

Establishing an Equitable Global Access to COVID-19 Vaccines

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Abstract. As the world gradually recovers to normalcy from the huge impact brought by the most severe pandemic outbreak in the recent century, a vast number of societal problems have been revealed and aggravated in the past two years, including the economic crisis, global unemployment, intensified discrimination, and exacerbated social inequality. Among many of the issues mentioned, the unequal distribution of the COVID-19 vaccines, caused by multiple factors such as the gap between countries' research and development ability, limited production capacity, etc., could be considered the priority that needs to be solved under the current situations to prevent the further possible damage caused by the epidemic. Though the World Health Organization (WHO), along with several other large international agencies, has proposed COVID-19 Vaccines Global Access (COVAX) to promote the equitable allocation of vaccines, there are still some potential issues that need to be further discussed. Therefore, this paper, theoretically, analyzes the problems and their potential causes in the current vaccine allocation scheme, and attempts to find an optimal method of distributing vaccines on the basis of existing COVAX, as well as improving governmental policies, and enhancing global cooperation. To this end, we specifically propose three points: 1) Improve the executive force based on the COVAX plan. 2) Implement the demand-driving allocation scheme. 3) Countries should enhance inter-governmental communication and cooperation to make vaccines more accessible, achieving the goal of herd immunity.

Keywords: COVID-19; Vaccines; COVAX; WHO; Global Cooperation; Inequality.

1. Introduction

Coronavirus was first identified and named after its crown-like appearance by scientists in the year of 1965 as it was found to be the cause of a common cold. There were in total 7 types of coronaviruses, including the known SARS-CoV and MERS-CoV that caused severe epidemic outbreaks regionally back in 2003 and 2012 respectively, as well as the newly discovered Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) that led to the current global pandemic of COVID-19 (short for Coronavirus Disease 2019). Patients infected with COVID-19 may exhibit symptoms such as high fever, dry cough, fatigue, sore throat, muscle pain, etc., with a certain possibility of catching pneumonia and other severe acute respiratory syndromes, but researchers have as well discovered a large proportion of asymptomatic patients. As the most severe plague in the past century, COVID-19 has brought a tremendous impact on human society, taking away more than 6.67 million lives from their dearest and causing trillions of economic losses by far. (Data collected from <https://news.google.com/covid19/map?hl=en-US&mid=%2Fm%2F02j71&gl=US&ceid=US%3Aen> on Aug 23, 2022.) Almost two years have passed since the first case was reported back in 2019, although there still isn't a specialized treatment for the disease, many patients have been cured through approaches including allopathic treatments, Unani medicines, and homeopathic treatments, along with the boost of their own immune system. The mortality rate of COVID-19 has dropped to approximately 0.2551% in the recent quarter (Recent quarter represents data obtained from April 20 to July 20, 2022.) from the previous 6.1681% reported in the first quarter since March 2020 when COVID-19 was declared a worldwide pandemic by WHO. (First quarter after COVID-19 was declared a worldwide pandemic by WHO represents data obtained from March 11 to June 11, 2020.) (Mortality rate obtained after manipulating the data collected from <https://covid19.who.int/data> on July 24, 2022.) Now, as people gradually move forward to the so-called post-pandemic era and attempt to recover to normalcy, plentiful social problems caused by the COVID-19 pandemic have occurred and become barriers to global recovery. And one of the most serious challenges people are facing is inequitable access to

