Hacettepe Sağlık İdaresi Dergisi, 2022; 25(1): 17-28

RESEARCH ARTICLE

GLOBAL VACCINATION INEQUALITY AND THE FACTORS THAT AFFECT THIS IN THE CONTEXT OF COVID-19

Berke AKKAYA *

ABSTRACT

COVID-19, a disease caused by the new type of coronavirus that emerged in Wuhan, China at the end of 2019, was initially isolated in Wuhan, but later, other cases emerged in Japan, South Korea, and Thailand along with China. At the end of January 2020, Italy announced that the first case of COVID-19 was detected. Thus, attempts to isolate the virus failed and the virus began to spread around the world, causing a global epidemic. Within the framework of the global actions required to prevent and slow down the transmission of COVID-19, many scientists from different countries have achieved astonishing scientific success by developing several safe and effective vaccines in less than a year after this virus was isolated and sequenced. In early 2021, more than 30 million doses of vaccine have been administered, but global vaccination practice has exposed obvious disparities in access to this life-saving vaccine. To investigate the success of global vaccination programs and to reveal what factors affect these programs, the global vaccination dataset and the dataset provided by the United Nations were combined and analyzed. In addition, it was aimed to explore the effects of political, economic, and demographic factors on the vaccination program. When the dataset was analyzed in the context of vaccines, it was observed that 40 countries tend to use one type of vaccine while 27 countries are using two or more vaccines. Looking at the factors that affect the vaccination programs; it has been concluded that individuals more likely to be vaccinated are the citizens from countries that are more democratically transparent and have higher GDP per capita and total health expenditure (as a percentage of GDP). Besides, it has been observed that citizens from countries with an approved vaccine developer are also more likely to be vaccinated.

Keywords: *COVID-19, Health Policies, Vaccination, Vaccine Inequality*

ARTICLE INFO

* *Res. Assist., Istanbul University, berkeakkaya@istanbul.edu.tr*
https://orcid.org/0000-0002-7903-956X

Recevied: 26.02.2021
Accepted: 07.03.2022

Cite This Paper:

Akkaya, B. (2022). Global Vaccination Inequality and the Factors that Affect this in the Context of COVID-19. Hacettepe Journal of Health Policy, 25(1), 17-28

ARAŞTIRMA MAKALESİ

KÜRESEL AŞI EŞİTSİZLİĞİ VE COVID-19 BAĞLAMINDA BU EŞİTSİZLİĞİ ETKİLEYEN FAKTÖRLER

Berke AKKAYA [*]

ÖZ

2019 yılının sonunda Çin'in Wuhan kentinde ortaya çıkan yeni tip korona virüsünün sebep olduğu bir hastalık olan COVID-19 önceleri Wuhan kentinde izole edilmiş fakat sonrasında Çin'in beraberinde Japonya, Güney Kore ve Tayland'da başka vakalar ortaya çıkmıştır. 2020 Ocak ayının sonlarında ise İtalya ilk COVID-19 vakasının tespit edildiğini duyurmuştur. Böylelikle virüsü izole etme girişimleri başarılı olamayıp virüs tüm dünyaya yayılmaya başlayarak küresel bir salgına neden olmuştur. COVID-19'un bulaşmasını önlemek ve yavaşlatmak için gereken küresel eylemleri artırmak için, farklı ülkelerden birçok bilim insanı, bu virüsün izole edilip dizinlemesinden sonra bir yıldan kısa bir süre içinde birkaç güvenli ve etkili aşı geliştirerek şaşırtıcı bir bilimsel başarı elde etmişlerdir. 2021 yılının başlarında, 30 milyondan fazla aşı dozu uygulanmıştır ancak küresel aşı uygulaması, bu hayat kurtarıcı aşıya erişimde bariz eşitsizlikleri ortaya çıkarmıştır. Küresel çapta aşılama programlarının başarısını keşfetmek ve bu aşılama programlarını hangi faktörlerin etkilediğini ortaya çıkarmak amacıyla küresel aşılama veri seti ile Birleşmiş Milletler tarafından sunulan veri seti birleştirilerek analiz edilmiştir. Bununla birlikte politik, ekonomik ve demografik faktörlerin aşılama programı üzerindeki etkilerinin keşfedilmesi amaçlanmıştır. Tüm bu uygulamalar sonucunda kullanılan aşılar bağlamında veri seti incelendiğinde 40 ülkenin tek aşı tipini kullanma eğiliminde olduğu ve 27 ülkenin ise iki veya daha fazla aşı kullandığı görülmüştür. Aynı zamanda, Amerika Birleşik Devletleri'nin, aşılama aşaması fark etmeksizin daha fazla kişinin aşı olduğu ülke iken İsrail ise tüm nüfustan yüzde olarak daha fazla kişinin aşı olduğu ülke olmuştur. Aşılama programlarını etkileyen faktörlere bakıldığında; aşı olma olasılığı daha yüksek olan bireylerin, demokratik olarak daha şeffaf olan ve aynı zamanda kişi başına GSYİH ve toplam sağlık harcaması (GSYİH yüzdesi) daha yüksek olan ülkelerin vatandaşları olduğu sonucuna varılmıştır. Aynı zamanda, onaylı aşı geliştiricisi bulunan ülkelerin vatandaşlarının da aşı olma ihtimalinin daha yüksek olduğu görülmüştür.

