invasion resulting from uncontrolled urbanization.

- **Intensification of trade and mobility.**

The intensification of trade and mobility has increased the movement of people, goods and domestic and wild animals between different regions of the world, allowing microorganisms to travel long distances in a very short time. In the 14th century, for example, the Black Death took 50 years to travel from China to Europe, whereas in 2003, the SARS virus reached Canada from China in just 10 days.

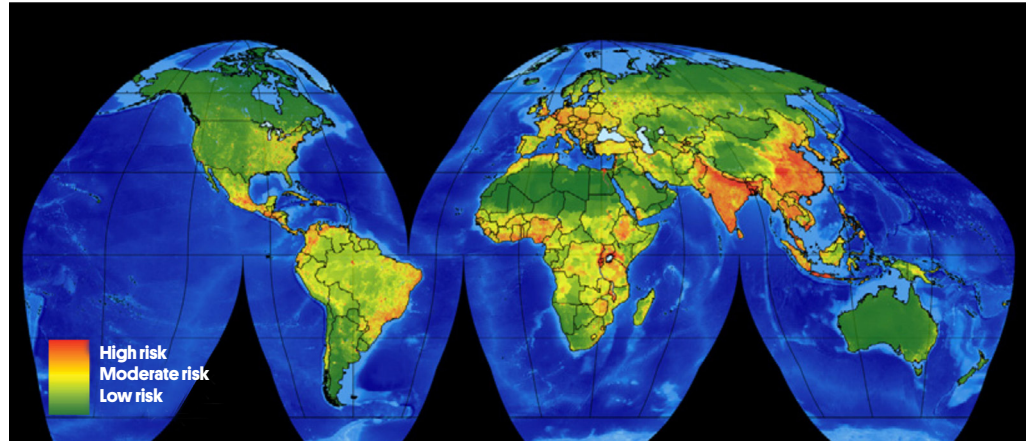
- **Sociocultural practices.** Sociocultural practices also play a role in the risk of a pathogen spillover. Practices such as the handling of wild animals hunted for consumption and wet markets, where wild animals are housed together with domestic animals for human consumption, increase the likelihood of zoonotic disease transmission.

The above factors have been used in predictive models to identify **hotspots—areas where emerging infectious diseases are most likely to arise** (see Figure 3).¹² A study conducted in 2008 identified large high-risk areas in Southeast Asia, Central America, South America, and West and Central Africa. These areas have already experienced multiple epidemic events, such as the Ebola outbreak in 2014, COVID-19, and recurring annual outbreaks of the Nipah virus in India, Bangladesh, and Malaysia ●

¹¹ Morse S.S., Mazet J.A., Woolhouse M, et al. (2012), Prediction and Prevention of the next pandemic zoonosis. *The Lancet. Prediction and prevention of the next pandemic zoonosis.*

¹² Morse S.S., Mazet J.A., Woolhouse M, et al. (2012), Prediction and Prevention of the next pandemic zoonosis. *The Lancet. Prediction and prevention of the next pandemic zoonosis.*

Figure 3. Global hotspots for emerging infectious diseases that originate in wildlife.



Source: Carlos Zambrana-Torrel in Morse S.S., Mazet J.A., Woolhouse M, et al. (2012), Prediction and Prevention of the next pandemic zoonosis. *The Lancet*. [Prediction and prevention of the next pandemic zoonosis](#).

3. When Will the Next Pandemic Occur?

“Trends from recent decades suggest that the next pandemic will be caused by a respiratory virus for which there is no effective treatment or vaccine.”

Throughout history, the most devastating epidemics and pandemics have been caused by both bacteria and viruses. Most of the major events in the 20th and 21st centuries, however, have been caused by a virus. The discovery of antibiotics significantly reduced the proportion of epidemics caused by bacteria, although this trend could reverse, with tragic consequences, if antimicrobial resistance (AMR) continues to rise (*see Box 1*). It is also worth recalling that bacteria still cause cholera outbreaks in various parts of the world and result in a million deaths from tuberculosis each year.

Trends from recent decades, however, suggest that the **next pandemic will be caused by a virus** for which there is no effective treatment or vaccine, and that it will be transmitted via the respiratory route rather than by the faecal-oral route (like cholera) or through contact (like Ebola). Human-to-human transmission is more difficult to control in infections caused by respiratory viruses, as the spread of the virus does not depend on hygiene mea-

asures (as with faecal-oral transmission) or avoidance of exposure to bodily fluids (as with contact transmission). Respiratory viruses spread when infected individuals expel virus-containing droplets by sneezing, coughing, or breathing. These droplets can remain airborne and be inhaled by others in the same space, or they can settle on surfaces and cause infection through contact. **Preventing these virus-laden droplets from infecting others through inhalation is challenging** and requires the use of high-protection masks, air purifiers with filters, and rooms equipped with special mechanisms that generate negative pressure. These mechanisms prevent air from escaping and allow it to be filtered before being expelled.

