

Preparedness for Pandemics with Vaccines and Other Means

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Abstract

Pandemics of new and reemerging infectious diseases are inevitable and predictable. The world must learn from its past mistakes and prepare in advance for the next pandemic. To prepare for the next pandemic, we must determine which factors exacerbated the pandemic in 2019 and learn from experience. COVID-19 is an RNA virus, meaning it can easily evolve and produce new variants. Scientists and researchers discovered that people are capable of disseminating the virus throughout the world despite exhibiting no symptoms of having the virus. The general public was aware of the symptoms that those with the disease experienced, and medical professionals were developing and locating effective treatments. To save lives, emphasizing vaccinations to the general population is vital. Pandemics, though predictable themselves, present governments, hospitals, and other medical facilities in all nations with an unpredictable period of intense mitigation attempts. The next battle against a global pandemic will only be won by global cooperation using science-based policies and approaches.

Keywords: pandemic, global health, vaccinations, research database, global policy, immunization, public health, COVID-19, flu, virus, quarantine

Introduction

“The microbe that felled one child in a distant continent yesterday can reach yours today and seed a global pandemic tomorrow.”

-Joshua Lederberg, Nobel Laureate (1925–2008)

A pandemic is a disease with a highly contagious outbreak that spreads across several nations and has a significant human impact. The health of people around the world is still threatened by the emergence and reemergence of infectious diseases like SARS-CoV-1, 2009 H1N1, Middle East Respiratory Syndrome coronavirus (MERS-CoV), Ebola virus, Zika virus, and most recently, SARS-CoV-2, also known as COVID-19 (U.S. Department of Health and Human Services, n.d.). Fortunately, we have developed effective countermeasures thanks to the efforts of people. Pandemic preparedness efforts, and the ongoing threat posed by emerging pathogens, have been brought to light during the ongoing SARS-CoV-2 pandemic that lasted from late 2019 to 2023. This paper aims to explore a science-based strategy to prepare for the next pandemic

Pathogens That Recently Caused Pandemics

SARS-CoV-2 (severe acute respiratory syndrome coronavirus) is a 29.9-kilobyte, single-stranded, enveloped, positive-sense RNA beta-coronavirus (Zhou et al., 2020; Wu et al., 2020). In addition, SARS-CoV-2 is an enveloped virus, meaning its genetic material is encased in a layer of proteins and lipids (called an envelope). The envelope contains structures (called "spike proteins") that aid the virus in attaching to infected human cells. Changes to this section could affect the ease with which a virus spreads and the efficacy of vaccines against it (Li, 2016).

The genome of SARS-CoV-2 is almost 90% identical to the sequences of bat-SL-CoVZC45 and bat-SL-CoVZXC21 and almost 97% identical to another bat CoV, RaTG13 (Dimonaco et al., 2020). In this instance, the general public may therefore conclude that bats were to blame for the COVID-19 pandemic. However, new research indicates that pangolins smuggled from Southeastern Asia to China,

along with other possible intermediate reptile hosts such as turtles and snakes, could be the direct source of the virus, rather than bats (Lam et al., 2020). In addition, the protein-coding genes of SARS-CoV-2 are almost 80% identical to those of SARS-CoV and have more than 50% identical to those of MERS-CoV. SARS-CoV and SARS-CoV-2 gain access to cells through the Angiotensin-Converting Enzyme 2 (ACE2) receptor (Guo et al., 2020; Paraskevis et al., 2020). Thus, we assume that the same treatments that halted the SARS-CoV and MERS-CoV pandemics will also be effective against SARS-CoV-2.

Viral Variants

As the COVID-19 pandemic has progressed, researchers have noted that the virus changes very quickly and that new variants may alter how we respond to the pandemic (Gray, 2021). At that point, scientists must keep track of any new SARS-CoV-2 variants. The best option is genomic surveillance, which collects genetic sequence data from representative populations in order to discover new variants and monitor alterations in circulating variants (CDC, n.d.-e, 2022).