Anahtar Kelimeler: *Aşı Eşitsizliği, Aşılama, COVID-19, Sağlık Politikaları*

MAKALE HAKKINDA

[*] *Arş. Gör., İstanbul Üniversitesi, berkeakkaya@istanbul.edu.tr*

https://orcid.org/0000-0002-7903-956X

Gönderim Tarihi: 26.02.2021
Kabul Tarihi: 07.03.2022

Atıfta Bulunmak İçin:

Akkaya, B. (2022). Global Vaccination Inequality and the Factors that Affect this in the Context of COVID-19. Hacettepe Sağlık İdaresi Dergisi, 25(1), 17-28

I. INTRODUCTION

COVID-19, an infectious disease caused by a Sars-Cov-2 virus, was first detected in Wuhan, China, towards to end of 2019. COVID-19 spread over time to Europe, North America, Asia-Pacific countries, and the whole world. As a result, this epidemic was declared a pandemic in mid-March 2020 (WHO, 2020a). With its high transmission rate, the cases of the virus began to be reported in all countries globally in January (Velavan and Meyer, 2020). This new type of coronavirus, which can be spread by air or by contact with infected people and contaminated areas, remains contagious for up to two weeks. Individuals infected with this virus can spread the virus even if they do not show any symptoms (CDC, 2020). Looking at the most obvious symptoms of the disease, there are high fever, cough, difficulty breathing, and loss of smell. In advanced stages, this disease even causes death as mentioned earlier. (Grant et al., 2020). Since the first cases were seen in China, the epicenter of this epidemic was originally in China. However, on March 13, 2020, the epicenter of the coronavirus epidemic changed to Europe (Kenny, 2020). Towards the end of February 2021, the number of deaths caused by COVID-19 was approximately 2.5 million, while the number of cases was approximately 110 million.

During the COVID-19 pandemic, many countries around the world have taken various measures to reduce the spread of the epidemic and flatten the spread curve of the outbreak. The peaks of the epidemic could be weakened several times in this way in different countries. This saved time for vaccine development studies and finding a cure for the disease by reducing the burden on the health system. (Anderson et al., 2020). By individual measures such as hand hygiene with various chemicals, use of protective masks, individual quarantine; public measures such as closing educational institutions and canceling collective events, reducing work mobility and workload in all sectors; and environmental measures such as cleaning public areas, the spread of the virus has been tried to be kept under control. (Qualls et al., 2017). Nevertheless, one way to be successful in the fight against COVID-19 depends on taking drastic measures and applying these measures without compromise. Looking at some of the measures taken against the virus; after understanding the importance of the epidemic, the administration in China has taken very drastic measures, including quarantining Wuhan, which is the starting point of the pandemic. South Korea has initiated mass test screenings, regional quarantines, and surveillance of infected individuals. Singapore has provided various financial supports to its infected and suspected citizens to voluntarily enter individual quarantine and introduced penalties for those who fail to comply with these measures. Taiwan has accelerated the production of masks, banned drug stockpiling. (McCurry et al., 2020). In addition to all these, with the spread of the epidemic worldwide, other world countries have taken serious measures such as individual quarantine and compulsory mask use. Lockdowns were imposed in Europe, Middle Eastern countries, and the United States, while financial support was provided to those affected by the epidemic.