Box 1. Antimicrobial resistance: the “silent” pandemic



AMR has often been described as a *silent pandemic*,^{13,14,15} a term suggesting that this resistance is spreading quietly and unnoticed across the globe and that its impact on morbidity, mortality, and healthcare costs has yet to be felt. Recent studies, however, suggest that this situation may have changed. Statistical models, for example, have shown that nearly 1.3 million global deaths in 2019 were directly attributable to AMR and that this resistance was linked, either directly or indirectly, to almost 5 million deaths, primarily in low- and middle-income countries.¹⁶ In addition, most of the deaths were caused by just **six bacterial species**, which are prevalent worldwide, posing a significant global health threat.

We have already witnessed how antibiotic-resistant bacteria can cause outbreaks and epidemics exacerbated by globalization, such as the **carbapenem-resistant Enterobacteriaceae outbreaks** that began locally but quickly spread to different parts of the planet. It is not difficult to envision the emergence of new AMRs that could spread easily across the world, making it impossible to effectively treat bacterial infections such as tuberculosis, cholera, and enterobacterial infections.

There are several viruses with characteristics that make them **potential candidates for causing the next pandemic**:

- **Influenza A virus.** Various strains of the influenza A virus circulate in animals. In birds, these strains are classified as low pathogenic or highly pathogenic. Highly pathogenic strains, primarily H5 and H7, are very infectious and deadly in birds.¹⁷ Some of the strains can be transmitted to other species, including humans, causing infections ranging from mild to fatal. Although sustained human-to-human transmission has not yet occurred, the H5N1 strain is of particular concern.¹⁸

- **Influenza A virus subtype H5N1.** The H5N1 strain has caused numerous outbreaks worldwide since it was first detected in 1996. In 2022, a variant began to spread among wild and domestic birds, causing significant global economic losses. Transmission to mammals, such as ferrets and sea lions, was subsequently detected. In

the United States, H5N1 was detected in cattle for the first time this year and was responsible for four cases of avian influenza among farm workers. There are currently outbreaks affecting cattle in 12 states and birds in 48. Surveillance systems for farm workers are being strengthened, but voluntary measures applied to animals do not appear to be working. Finland¹⁹ recently became the first country to vaccinate farm workers at increased risk of avian influenza.

The US Department of Health and Human Services recently granted Moderna \$176 million to develop an mRNA-based pandemic influenza vaccine.²⁰

- **Coronavirus.** Examples of coronavirus are SARS, SARS-CoV-2 (which causes COVID-19), and MERS. These viruses spread effectively through the air and can cause disease presentations ranging from asymptomatic illness to death.

¹³ Cullen A. (2024), Antimicrobial resistance: A silent pandemic. Imperial College of London. [Antimicrobial resistance: A silent pandemic](#).

¹⁴ RTVE (2024). 'Documentos TV' estrena 'La pandemia silenciosa' <https://www.rtve.es/rtve/20240212/documentos-tv-estrena-pandemia-silenciosa/15966365.shtml>

¹⁵ World Health Organization (2023). Global antimicrobial resistance forum launched to help tackle common threat to planetary health. <https://www.who.int/news-room/articles-detail/global-antimicrobial-resistance-forum-launched-to-help-tackle-common-threat-to-planetary-health>

¹⁶ Antimicrobial Resistance Collaborators (2022), Global burden of bacterial antimicrobial resistance in 2019: a systematic analysis. *The Lancet*, Vol 399, Issue 10325, P629-655. [https://www.thelancet.com/journals/lancet/article/PIIS0140-6736\(21\)02724-0/fulltext#seccetitle10](https://www.thelancet.com/journals/lancet/article/PIIS0140-6736(21)02724-0/fulltext#seccetitle10)

¹⁷ Pan American Health Organization. Avian Influenza. <https://www.paho.org/es/temas/influenza-aviar>

¹⁸ World Health Organization (2024). Influenza: A (H5N1). <https://www.who.int/news-room/questions-and-answers/item/influenza-h5n1>

¹⁹ Itziar Peinado (2024). Finlandia se convierte en el primer país del mundo en vacunar a su población contra la gripe aviar. ConSalud. https://www.consalud.es/pacientes/finlandia-primer-pais-mundo-iniciar-vacunacion-gripe-aviar-en-humanos_145667_102.html