Asymptomatic Individuals

At the very onset of the COVID-19 pandemic, all patients exhibited symptoms (CDC, n.d.-c, 2022). However, as a result of the development and evolution of viruses, some asymptomatic individuals have been identified as being capable of transmitting the disease. It has been addressed how to prevent those without symptoms from spreading the disease. People who are infected but have no symptoms can spread the disease in two ways: when they are presymptomatic (infectious before they develop symptoms) or when they never develop symptoms (never symptomatic or asymptomatic infections) (Johansson et al., 2021). This experimental decision analytic model evaluated various scenarios for the infectious period and the proportion of transmission from asymptomatic individuals and estimated that more than 50% of all transmission originated from asymptomatic individuals (Johansson et al., 2021). The results of the study suggest that identifying and isolating individuals with COVID-19 symptoms may not be sufficient

to stop the spread of SARS-CoV-2 (Johansson et al., 2021). The proportion of transmission from asymptomatic individuals and the infectious period varied based on the best-published estimates, and the decision analytic model assessed the relative contributions of transmission from presymptomatic, never symptomatic, and symptomatic individuals across various scenarios (Johansson et al. 2021). The study kept a 5-day median for the incubation period, 10 days for the infectious period, and a 3-day to 7-day range (-2 days to +2 days) for the peak infectiousness. To investigate different scenarios, SARS-CoV-2 was evaluated across a range from 0% to 70% (Johansson et al. 2021).

It is crucial to recognize this study's limitations. Despite the complexity of the phenomenon being modeled, the average infectiousness of SARS-CoV-2 infections over time is poorly represented by the model (Johansson et al. 2021). It is a simple model. However, the simplicity intentionally examines assumptions about the timing of peak infectiousness and transmission among asymptomatic individuals. The absence of quantitative precision in the results emphasizes the qualitative significance of these two factors. The conclusion that asymptomatic transmission plays a crucial role in the transmission dynamics of SARS-CoV-2 holds true under a broad range of hypotheses (Johansson. et al., 2021).

Symptoms and Treatments

In general, fever, dry cough, tachypnea, and shortness of breath are the initial symptoms for SARS-CoV-2 (COVID-19) (Hui et al., 2020). Also, in a separate study, confusion, chest pain, vomiting, and nausea were also listed as COVID-19 symptoms (Chen et al., 2020). Additional symptoms include a sore throat, sneezing, a stuffy nose, coughing up mucus, a lack of smell and an upset stomach, a rash or discoloration of the fingers or toes, and viral conjunctivitis. On their X-rays, most COVID-19 patients had "ground-glass lung opacity" (Sahin et al., 2020). In addition to harming the heart and digestive system, SARS-CoV-2 can cause rapid kidney failure (Chen et al., 2020; Leung et al., 2003). Moreover, when the liver symptoms of 148 COVID-19 patients were evaluated, it was discovered that more than one-third of hospitalized COVID-19 patients had abnormal liver function and stayed longer in the hospital (Fan et al.,

2020).

Scientists and physicians have worked tirelessly to develop the following drugs, treatments, and therapies for COVID-19: NSAIDs (nonsteroidal anti-inflammatory drugs), dexamethasone (Zhou et al., 2020), and other corticosteroids (prednisone, methylprednisolone) (Wang et al., 2020). They are readily available and inexpensive: Tocilizumab (mostly in combination with azithromycin. A) for the treatment of hospitalized adults; Remdesivir (anti-(RNA)viral drug), which COVID-19 sufferers. However, chloroquine and hydroxychloroquine have been concluded by drug researchers that the drug does not benefit patients.

The Necessity of Vaccines

Vaccines are crucial throughout the pandemic. From September 13, 2020, to September 15, 2021, 602 community contacts were enrolled in the Assessment of Transmission and Contagiousness of COVID-19 in the Contacts cohort study using the UK contact-tracing system (Singanayagam, et al., 2022). These contacts provided 8,145 upper respiratory tract samples over a period of up to 20 days and were linked to 471 COVID-19 index cases in the United Kingdom (Singanayagam, et al., 2022). In the study, delta (n = 29), alpha (n = 39), and pre-alpha (n = 49) infections were compared to delta (n = 16), alpha (n = 39), and pre-alpha (n = 49) infections in unvaccinated individuals. The primary findings analyzed the secondary attack rate (SAR) among household contacts, categorized by vaccination status of contacts and vaccination status of index cases. Vaccination accelerated viral clearance and decreased the risk of delta variant infection (Singanayagam, et al., 2022). The variants are detrimental to people's health and challenging for scientists to track (Singanayagam, et al., 2022). Therefore, it is valuable to reduce the potential danger of spreading newly evolved variants to people.