Efforts to develop the COVID-19 vaccine, aimed at providing acquired immunity against COVID-19, began after the virus was isolated and its genetic sequence was published (WHO, 2020b). Since the beginning of 2020, the pace of vaccine development, achieved through a unique partnership between the multinational pharmaceutical industry and governments, has led to the emergence of many different vaccine candidates in 2020. Pharmaceutical companies, governments, international organizations, and universities have acted to develop vaccine candidates, immunize against COVID-19 infection and prepare for global vaccination programs (Le et al., 2020). As of February 2021, there are more than 200 vaccine candidates in total (COVID-19 vaccine tracker, 2021a). 66 of the candidates are in the clinical trial process; There are 17 of them in the first phase trials, 23 of them between the first phase and second phase trials, 6 of them in the second phase trials, and 20 of them in the third phase trials. 19 of the vaccines in the third phase trial show up to 95% effectiveness in preventing COVID-19 infections (WHO, 2021a). By February 2021, ten of these vaccines in the third phase trial have been approved for public use by at least one government or authorized agency (COVID-19 vaccine tracker, 2021b). These approved vaccines can be grouped as follows: two RNA vaccines, one of them is known as the vaccine developed in partnership with German pharmaceutical companies, and the other one is the vaccine developed in partnership with American organizations and an American pharmaceutical company; Three traditional inactivated vaccines, two of them are the

vaccines developed by Chinese pharmaceutical companies and the other one developed by an Indian-based pharmaceutical company. Four viral vector vaccines, including a vaccine developed by the Russians, a vaccine developed in partnership with a British pharmaceutical company and the University of Oxford, a vaccine developed by a Chinese pharmaceutical company, and a vaccine developed in the Netherlands in partnership with an international pharmaceutical company and lastly, a peptide vaccine developed by the Russians (Funk et al., 2020). Although vaccines are developed in different ways, their function is generally similar, and this function is built on immunization. Immune cells can keep in mind whether the same pathogen is re-infecting the body. Since these pathogens are previously inactivated, they can destroy them before they can spread throughout the body (Vetter et al., 2017). However, after the approval of many different vaccines, countries around the world have started to prepare and implement phased vaccination programs that prioritize those who are at the highest risk of being affected by COVID-19 and who are directly exposed to the Sars-Cov-2 virus, such as healthcare workers, and who are also at high risk of transmission (Beaumont, 2020). According to reports from various health organizations, more than 200 million doses of the COVID-19 vaccine were administered worldwide at the end of February 2021 (Hannah et al., 2021).

The success of this vaccine development, which was achieved in such a short time by shortening the standard vaccine development timelines that normally take years and accelerating the clinical trial steps, created a sense of insecurity problem in various parts of the society. Besides, problems emerged on the access to vaccines due to geopolitical problems and the obstacles to producing billions of doses of vaccines that need to be administered in two doses to each individual. With all these problems, what was needed to prevent the growth of the COVID-19 and to end the pandemic was to achieve global immunity. The only way to achieve global immunity is to ensure equal access to vaccines individually and the equal distribution of vaccines globally (Thorne, 2020). Just after the current situation took place, the governments that have the resources to finance emergency production secured their vaccines. Some governments also have pledged to purchase the COVID-19 vaccine before the vaccines are yet produced. High-income countries signed contracts towards the end of 2020 to purchase 51% of the pre-order doses, although they only represent 14% of the global population. Some high-income countries have purchased more doses than needed to vaccinate their entire population. (So and Woo, 2020). In January 2021, WHO Director-General Ghebreyesus drew attention to the problem of the vaccine's distribution inequality. Ghebreyesus stated that 49 of the high-income countries in the world have about 40 million doses of vaccine, while one of the lowest-income countries only has 25 doses of vaccine (WHO, 2021b). Specifically, Canada, Australia, and Japan, which have a fairly low percentage of COVID - 19 cases worldwide, have ordered a total of one billion doses of vaccine. Concerns have increased that high-income countries will be able to receive their vaccines between 2020-21 and that in developing countries, vaccination will continue until 2023-24 (WHO, n.d.). While high-income countries pre-ordered from thirteen different vaccine manufacturers, low-middle-income countries' pre-orders were made primarily for the lowest cost vaccine (Mullard, 2020).

Considering all this information and explanations, it can be said that in the COVID-19 global vaccine practice, there are obvious inequalities in access to this life-saving vaccine. In this study, country-specific factors such as population density, GDP per capita, and health expenditures that may affect the emergence of vaccine inequality are analyzed. It was also questioned whether countries producing vaccines give themselves a priority in vaccine distribution. Inspired by the 2020 Corruption Perceptions Index (CPI) published by Transparency International, the corruption perception factor was also discussed in the study. Corruption, which is defined as the improper use of public power for private interests and as a factor associated with the response of countries to the crisis (Menocal and Taxell, 2015), caused even more democratic backsliding during the COVID-19 outbreak, according to the 2020 CPI report by Transparency International (Transparency International, 2021). However, in the published index, it is stated that countries with better performance in corruption perception, invest more in health services and can provide health insurance to their citizens. Transparency International's Chairman Rubio stated that she sees the COVID-19 pandemic as a corruption crisis, not just a health crisis, and the world has failed to manage it.