²⁰ HHS (2024). HHS provides \$176 million to develop pandemic influenza mRNA-based vaccine. <https://www.hhs.gov/about/news/2024/07/02/hhs-provides-176-million-develop-pandemic-influenza-mrna-based-vaccine.html>

• **An unknown virus.** The next pandemic-causing virus may already be circulating in a wild animal population, unknown to us. The PREDICT global virome project was launched to map the genetic make-up of the world's viruses to help identify those with pandemic potential. The term *Disease X*²¹ was coined by the WHO to represent a hypothetical pathogen that could cause the next pandemic. (SARS-

CoV-2, for example, was unknown before the COVID-19 pandemic). We must be prepared •

4. What Mechanisms are Available for Dealing with the Next Pandemic?

“The COVID-19 crisis made it clear that fragmented solutions lacking truly broad and effective international coordination are insufficient for dealing with large-scale emergencies.”

COVID-19 spurred multiple initiatives aimed at strengthening global pandemic preparedness worldwide, with most countries and regions implementing mechanisms to prevent, prepare for, respond to, and recover from future pandemics.

Mechanisms have been established at the **national, regional, and international** levels. **Singapore**, for example, amended specific legislation (the Infectious Diseases Act) to improve its pandemic preparedness and, among other actions, created a new communicable diseases agency, a Healthcare Reserve Force, and a Programme for Research in Epidemic Preparedness and Response.²² In the United States, Johns Hopkins University created the Disease X Medical Countermeasure Program, which focuses on various viral families with pandemic potential.²³ Other countries have implemented similar strategies according to their financial capacity and the political will of their leaders.

Examples of **regional initiatives** include the COVID-19 Response Fund established by the African Union. One of the aims of this fund is to boost the capacity of the Africa Centres for Disease Control to respond to public health emergencies

across the continent.²⁴ Another regional example is the European Commission's Health Emergency Preparedness and Response Authority (HERA), whose mission is to “prevent, detect, and rapidly respond to health emergencies”.²⁵

While regional and national initiatives are important and play a crucial role in pandemic preparedness and response, the COVID-19 crisis made it clear that fragmented solutions lacking truly **broad and effective international coordination** are insufficient for dealing with large-scale emergencies. As we have repeatedly heard in the past 4 years, pandemics do not recognize borders. It will be of little use to Singapore, for example, to be one of the best-prepared countries for a pandemic if a respiratory virus is rampant in neighbouring Malaysia or in a country like the United States where millions of residents travel abroad each year. In addition, these mechanisms, especially at a national level, are highly susceptible to political changes that could alter their composition, scope, or funding. Truly global and, crucially, binding solutions must now be our focus. There are both successful and unsuccessful examples of such solutions.

²¹ Adelaida Sarukhan (2024), What will the next disease X be?

<https://www.isglobal.org/en/healthisglobal/-/custom-blog-portlet/-cual-sera-la-proxima-enfermedad-x>

²² MOH. Being Prepared for a Pandemic. <https://www.moh.gov.sg/diseases-updates/being-prepared-for-a-pandemic>

²³ Johns Hopkins Center for Health Security. Disease X Medical Countermeasure Program. <https://centerforhealthsecurity.org/our-work/research-projects/disease-x-medical-countermeasure-program>

²⁴ African Union. AU COVID-19 Response Fund. <https://au.int/en/aucovid19responsefund>

²⁵ European Commission. Directorate-General for Health Emergency Preparedness and Response Authority. https://commission.europa.eu/about-european-commission/departments-and-executive-agencies-old/health-emergency-preparedness-and-response-authority_en



The **best example is the Pandemic Fund**, hosted by the World Bank and created to establish a stable and global financing mechanism for pandemic preparedness efforts. It grants funds to individual countries or groups of countries to improve their pandemic preparedness and response capacities. Although the deliverables are essentially national and regional mechanisms, what is interesting about the Pandemic Fund is its financing mechanism, as it represents a global response to the material challenges of pandemic preparedness. The results so far have been very promising, with countries raising an additional six dollars for every dollar invested by the fund, stimulating public investment in preparedness and response.



At the other extreme is the Pandemic Treaty, which was downgraded to a Pandemic Agreement after it became clear that it would not become the binding mechanism initially envisioned. In 2021, 25 world leaders—together with the President of the European Council, Charles Michel, and the WHO Director-General, Tedros Adhanom Ghebreyesus—called for the creation of an International Pandemic Treaty to establish a true governance architecture for pandemic preparedness. More than 3 years later, negotiations are ongoing and the deadline for delivering a result has been extended by another year. The outcome is not expected to be binding and will probably be a mere statement of intent, with no mechanisms to ensure compliance. Significant progress, however, has been made with amendments to the International Health Regulations.