COVID-19 vaccines. As long as there are patients infected with COVID-19, chances of virus mutations and re-emergence occur. Thereby, it is significant for people to develop herd immunity globally by getting vaccinated. Nevertheless, according to the data reported to the World Health Organization (WHO), wealthy countries are hoarding large supplies of vaccines, some even have several times more doses of vaccines than their entire population, while some low- and middle-income countries do not even have enough vaccines that meet the basic demand of healthcare workers fighting against the epidemic in the frontline, not to mention how hard it is to establish herd immunity in these less well-developed regions. As a result, finding a framework that allows equitable allocation of COVID-19 vaccines is of prime importance to returning to normalcy. As the COVID-19 Vaccines Global Access (COVAX) proposed by WHO, Global Alliance for Vaccines and Immunizations (Gavi), and UNICEF, the fundamental principle of such reallocation must be based on the thorough consideration of the aged population and children who are at greater risk of getting infected since their immune system is weaker, as well as the actual infected population in each country. Countries with higher severity of epidemic outbreaks will receive distributed vaccines sooner. Hence, this paper will theoretically analyze the current COVID-19 vaccine distribution scheme and attempt to find a useful method of establishing equitable access to vaccines based on the current COVAX plan.

2. Literature Review

COVID-19, short for Coronavirus Disease 2019, is a disease caused by Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2) that may lead to death by respiratory failure. Patients infected with COVID-19 may experience multiple types of syndromes, but there's also the chance that patients are asymptomatic. Though there is no precise treatment for curing this disease, many patients have been healed by allopathic treatments and homeopathic treatments [Ali, I., & Alharbi, O. M., 2020]. Currently, one of the best options to prevent further impact brought by the COVID-19 epidemic is to establish worldwide herd immunity by getting vaccinated.

However, the unequal distributions of COVID-19 vaccines have been a huge challenge in developing worldwide herd immunity [Burki, T., 2021], especially in low- and middle-income countries such as Bangladesh and some African countries [Loembé, M. M., & Nkengasong, J. N., 2021; Mahmud-Al-Rafat, A., Hewins, B., Mannan, A., Kelvin, D. J., & Billah, M. M., 2022], due to a series of factors, including 1) Low socioeconomic status and low levels of income and education. 2) Challenging geological landscape for distribution. 3) Poor access to immunization facilities for marginalized groups (e.g., slums and migratory populations). 4) Strict requirements for vaccine transportation and storage. 5) Raised levels of vaccine hesitancy and fear in less well-developed countries. 5) Violent conflicts have also been a barrier to the equal distribution of vaccines. 6) Overburdened healthcare systems and bad vaccine distribution infrastructure. [Acharya, K. P., Ghimire, T. R., & Subramanya, S. H., 2021; Wells, C. R., & Galvani, A. P., 2022]. Furthermore, rich countries are making direct deals with biopharmaceutical companies, wearing out the available supply of vaccines for other countries and undermining COVID-19 Vaccines Global Access [Asundi, A., O'Leary, C., & Bhadelia, N., 2021]. Acknowledged the issue, the World Health Organization (WHO), along with Global Alliance for Vaccines Immunizations (Gavi), Coalition for Epidemic Preparedness Innovations, and UNICEF, started the COVID-19 Vaccines Global Access (COVAX) program, aimed to support vaccine R&D and provide financial aid to purchase more supplies of vaccines for poor countries [Binagwaho, A., Mathewos, K., & Davis, S., 2022; Callaway, E., 2020].

Furthermore, there are several points that are significant for governments to build an appropriate fundamental COVID-19 vaccine allocation scheme: 1) Respected and adaptable governance is needed in order to earn the trust and confidence of the international community and promote equitable allocation. 2) Adequate and manageable financing is needed to fund the development and production of new vaccines and therapeutics. 3) Equitable global distribution of COVID-19 therapeutics and vaccines should be built based on concrete evidence of health-driven allocation and open collaboration between countries. Countries should not pursue a competition to develop and distribute

vaccines but should work with each other and reverse the impact brought by the COVID-19 epidemic to the largest extent [Bollyky, T. J., Gostin, L. O., & Hamburg, M. A., 2020].