II. MATERIAL AND METHODS

The global vaccination dataset was combined with the dataset containing country information provided by the UN in this study, which was conducted to capture the success of these programs and to question the vaccine inequality. Correlation analysis was used together with statistical data analysis methods to reveal the political, economic, and demographic factors affecting vaccination. The datasets used in the study are as follows:

- Country Profile Dataset: It contains indicators of all countries in UN Data (United Nations, n.d.).
- Country Vaccination Dataset: It includes vaccination data of countries (Preda, 2021).
- CPI 2020 Dataset: It includes 2020 CPI scores, ranking Countries / Regions according to their perceived corruption levels (Transparency International, 2021).
- Country of Origin Dataset for Vaccines: It includes approved vaccines and their country of origin (The Council on Foreign Relations, 2021).

These datasets contain key statistical indicators of the countries. It covers some major sections like economic, social, environmental, and infrastructure indicators with general information. Looking in Country Profile Dataset; surface measurements of countries, population in thousands, population density, ratio of gender (per 100 f m), gross domestic product (million current US dollars), gross domestic product growth rate (annual%, constant 2005 prices), gross domestic per capita revenue (current US dollar) variables are included. Then, when the Country Vaccination Dataset is examined, it is seen that there are variables such as the number of vaccines ordered, the total number of people vaccinated, the number of daily vaccinations. The information provided in this dataset is between 13 December 2020 and 6 February 2021. As mentioned before CPI 2020 Dataset includes countries' corruption perception scores. Country-of-Origin dataset for vaccines includes the origin of the countries where the vaccines are produced. There are more than 200 countries in the Country Profile Dataset, while there are 91 countries in the Country Vaccination Dataset. At the same time, while Scotland, Wales, and Northern Ireland are considered separately in the Country Profile Dataset, where these countries are considered in the United Kingdom in the Country Vaccination Dataset. Thus, the number of instances in the merged dataset is 88 in total.

After analyzing descriptive statistics in geographic, demographic, and political contexts with this merged dataset, correlation analysis was applied to analyze the relationship between the variables in these contexts and the vaccination process. Correlation analysis is a statistical method that provides information about the relationship between variables, the direction, and the severity of this relationship. The correlation coefficient obtained as a result of this analysis is a coefficient showing the importance of the power of the relationship between variables. The correlation coefficient takes a value between -1 and 1. A correlation coefficient approaching 0 indicates the presence of a weak relationship between variables. There is a positive relationship if the variables are increasing or decreasing together, and a negative relationship if one of the variables is increasing and the other decreases (Miller and Miller, 2004). In the study, Python 2.7 was used in the editing and merging stages of the datasets, while SPSS 21 was used in the analysis stage. The data used in the study were obtained from open sources, therefore, ethics committee approval is not required.

III. RESULTS

While preparing the dataset, it was necessary to produce some variables. Assuming that a person typically receives 2 doses of vaccine to become fully vaccinated, the number of fully vaccinated persons for a given country can be expressed as half the total number of vaccines. The percentage of vaccination of the total population was found by dividing the number of fully vaccinated persons by the population. The male percentage of the total population was found as [(Ratio of Sex / Ratio of Sex + 100) / 100], then the percentage of women of the total population was found. Finally, it was discovered how much of the total number of fully vaccinated people were women or men. Looking at Table 1, it is seen that there is an average of 3.6 million vaccinations in the world. The average ratio of

total expenditures to health expenditures is 7.3%. The average estimated number of people vaccinated is 1.8 million, of which 931.608 of these are men and 909.515 are women.

Table 1. Descriptive Statistics of the Merged Dataset on Country Profile and Vaccinations