Dilemmas and Solutions

There were severe shortages of essential drugs and personal protective equipment (PPE) during the pandemic that affected the United States and the rest of the world. Due to the pandemic, some of the

world's finest healthcare systems, such as Italy's Servizio Sanitario Nazionale, and some of the largest, such as Brazil's Sistema Nacional de Saúde, were discovered to be severely overworked and on the verge of collapse. Even now, essential routine healthcare services in these nations are still in jeopardy without recovery (Horowitz, 2020). Staff, supplies, space, and systems are required for quality healthcare (Filip et al., 2022). In the early stages of community transmission, for instance, the United Kingdom government attempted to rapidly expand capacity by constructing seven emergency hospitals (Filip et al., 2022). Though the government invested hundreds of millions of dollars in underutilized hospitals, only a few of them were being utilized proficiently at that time due to the need for more trained individuals (Filip et al., 2022).

During this time, several East Asian nations constructed their infrastructures with the help of the general public, allowing them to avoid lockdowns significantly (OECD, n.d.). Thus, even the most remote regions were covered. Vietnam utilized local governance structures to facilitate the coordination of community-based quarantine and self-isolation, and Japan trained public health nurses expeditiously so they could perform a thorough job of tracing past and future contacts (Nam, 2021). Within the first few weeks of the outbreak, each variable facilitated the identification of the primary transmission clusters (Safer et al., 2021).

Global Collaboration

The COVID-19 pandemic has taught us the significance of large groups of scientists analyzing the same data and agreeing on the best course of action for public health. The World Health Organization COVID-19 Research Database is updated daily (Monday through Friday) through manual searches, searches of bibliographic databases, and the addition of other scientific articles cited by experts (WHO, n.d.-b). This database is a repository of the most recent writing on the subject in multiple languages. Frequently, new research is added, even if it is incomplete. On the other hand, international cooperation and deteriorating relations between the world's most powerful nations would promote global development and the equitable distribution of COVID-19 diagnostics and treatments.

In addition, the International Health Regulations (IHR), a legally binding international agreement signed by 196 nations and updated in 2005, would be of great assistance during the pandemic. The IHR maintains core capacities for preventing, detecting, and responding to dangerous disease outbreaks, as well as policies for locating and sharing critical epidemic information. It is evident to the public that the international alert system is insufficient when a respiratory pathogen spreads rapidly. The obligatory International Health Regulations (IHR) (2005) are a conservative instrument that slows action rather than accelerating it. As the SARS-CoV-2 virus spreads globally, IHR procedures are taking longer, according to some reports (WHO, n.d.-c2022).

Conclusion

When COVID-19 arrived, many people felt overwhelmed and were uncertain about what they should do; therefore, it is necessary for us to review, analyze, and summarize the information. In this scenario, instead of being at a loss for what action to take, people can prepare for the next pandemic by designing a science-based strategy.

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References

- Centers for Disease Control and Prevention. (n.d.-a). Human coronavirus types. Centers for Disease Control and Prevention. <https://www.cdc.gov/coronavirus/types.html>
- Centers for Disease Control and Prevention. (n.d.-b). Scientific brief: SARS-COV-2 transmission. Centers for Disease Control and Prevention. <https://www.cdc.gov/coronavirus/2019-ncov/science/science-briefs/sars-cov-2-transmission.html>
- Centers for Disease Control and Prevention. (n.d.-c). Symptoms of COVID-19. Centers for Disease Control and Prevention. <https://www.cdc.gov/coronavirus/2019-ncov/symptoms-testing/symptoms.html>
- Centers for Disease Control and Prevention. (n.d.-d). Variants of the virus. Centers for Disease Control and Prevention. <https://www.cdc.gov/coronavirus/2019-ncov/variants/index.html>
- Centers for Disease Control and Prevention. (n.d.-e). What is genomic surveillance?. Centers for Disease Control and Prevention. <https://www.cdc.gov/coronavirus/2019-ncov/variants/genomic-surveillance.html>
- Community transmission and viral load kinetics of the SARS ... - the lancet. (n.d.-a). [https://www.thelancet.com/pdfs/journals/laninf/PIIS1473-3099\(21\)00648-4.pdf](https://www.thelancet.com/pdfs/journals/laninf/PIIS1473-3099(21)00648-4.pdf)
- Council on Foreign Relations. (n.d.). Findings | pandemic preparedness: Lessons from covid-19. Council on Foreign Relations. <https://www.cfr.org/report/pandemic-preparedness-lessons-COVID-19/findings/>
- Michael A. Johansson, P. (2021, January 7). SARS-COV-2 transmission from people without COVID-19 symptoms. JAMA Network Open. <https://jamanetwork.com/journals/jamanetworkopen/fullarticle/2774707>