Except for the vaccine nationalism that undermines the effectiveness of the existing COVAX, there are also other potential threats to this allocation scheme as the standard of accepted exceptions of justifiable departures from the principle of equal distribution is not well specified. Therefore, scientists have proposed an extra model known as the Fair Priority Model (FPM) that may appropriately supplement the COVAX's PAS system. Unlike the PAS treats equitable access to vaccines in terms of countries, the FPM treats fairness and justice in units of individuals, allowing vaccines to be allocated based on the potential risks and individual needs which is a more comprehensive and thorough plan [Emanuel, E. J., Persad, G., Kern, A., Buchanan, A., Fabre, C., Halliday, D., ... & Richardson, H. S., 2020; Emanuel, E. J., Luna, F., Schaefer, G. O., Tan, K. C., & Wolff, J., 2021].

3. Data and Analysis

3.1 Data

This paper will analyze the current global inequitable allocation of COVID-19 vaccines from multiple aspects, including the connections between the average access to vaccines (measured by the total doses available per 1,000 people), the severity of the epidemic outbreak (measured by infected cases per 1,000 people), and the degree of economic development (measured by nominal GDP per capita reported in 2019) in each country according to the comprehensive data obtained.

3.2 Analysis of Current Global Vaccine Allocation

3.2.1 The Relationship between the Degree of Economic Development and the Severity of the Epidemic Outbreak

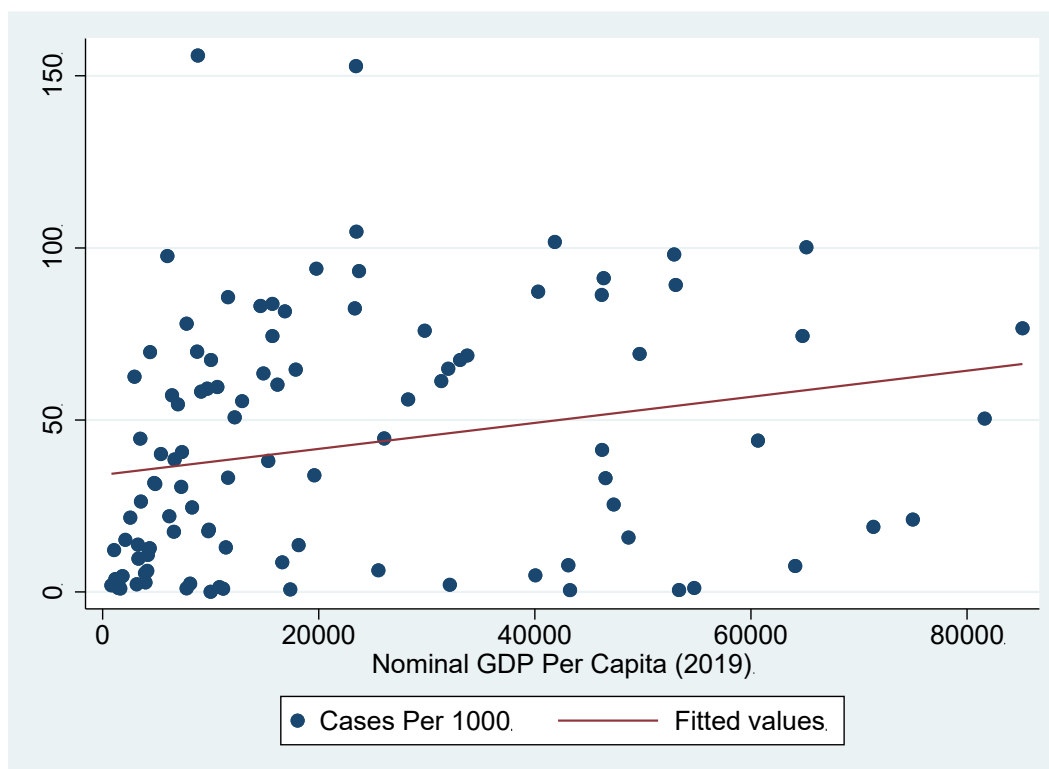


Figure 1. The relationship between nominal GDP per capita (2019) and COVID-19 cases per 1,000 people in each country