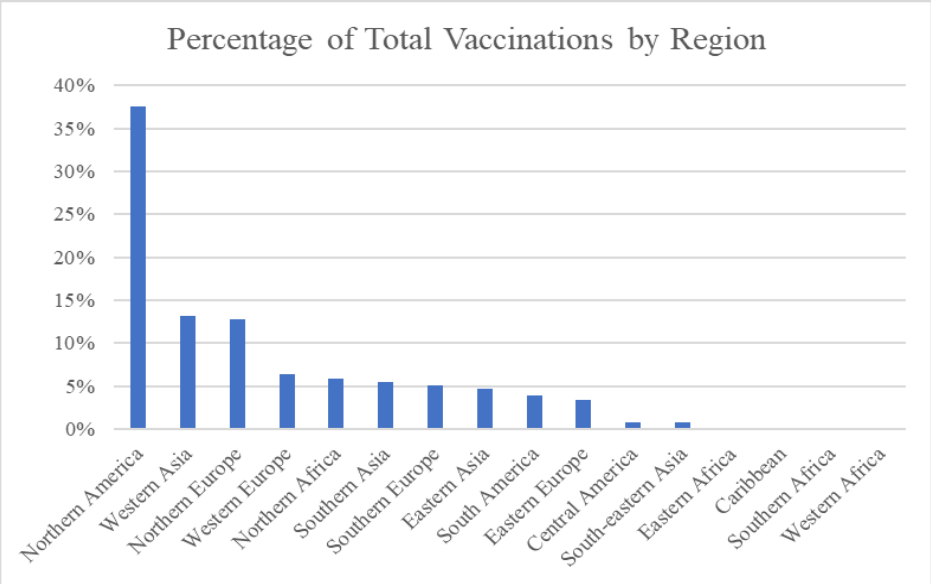
VARIABLES	Mean	Std. Dev.
Total Vaccination	3682247	14287138
Population in Thousands	63413	209667
Ratio of Sex (m per 100 f)	105.12	31.16
GDP per Capita (current US$)	27648.2	31429.6
Health: Total expenditure (% of GDP)	7.3	2.8
Estimated Fully Vaccinated People	1841123	7184507
Percent of Vaccination to Population (%)	71.9	180.1
Male Percentage of Population (%)	50. 6	4.6
Female Percentage of Population (%)	49.4	4.6
Vaccinated Males	931608	102268252
Vaccinated Females	909515	101442208

After looking at this combined dataset in general, the results of the study were examined under 3 different categories; geographic, demographic, and political in order to obtain more detailed results.

3.1. Geographic Analysis

The purpose of the geographic analysis is to see how the distribution of vaccination has changed in the world. Within the scope of geographical analysis, the dataset is filtered in the context of geographical regions. Percentage of Total Vaccinations by Region are presented in Chart 1.

Chart 1. Percentage of Total Vaccinations by Region



In the North America Region, where 38% of total vaccination is seen, there are approximately 1.3 million vaccinations in Canada, while 60 million vaccines are seen in the United States. While the United Arab Emirates is ahead with 4.79 million vaccines in Western Asia, where 13% of total vaccination is seen, the United Kingdom is ahead with 14.5 million in Northern Europe, where 13% of total vaccination is seen. In Africa where is the lowest total vaccination, approximately 15 thousand vaccines were administered in South Africa and 107 vaccines were administered in Saint Helena. Except for these inferences, the vaccination rates in other regions are close to each other.

3.2. Demographic Analysis

The demographic analysis aims to see the effect of GDP per Capita and Health Expenditures on the vaccination rate of the total population. Within the scope of demographic analysis, Spearman Correlation Analysis was used because instances were relatively low in the dataset (*n=88*) and all variables did not show normal distribution ($p < 0.05$).

The variable Total Vaccination was excluded from the analysis because the correlation between the Total Vaccination variable and the Estimated Fully Vaccinated People variable was very high, in other words, since one can express the other. Male Percent of Population and Female Percent of Population variables were not included in the analysis because they are derived from the Ratio of Sex variable. At the same time, Vaccinated Males and Vaccinated Females variables were excluded from the analysis because those variables had a strong correlation with the Estimated Fully Vaccinated People variable and had no effect on the subject to be investigated in the analysis.

Table 2. Correlation Matrix of Demographic Analysis

VARIABLES	Population in Thousands	GDP per Capita	Health Total Expenditure	Estimated Fully Vaccinated People	Percent of Vaccination to Population
Population in Thousands	1.00				
GDP per Capita	-0.35**	1.00			
Health Total Expenditure	-0.03**	0.46**	1.00		
Estimated Fully Vaccinated People	0.48**	0.24*	0.26*	1.00	
Percent of Vaccination to Population	-0.15**	0.53**	0.40**	0.71**	1.00

**Correlation is significant at the 0.01 level.*
***Correlation is significant at the 0.05 level.*

When the results of the Correlation Analysis performed with the remaining variables in Table 2 are examined; it is seen that there is a strong, 0.53-degree, positive relationship between the GDP per Capita variable and Percent of Vaccination to Population. It is concluded that citizens of countries with higher GDP are more likely to be vaccinated. Considering the effect of health expenditures on vaccination, it is seen that there is a moderate, 0.40-degree, positive relationship between the Health Total Expenditure variable and the Percent of Vaccination to Population variable. This situation can be interpreted as that citizen of countries that allocate more budgets to health expenditures are more likely to be vaccinated.