Pandemics. Pandemics | Ready.gov. (n.d.). <https://www.ready.gov/pandemic>

Report of the Independent Panel for Pandemic Preparedness ... - the lancet. (n.d.-b).

<https://www.thelancet.com/journals/lancet/article/PIIS0140-6736%2821%2901095-3/fulltext>

U.S. Department of Health and Human Services. (n.d.). Pandemic preparedness. National Institute of

Allergy and Infectious Diseases. <https://www.niaid.nih.gov/research/pandemic-preparedness>

World Health Organization. (n.d.-a). Coronavirus disease (covid-19). World Health Organization.

<https://www.who.int/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/q-a-coronaviruses#:~:text=symptoms>

World Health Organization. (n.d.-b). Global Research on Coronavirus Disease (COVID-19). World

Health Organization. <https://www.who.int/emergencies/diseases/novel-coronavirus-2019/global-research-on-novel-coronavirus-2019-ncov>

World Health Organization. (n.d.-c). International Health Regulations. World Health Organization.

https://www.who.int/health-topics/international-health-regulations#tab=tab_1

Wu, F., Zhao, S., Yu, B., Chen, Y. M., Wang, W., Song, Z. G., ... & Zhang, Y. Z. (2020). A new coronavirus associated with human respiratory disease in China. *Nature*, 579(7798), 265-269.

Paraskevis, D., Kostaki, E. G., Magiorkinis, G., Panayiotakopoulos, G., Sourvinos, G., & Tsiodras, A. S. (2020). Full-genome evolutionary analysis of the novel corona virus (2019-nCoV) rejects the hypothesis of emergence as a result of a recent recombination event. *Infection, Genetics and Evolution*, 79, 104212.

Zhou, P., Yang, X. L., Wang, X. G., Hu, B., Zhang, L., Zhang, W., ... & Shi, Z. L. (2020). A pneumonia outbreak associated with a new coronavirus of probable bat origin. *nature*, 579(7798), 270-273.

- Lam, T. T. Y., Shum, M. H. H., Zhu, H. C., Tong, Y. G., Ni, X. B., Liao, Y. S., ... & Guan, Y. (2020). Identification of 2019-nCoV related coronaviruses in Malayan pangolins in southern China (preprint).
- Guo, Y. R., Cao, Q. D., Hong, Z. S., Tan, Y. Y., Chen, S. D., Jin, H. J., ... & Yan, Y. (2020). The origin, transmission and clinical therapies on coronavirus disease 2019 (COVID-19) outbreak—an update on the status. *Military medical research*, 7, 1-10.
- Cascella, M., Rajnik, M., Aleem, A., Dulebohn, S., & Di Napoli, R. (2023). Features, evaluation, and treatment of coronavirus (COVID-19). *StatPearls*.
- Sahin, A. R., Erdogan, A., Agaoglu, P. M., Dineri, Y., Cakirci, A. Y., Senel, M. E., ... & Tasdogan, A. M. (2020). 2019 novel coronavirus (COVID-19) outbreak: a review of the current literature. *EJMO*, 4(1), 1-7.
- Fan, Z., Chen, L., Li, J., Cheng, X., Yang, J., Tian, C., ... & Cheng, J. (2020). Clinical features of COVID-19-related liver functional abnormality. *Clinical Gastroenterology and Hepatology*, 18(7), 1561-1566.
- Leung, W. K., To, K. F., Chan, P. K., Chan, H. L., Wu, A. K., Lee, N., ... & Sung, J. J. (2003). Enteric involvement of severe acute respiratory syndrome-associated coronavirus infection. *Gastroenterology*, 125(4), 1011-1017.
- Hui, D. S., Azhar, E. I., Madani, T. A., Ntoumi, F., Kock, R., Dar, O., ... & Petersen, E. (2020). The continuing 2019-nCoV epidemic threat of novel coronaviruses to global health—The latest 2019 novel coronavirus outbreak in Wuhan, China. *International journal of infectious diseases*, 91, 264-266.
- Wang, D., Hu, B., Hu, C., Zhu, F., Liu, X., Zhang, J., ... & Peng, Z. (2020). Clinical characteristics of 138