If we define countries with “severe COVID-19 outbreaks” as countries that report more than 69.2 confirmed COVID-19 cases in every 1,000 people (75th percentile in the cases per 1,000 people

dataset), then it may be surprising to find out that there are relatively more countries with GDP per capita above average (mean nominal GDP per capita: US\$21,562.21) with severe COVID-19 outbreaks than those countries with lower GDP per capita. To be more specific, there are 19 countries with above-average GDP per capita that are categorized as “countries with severe pandemic outbreaks” while only 13 countries with GDP per capita lower than average are. Furthermore, if we make a parallel comparison within countries with lower degrees of economic development (i.e., countries with GDP per capita below US\$21,562.21), we may find out that there are actually more lower-income countries with mild pandemic outbreaks -- 19 countries reported less than 9.69 COVID-19 cases in every 1,000 people (25th percentiles in the dataset) -- than those with severe pandemic outbreaks (only 13 lower-income countries reported more than 69.2 cases in every 1,000 people). Nevertheless, as we compose the two-way graph shown below in Figure 1, we found the correlation coefficient of these variables is only 0.2215, demonstrating that there’s a weak association between a country’s degree of economic development and the severity of the COVID-19 pandemic outbreak.

3.2.2 The Relationship between the Severity of the Epidemic Outbreak and Average Access to Vaccines

By comparing the data of total infected cases per 1,000 people and available COVID-19 vaccine doses per 1,000 people in each country, it may seem that there are sufficient supplies of vaccines with a mean of 182.3 doses per country while the mean of confirmed COVID-19 cases per country is only 42.9 cases in every 1,000 people. However, as we rule out all the outliers in the dataset (Doses per 1,000 \in [0, 730.4) and Cases per 1,000 \in [0, 164.9)) and compose a two-way graph as figure 2 shows below, we found no strong association with a correlation coefficient of 0.4388. This result, on the other hand, indicates that countries with more serious COVID-19 outbreaks that need a larger capacity of vaccines to improve their situations may not have access to it. As we have mentioned above, we define countries with “severe COVID-19 outbreaks” as countries reporting more than 69.2 confirmed cases in every 1,000 people (75th percentile in the cases per 1,000 people dataset) and define possessing “sufficient supplies of vaccines” as having more than 320 doses per a population of 1,000 or possessing “inadequate supplies of vaccines” as having less than 57.7 doses per a population of 1,000. According to the statistics, though the majority of severely affected countries are hoarding “sufficient supplies of vaccines” (14 countries), there are still countries with inadequate vaccine supplies such as South Africa, demonstrating that the current vaccine allocation is not equitable.

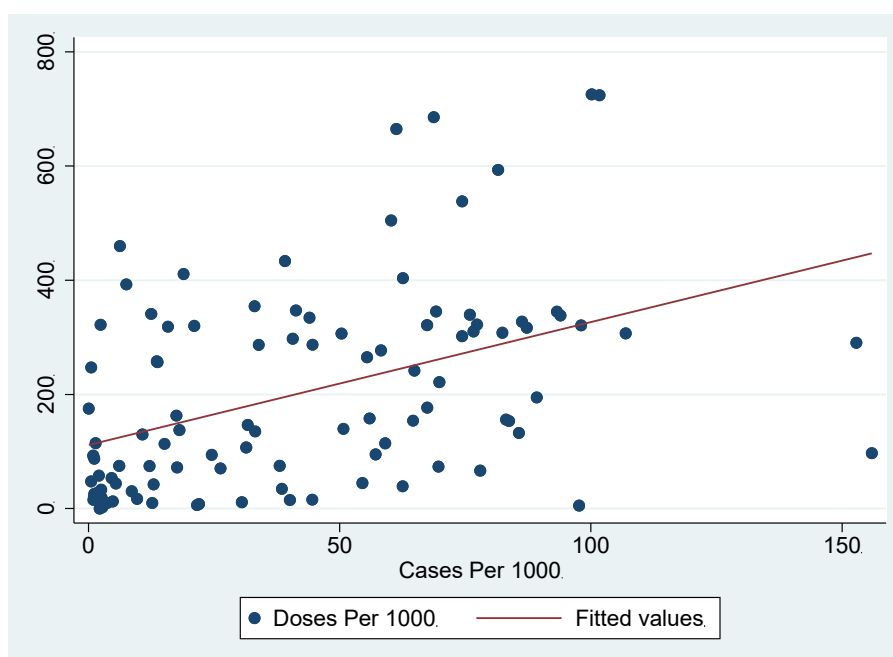


Figure 2. The relationship between reported COVID-19 cases per 1,000 people and COVID-19 vaccine doses available per 1,000 people in each country