3.3. Political Analysis

Within the scope of the political analysis, the focus has been on corruption as a factor strongly associated with countries' response to the crisis, as stated earlier. Countries with lower corruption perception scores, which increased during the COVID-19 pandemic, respond less democratically to the crisis. Therewithal, while evaluating vaccine inequality in the context of political analysis, the factor that has an impact on access to the drug/vaccine is the patent and license phenomenon (WHO, 2018). In this study, patent and license information and data are not discussed, which is an important limitation of the study. Medicines, like other inventions, are legally protected from copying by patents, and vaccines are no exception. At the same time, widespread and free access to the vaccine underlies

the success of vaccinations. Widespread and free access to the drug/vaccine cannot be achieved due to various diplomatic reasons, as well as the fact that countries or vaccine/drug developers in the private sector have patents and licenses (Sparke & Anguelov, 2012). Problems such as the priority of the country where the patent or license is developed in accessing the drug/vaccine, and the financing of the high-cost vaccine development process by high-income countries also reveal vaccine inequality (Oehler & Vega, 2021). It is seen in the literature that this situation is called vaccine diplomacy (Blume, 2020). Considering the studies conducted in this context, most of the existing COVID-19 vaccines developed have gone to rich countries. As of May 7, 2021, high-income countries had received approximately 5 billion COVID-19 vaccines, while low-income countries had only received approximately 270 million doses of vaccines (Su et al., 2021). As can be seen from the geographical analysis made within the scope of our study, North American countries such as the United States and Canada are quite ahead in total vaccination. North American countries are followed by Western Asian countries such as Kuwait, United Arab Emirates, and Northern and Western European countries. Countries in these regions are known to be high-income countries.

In the political analysis made in this study, the latest version of the 2020 CPI Report includes the 2020 CPI scores which rank countries/regions according to their perceived levels of public sector corruption, was added to the dataset and the existence of its relationship with vaccination was questioned.

Table 2. Correlation Matrix of Political Analysis

VARIABLES	***CPI Score***
GDP per Capita	0.88**
Percent of Vaccination to Population	0.56**
Health Total Expenditure	0.56**
Population in Thousands	-0.32**
Estimated Fully Vaccinated People	0.27*

**Correlation is significant at the 0.01 level.*
***Correlation is significant at the 0.05 level.*

When the significant results obtained from the Correlation Analysis between CPI Scores and other variables in Table 3 are examined; it is observed that there was a strong positive relationship of 0.88 degrees between the GDP per Capita and the perception of corruption values of countries. When the effect of the perception of corruption on vaccination is examined, there is a strong positive relationship of 0.56 degrees between the perception of corruption and the Percent of Vaccination to Population. This situation can be interpreted as countries that promote transparency have responded positively to the COVID-19 crisis in terms of the number of administered vaccinations. At the same time, it can be seen that as the transparency of countries increases, health expenditures also increase, with the correlation coefficient being 0.56.

3.3. Additional Analysis

This section examines whether countries that have developed currently approved vaccines give priority to certain countries/regions in vaccine distribution. Hence, the dataset including the approved vaccines and their countries of origin were considered within the scope of the analysis. The approved vaccines and their countries of origins are as follows (The Council on Foreign Relations, 2021):

- Pfizer/BioNTech vaccine is from Germany,
- Moderna vaccine is from only the United States,
- Oxford/AstraZeneca vaccine is from Sweden,
- Sinopharm vaccine is from China,
- Sputnik V vaccine is from Russia,

- CNBG vaccine is from China,
- Sinovac vaccine is from China,
- Covaxin vaccine is from India.

When the countries of origin of the approved vaccines are examined in terms of the ratio of fully vaccinated people to the population of the countries; the average percentage of fully vaccinated persons among the total population of countries that developed the vaccine was found to be 85%. Since the average percentage of fully vaccinated people among the total population of countries that developed the vaccine is 85%, it can be said that the citizens of the country where approved vaccines are developed are given priority in vaccine distribution. The finding in the additional analysis that rich countries benefit from the production of indigenous vaccines while poorer countries do not have immediate access to vaccines is termed vaccine nationalism (Chohan, 2021). This term is related to the concept of vaccine diplomacy. It is not surprising that this finding was obtained in the study, as vaccine nationalism is a phenomenon also observed in the H1N1 and Ebola crises (Santos Rutschman, 2020).