If the H5N1 avian influenza virus proves capable of causing a new pandemic, what response can we expect?

While some countries will be better prepared to deal with a new pandemic caused by a respiratory virus, significant challenges will persist due to institutional, legal, and financial gaps created by a divided international community that is more concerned with resources and borders than with an effective response. Any investments in epidemiological surveillance and medical supply stockpiling, whether re-



gional or national, will be very welcome and will save lives. Nonetheless, we should recall that SARS-CoV was detected quickly and its genetic sequence released in record time. China was the first country to close its borders and declare a nationwide lockdown. Vaccines were also developed in record time thanks to 15 years of prior coronavirus research and a \$12-billion investment. However, this may not necessarily be the case with the next pandemic,²⁶ and it was still not enough to prevent 7 million deaths in the last one. To change the course of the next pandemic, we must be willing to change our behaviour ●

²⁶ Johns Hopkins Center for Health Security. Disease X Medical Countermeasure Program. <https://centerforhealthsecurity.org/our-work/research-projects/disease-x-medical-countermeasure-program>.

5. Recommendations for the Next Pandemic

“We are still in time to strengthen our preparedness and response capacities for the next pandemic.”

We are still in time to strengthen our preparedness and response capabilities for the next pandemic. Funding, political will, and social interest can still be harnessed to advance initiatives that will bolster global governance and stable funding for pandemic preparedness. Below are some recommendations for helping to achieve this:

- The **Pandemic Agreement** must be urgently approved.²⁷ States must be willing to cede power and independence to ensure that the most crucial resolutions, such as the equitable distribution of vaccines, are binding. Without accountability mechanisms, countries will be reluctant to share resources during a pandemic. The agreement should include mechanisms for free access to information on pathogens and technology transfer, and it should also include civil society, whose skills and capacities were underutilized during the COVID-19 pandemic.
- Pandemic preparedness and response resources must be **distributed equitably** among countries, not just for ethical reasons but also because a lack of preparedness in individual countries places all countries at risk.²⁸
- The Global North must support the building of capacities for developing and producing medical countermeasures (such as vaccines) in the **Global South** to reduce dependence on donations. **Effective epidemiological surveillance**

capacities must be established in all countries and incentives provided to encourage the reporting of new pathogens or variants of existing ones.

- The Pandemic Agreement, or any another binding treaty, must ensure sufficient funds to guarantee the activities of the **WHO** beyond emergency response mechanisms. As recently highlighted by the Independent Panel for Pandemic Preparedness and Response, the WHO must have greater authority and independence to act as a global health coordinating body with some degree of control over countries and appropriate accountability mechanisms.
- The **amendments to the International Health Regulations** approved at the 77th World Health Assembly must be implemented within the approved timeframe.

The Independent Panel for Pandemic Preparedness and Response established a 12-month timeline, starting in July 2024, for the implementation of measures to prepare us for the next pandemic. They are not the only experts warning that time is running out if we are to prevent a repetition of the losses sustained during COVID-19. The next pandemic is going to happen and we alone are responsible for how hard it will hit us ●

²⁷ Agúndez L., Fanjul G. y Plasència A. (March 2024) Why is it urgent to reach an agreement on pandemics? A proposal for a European Position. Barcelona Institute for Global Health (ISGlobal). Series: All-Hazards Preparedness and Response #58. <https://www.isglobal.org/en/-/por-que-es-urgente-acuerdo-pandemias-propuesta-posicion-europea>

²⁸ Torreele E, Kazatchkine M, Liu J, Dybul M, Cárdenas M, Singh S, Quigley HL, McNab C, Sirleaf EJ, Mazzucato M, Clark H. Stopping epidemics when and where they occur. *Lancet*. 2023 Feb 4;401(10374):324-328. doi: 10.1016/S0140-6736(23)00015-6. Epub 2023 Jan 12. PMID: 36642089; PMCID: PMC9836401.

²⁹ Executive Summary — No Time to Gamble: Leaders Must Unite to Prevent Pandemics (June 2024)

A report by The Right Honourable Helen Clark and Her Excellency Ellen Johnson Sirleaf. https://live-the-independent-panel.pantheonsite.io/wp-content/uploads/2024/06/No-Time-To-Gamble_Exec-Summary.pdf

TO LEARN MORE

- Johns Hopkins Center for Health Security. Disease X Medical Countermeasure Program. <https://centerforhealthsecurity.org/our-work/research-projects/disease-x-medical-countermeasure-program>
- Executive Summary — No Time to Gamble: Leaders Must Unite to Prevent Pandemics (June 2024)

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