3.2.3 The Relationship between the Degree of Economic Development and Average Access to Vaccines

As we exclude all the outliers and compose the two-way graph shown below in figure 3, it is not hard to find out that there's a comparatively clear association between a country's degree of economic development and its average access to COVID-19 vaccines with a correlation coefficient of 0.5889, indicating that countries with higher GDP per capita may possess larger supplies of vaccines. Several potential factors may have contributed to this inequitable access to COVID-19 vaccines: To begin with, this data conforms to the fact that richer countries have more advanced technologies as well as vaccine R&D capabilities, they can develop, transport, and allocate vaccines to meet their domestic needs. In contrast, lower-income countries may not have enough funds to develop their own vaccines but can only make purchases from biopharmaceutical companies from other countries. Moreover, because of the strict ambient temperature requirements (According to the Australian Government Department of Health and Aged Care, take Pfizer COVID-19 vaccine as an example, vaccines have a shelf life of 12 months at -90°C to -60°C . Vials can be stored at domestic freezer temperatures (-25°C to -15°C) for up to 2 weeks. Vials can be returned to -90°C to -60°C within the original shelf life.), the transportation and storage of vaccines are also considerable challenges in distributing vaccines in these countries due to their less well-developed healthcare facilities. Thirdly, people in less well-developed regions have greater vaccine hesitancy due to lower socioeconomic status and lower levels of education. And since lots of local healthcare systems have been extremely overwhelmed during the epidemic, the lack of executive force led to even harder situations for local vaccine distribution. Finally, numerous richer countries have already pre-ordered and hoarded large quantities of vaccines, some even possess multiple times more doses of vaccines than their entire population, leaving quite limited doses for the lower-income countries to even meet their basic needs.