III. DISCUSSION AND CONCLUSION

With the emergence of the global COVID-19 epidemic in late 2019 and its highly devastating effects from 2020 to the present, the COVID-19 vaccine, which was developed with great success in a short time, has become a life-saving tool in this health crisis. Despite this clinical success, there is growing concern about inequality in vaccine distribution around the world. So, as mentioned before, this inequality has been emphasized by many authorities. Therefore, the purpose of this study is to evaluate the main factors affecting the global distribution of COVID-19 vaccines and to reveal the factors affecting vaccine inequality. This study specifically aims to consider whether political, economic, and demographic factors have an impact on access to vaccines. Using the standard approach of data science and statistical analysis with in-depth analysis of the data provided and included, this study provided an important insight into the factors affecting the global distribution of COVID-19 vaccines.

In this study, the comparison of the total vaccines among the world regions showed that there is an unfair allocation for the vaccines administered so far. One of the most interesting findings was the large gap observed in vaccine distribution across world regions; For example, all African people administered less than 1%, while North American people accounted for about 40% of total world vaccines. As mentioned in the scope of political analysis the main reason for this finding is international drug monopolies and current patent and license applications. Although the data within the scope of justification were not evaluated in the study, it was mentioned that this situation is called vaccine diplomacy in the context of studies in the literature. The reasons behind vaccine diplomacy are the diplomatic priority of the country where the patent or license is developed in accessing the drug/vaccine, and the high-income countries' ability to support the high-cost vaccine development process.

Geographically, the analysis results conclude that European and North American people are the most likely to be fully vaccinated, with a percentage ranging from 15% to 51%, and Africans are less likely to be vaccinated collectively, at a rate of 1%. In other words, given the same daily vaccination rate and assuming typical 2 doses of vaccines, it can be predicted that European and North American populations will be fully vaccinated by March 2022, conversely, the full vaccination date of Africans is predicted to be 2037. Demographically, the analysis results show that citizens of countries with higher GDP per Capita are vaccinated more and faster, whereas citizens of countries with lower GDP per Capita are vaccinated more slowly. At the same time, it can be said that the citizens of the countries that allocate more budget to health expenditures are vaccinated more. Politically, the finding of a significant positive correlation between the CPI score for countries and total vaccinations from the correlation analysis confirms Transparency International's statement shows that corruption undermines the global health response to COVID-19. It can be said that countries that show transparency, allocate more budgets to health expenditures and these countries are better off vaccinating their citizens.

As a result, vaccine inequality has been a major concern in the COVID-19 pandemic. It is seen that developed countries will benefit from the vaccine production that they have developed and less developed countries will not be able to access the vaccine as soon as possible. At the same time, wealthier countries have prioritized access to vaccines because of their ability to pay (UN, 2021). Although the UN-supported COVAX program was created to counter this inequality, unequal distribution of vaccines was observed among high, middle and low income countries in 2021 based on the principle of vaccine nationalism and vaccine diplomacy (Kupferschmidt, 2020). Globally, the problem is distribution due to licenses/patents, and the economic power of countries. However, many countries still have inadequate vaccination rates due to problems such as vaccine stockpiling, booster doses and lack of funds for vaccine infrastructure.

There are, however, several explanations for these findings. It could be concluded from the demographical, economic, and political analysis that significant inequalities in vaccine access could be attributed to many factors. In conclusion, according to the findings from the analyzes in this study, people more likely to be vaccinated are the people who come from countries of:

- Higher in CPI score.
- Higher in health total expenditure (% of GDP).
- Higher in GDP per capita.
- Approved-vaccine developer.

For future research, more accurate results can be obtained with the completion of vaccination programs and vaccination distribution process, but evidently that this process will continue for several more years as it is mentioned in this study. Therefore, these datasets which have a dynamic and constantly changing structure should be examined at certain time intervals. It should be questioned whether the vaccine inequality continues and the factors affecting this inequality have changed. Meanwhile, this analysis can be carried out with different and more varied variables, as many different factors can affect this vaccine inequality. Variables related to patent and licensing processes of vaccines can be included in the future studies. Thus, the concepts of vaccine diplomacy and vaccine nationalism can be examined in more detail.

Ethical Approval: The data used in the study were obtained from open sources, therefore, ethics committee approval is not required.

REFERENCES

Anderson, R., Heesterbeek, H., Klinkenberg, D., & Hollingsworth, T. (2020, March 9). How will country-based mitigation measures influence the course of the COVID-19 epidemic? *The Lancet, 395*(10228), 931-934.

Beaumont, P. (2020, November 18). *Covid-19 vaccine: who are countries prioritising for first doses?* The Guardian. https://www.theguardian.com/world/2020/nov/18/covid-19-vaccine-who-are-countries-prioritising-for-first-doses.