- hospitalized patients with 2019 novel coronavirus–infected pneumonia in Wuhan, China. *jama*, 323(11), 1061-1069.
- Chen, N., Zhou, M., Dong, X., Qu, J., Gong, F., Han, Y., ... & Zhang, L. (2020). Epidemiological and clinical characteristics of 99 cases of 2019 novel coronavirus pneumonia in Wuhan, China: a descriptive study. *The lancet*, 395(10223), 507-513.
- Lederberg, J. (1988). Medical science, infectious disease, and the unity of humankind. *JAMA*, 260(5), 684-685.
- Zhou, P., Yang, X. L., Wang, X. G., Hu, B., Zhang, L., Zhang, W., ... & Shi, Z. L. (2020). Discovery of a novel coronavirus associated with the recent pneumonia outbreak in humans and its potential bat origin. *BioRxiv*, 2020-01.
- Safer, M., Letaief, H., Hechaichi, A., Harizi, C., Dhaouadi, S., Bouabid, L., Darouiche, S., Gharbi, D., Elmili, N., Ben Salah, H., Hammami, M., Talmoudi, K., Moussa, R., Charaa, N., Termiz, H., Ltaief, F., Tounekti, H., Makhlouf, M., Belguith Sriha, A., Ben Fredj, M., ... Bouafif Ben Alaya, N. (2021). Identification of transmission chains and clusters associated with COVID-19 in Tunisia. *BMC infectious diseases*, 21(1), 453. <https://doi.org/10.1186/s12879-021-06107-6>
- Nam, N. H., Do Le, B. T., & Huy, N. T. (2021). Community-Based Measures to Against the COVID-19: An Experience From Vietnam With Consecutive 3 Months of no New Infection in the Community During the First Wave of Pandemic. *Frontiers in public health*, 9, 583655. <https://doi.org/10.3389/fpubh.2021.583655>
- Johansson, M. A., Quandelacy, T. M., Kada, S., Prasad, P. V., Steele, M., Brooks, J. T., Slayton, R. B., Biggerstaff, M., & Butler, J. C. (2021). SARS-CoV-2 Transmission From People Without COVID-19 Symptoms. *JAMA network open*, 4(1), e2035057. <https://doi.org/10.1001/jamanetworkopen.2020.35057>

Singanayagam, A., Hakki, S., Dunning, J., Madon, K. J., Crone, M. A., Koycheva, A., ... & Lackenby, A. (2022). Community transmission and viral load kinetics of the SARS-CoV-2 delta (B. 1.617. 2) variant in vaccinated and unvaccinated individuals in the UK: a prospective, longitudinal, cohort study. *The lancet infectious diseases*, 22(2), 183-195.

Dimonaco, N. J., Salavati, M., & Shih, B. B. (2020, December 30). Computational analysis of SARS-COV-2 and SARS-like coronavirus diversity in human, Bat and Pangolin populations. *Viruses*. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7823979/>

Li F. (2016). Structure, Function, and Evolution of Coronavirus Spike Proteins. *Annual review of virology*, 3(1), 237–261. <https://doi.org/10.1146/annurev-virology-110615-042301>

Gray, R., & Gray, R. (2021, March 29). Covid-19 variants: Five things to know about how coronavirus is evolving. *Horizon Magazine*. <https://ec.europa.eu/research-and-innovation/en/horizon-magazine/covid-19-variants-five-things-know-about-how-coronavirus-evolving>

The territorial impact of covid-19: Managing the crisis across ... - OECD. (n.d.). <https://www.oecd.org/coronavirus/policy-responses/the-territorial-impact-of-COVID-19-managing-the-crisis-across-levels-of-government-d3e314e1/>

Filip, R., Gheorghita Puscaselu, R., Anchidin-Norocel, L., Dimian, M., & Savage, W. K. (2022, August 7). Global challenges to public health care systems during the COVID-19 pandemic: A review of pandemic measures and Problems. *Journal of personalized medicine*. <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9409667/>