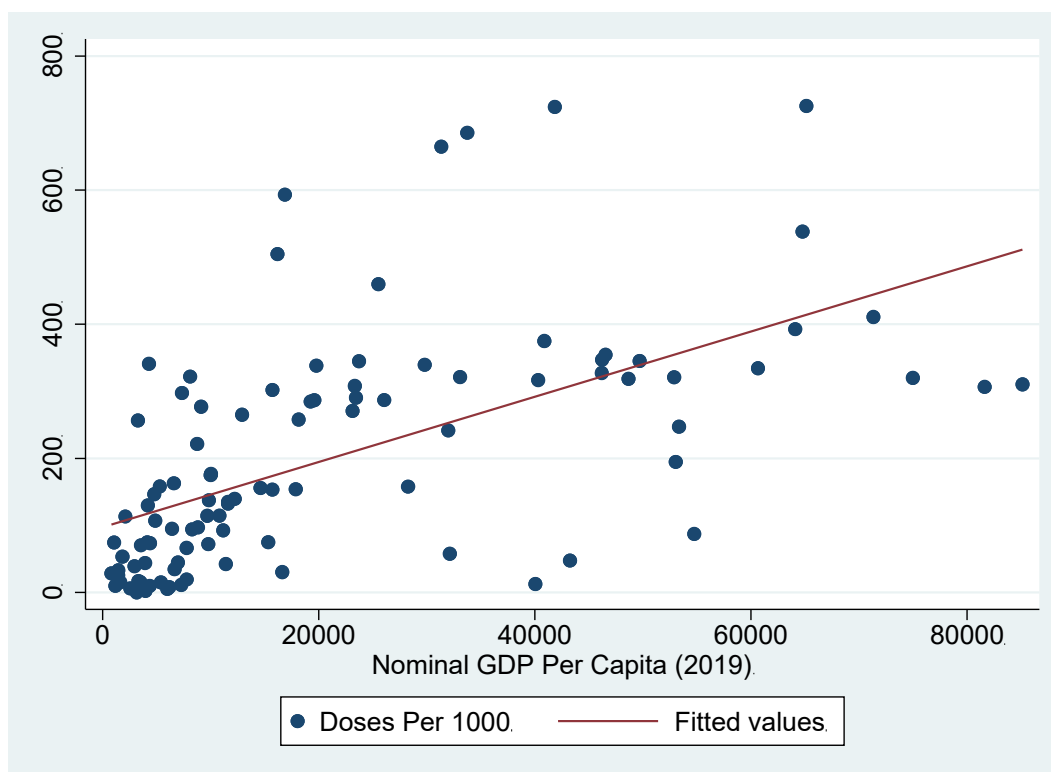


Figure 3. The relationship between nominal GDP per capita (2019) and COVID-19 vaccine doses available per 1,000 people in each country

3.3 Improvements of Vaccine Distribution Mechanism upon COVAX

The COVID-19 Vaccines Global Access (COVAX) plan proposed by World Health Organization (WHO), Global Alliance for Vaccines and Immunizations (Gavi), Coalition for Epidemic

Preparedness Innovations (CEPI), and UNICEF is aimed to act as an accelerator to the development, production, and distribution of COVID-19 vaccines. COVAX is designed based on the “fair allocation framework” mechanism put forward by WHO, it will distribute vaccines to different tiers of people according to different risk levels in each phase. However, the estimated proportion of the “tier 1 population” who has the highest priority of receiving vaccines, including healthcare workers in the frontline, aged people over 65 years old, and people having underlying conditions that put them at higher risks of death, is 20% of each country – a fixed ratio for all. No countries can increase their coverage before all countries are offered enough doses to vaccinate their “tier 1 population”. (Brief introduction to the COVAX allocation mechanism based on information obtained from https://www.gavi.org/vaccineswork/how-can-we-make-fair-and-equitable-access-reality?gclid=CjwKCAjwu5yYBhAjEiwAKXk_eOXJYJ3j9Tmdw-6e9NktPez2s-UGShQsUwbn83avMwCS6zY2UpwllhoC47cQAvD_BwE.) Admittedly, an equal share of vaccines for each country seems to be a fair allocation mechanism, especially when it can effectively reduce the impact brought by vaccine nationalism by preventing richer countries from hoarding tremendous supplies of vaccines (though vaccine hoarding still exists in many high-income countries since governments can make deals with the local biopharmaceutical companies in advance). However, setting a uniform baseline is an act that lacks solid consideration of differences in specific national conditions. According to the data from Population Reference Bureau, the elderly aged over 65 years old alone make up more than 20% of the entire population in countries such as Japan, Italy, Finland, Portugal, Greece, etc. (Detailed data are shown in Table 1 below, obtained from <https://www.prb.org/resources/countries-with-the-oldest-populations-in-the-world>.), not to mention that the aged people are only a single group of “tier 1 population” of COVAX who needs protection from the vaccine. Worse still, due to the rapid change of the global situation, there are currently many cases of emergencies such as wars and natural disasters that increase people’s exposure to the epidemic and bring about more people at greater risk of infection into the “tier 1 population”, intensifying the demand of vaccines. Although the Gavi acknowledged this issue and recommended that the initial doses should be distributed fairly to all countries until they are able to protect 3% of their population, especially those groups of people who are themselves at high risk of getting infected and possess high possibilities of infecting others, they did not impose any rigid requirements or detailed specification, which may lead to discrepancies in the implementations of this scheme and thereby reduce the effectiveness of vaccination. Additionally, a similar problem occurs when the WHO claimed that COVAX would accept justifiable departures from their standard line of equal proportional allocation scheme without elaborating specific instructions, there are too many uncontrollable factors that need to be taken into account and may consequently undermine the COVAX. As a result, scientists have proposed another allocation system – the “Fair Priority Model (FPM)” – to improve the COVAX system [Emanuel, E. J., Persad, G., Kern, A., Buchanan, A., Fabre, C., Halliday, D., ... & Richardson, H. S., 2020; Emanuel, E. J., Luna, F., Schaefer, G. O., Tan, K. C., & Wolff, J., 2021]. Unlike the original COVAX plan which is based on the demand of each country and promotes equality among nations, the FPM is focused on pursuing individual equity. The FPM will proceed in three separate phases with progressive periodical goals: (1) decrease direct and indirect deaths from COVID-19, (2) reduce the economic impact brought by the pandemic, and (3) diminish infections. In the first as well as the most crucial and challenging phase, vaccine doses will be allocated to people based on their probabilities of premature deaths evaluated by using the Standard Expected Years of Life Lost (SEYLL). Compared to the FPM, it is true that the original COVAX plan prioritizes and protects people with a greater chance of infection such as the healthcare workers on the frontline, but apparently, COVAX has not evaluated the actual damage that may be brought by the epidemic. Premature deaths, for instance, are one of the physical harms that need to be prevented by vaccination. However, even under the circumstances when almost all the healthcare systems are overwhelmed, medical workers, especially those in high-income countries, still have the most access to different types of protective equipment that keep them safe. Or, in an even worse scenario, the medical equipment and their own professional skills can at least prevent them from death. On the contrary, those aged people over 65 years old and other people

having underlying conditions without people looking after them, medical supplies, and professional skills may be harmed the most. Considering this way from the perspective of FPM, the latter ones may be more prioritized in getting vaccinated than the former ones. So, this case indicates that everyone would have the same equitable access to the vaccines under the evaluation of their situations, including those individuals who are in danger because of their governments' inappropriate responses. Despite all the differences between these two vaccine distribution schemes, there is never a perfect allocation method that can take every single factor into considerations. Thus, using these two allocation schemes at the same time may be the optimal solution to the current issue since the COVAX system is a solid default basis while the FPM works well as a compensatory mechanism that allows it to be more enhanced and comprehensive.

Table 1. Top 10 countries with the largest percentage of older adults

	Country	% 65+	Age 65-74	Age 75-84	Age 85 and over	65+ Pop. (Million)	Total Pop. (Million)
1	Japan	28.2	50	34	16	35.58	126.18
2	Italy	22.8	49	35	16	13.76	60.34
3	Finland	21.9	58	30	12	1.21	5.52
4	Portugal	21.8	51	35	14	2.24	10.27
5	Greece	21.8	48	35	17	2.33	10.70
6	Germany	21.4	47	39	14	17.78	83.10
7	Bulgaria	21.3	59	31	9	1.49	6.98
8	Croatia	20.4	54	34	12	0.83	4.05
9	France	20.3	54	29	17	13.16	64.83
10	Latvia	20.3	50	36	15	0.39	1.91

4. Conclusion

This paper has thoroughly summarized and analyzed information related to worldwide inequitable access to COVID-19 vaccines and used three statistical models to find the interconnections between three factors -- a country's economic development, the severity of the epidemic outbreak, and its available supplies of vaccines. Obviously, the third model shows that there's a relatively strong association between the doses of vaccines allocated to a country and its degree of economic development where countries with above-average GDP per capita have possessed more vaccines than those countries with below-average GDP per capita, which also conform to the information we summarized that rich countries are hoarding vaccines by making direct deals with vaccine manufacturing companies as they have more funds for purchasing and more advanced technology in transporting and storing vaccines, leaving less well-developed countries the limited amount of vaccines to utilize. It is of huge importance to change the current situation by strengthening global cooperation, following the basic COVAX allocation scheme, and enhancing it with compensations such as FPM to establish equitable global vaccine access, and ending the COVID-19 epidemic completely to avoid further impacts brought to human society.

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