Blume, S. (2020). The Politics of Global Vaccination Policies. In C. McInnes, K. Lee, & J. Youde. (Ed.)., *The Oxford Handbook of Global Health Politics* (pp. 583-605). Oxford University Press.

CDC. (2021, July 14). *How COVID-19 spreads*. Centers for Disease Control and Prevention. https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/how-covid-spreads.html.

Chohan, U. W. (2021, January 16). *Coronavirus & vaccine nationalism.* CASS Working Papers on Economics & National Affairs 2021. http://dx.doi.org/10.2139/ssrn.3767610.

COVID-19 vaccine tracker. (2021a, February 16). *COVID-19 vaccine tracker landscape.* COVID-19 vaccine tracker. https://vac-lshtm.shinyapps.io/ncov_vaccine_landscape/.

COVID-19 vaccine tracker. (2021b, February 19). *COVID-19 vaccine trial map.* COVID-19 vaccine tracker. https://vac-lshtm.shinyapps.io/ncov_vaccine_landscape/.

Funk, C. D., Laferrière, C., & Ardakani, A. (2020). A snapshot of the global race for vaccines targeting SARS-CoV-2 and the COVID-19 pandemic. *Frontiers in Pharmacology, 11*(937), 1-17.

Grant, M., Geoghegan, L., Arbyn, M., Mohammed, Z., McGuinness, L., Clarke, E., & Wade, R. (2020). The prevalence of symptoms in 24,410 adults infected by the novel coronavirus (SARS-CoV-2; COVID-19): A systematic review and meta-analysis of 148 studies from 9 countries. *PloS One, 15*(6), 1-19.

Hannah, R., Esteban, O. O., Beltekian, D., Mathieu, E., Hasell, J., Macdonald, B.,& Roser, M. (2021, February 19). *Coronavirus (COVID-19) vaccinations.* Our World in Data. https://ourworldindata.org/covid-vaccinations.

Kenny, P. (2020, March 13). *WHO: Europe is new epicenter of coronavirus pandemic*. Anadolu Agency. https://www.aa.com.tr/en/europe/who-europe-is-new-epicenter-of-coronavirus-pandemic/1765452.

Kupferschmidt, K. (2020, July 28). *'Vaccine nationalism' threatens global plan to distribute COVID-19 shots fairly*. Science.org. https://www.science.org/content/article/vaccine-nationalism-threatens-global-plan-distribute-covid-19-shots-fairly.

McCurry, J., Ratcliffe, R., & Davidson, H. (2020, March 11). *Mass testing, alerts and big fines: the strategies used in Asia to slow coronavirus*. The Guardian. https://www.theguardian.com/world/2020/mar/11/mass-testing-alerts-and-big-fines-the-strategies-used-in-asia-to-slow-coronavirus.

Menocal, A., & Taxell, N. (2015). *Why corruption matters: understanding causes, effects, and how to address them.* London: DFID Evidence Paper.

Miller, I., & Miller, M. (2014). *John E. Freund's mathematical statistics with applications*. Pearson.

Mullard, A. (2020, November 30). How COVID vaccines are being divvied up around the world. *Nature, 30*(10.1038).

Qualls, N., Levitt, A., Kanade, N., Wright-Jegede, N., Dopson, S., Biggerstaff, M.,& Uzicanin, A. (2017, April 21). Community mitigation guidelines to prevent pandemic influenza. *Recommendations And Reports: Morbidity And Mortality Weekly Report, 66*(1), 1-34.

Oehler, R. L., & Vega, V. R. (2021). Conquering COVID: How global vaccine inequality risks prolonging the pandemic. *Open Forum Infectious Diseases, 8*(10), 1-3.

Preda, G. (2021). *COVID-19 world vaccination progress*. Kaggle. https://www.kaggle.com/gpreda/covid-world-vaccination-progress.

Santos Rutschman, A. (2020). The reemergence of vaccine nationalism. *Georgetown Journal of International Affairs, Saint Louis U. Legal Studies Research Paper*, (2020-16).

So, A., & Woo, J. (2020). Reserving coronavirus disease 2019 vaccines for global access: cross sectional analysis. *BMJ, 371:m4750*, 1-8.

Sparke, M., & Anguelov, D. (2012). H1N1, globalization and the epidemiology of inequality. *Health & Place, 18*(4), 726-736.

Su, Z., McDonnell, D., Li, X., Bennett, B., Šegalo, S., Abbas, J. & Xiang, Y.-T. (2021). COVID-19 vaccine donations—vaccine empathy or vaccine diplomacy? A narrative literature review. *Vaccines, 9*(9), 1-10.

Le, T. T., Cramer, J., Chen, R., & Mayhew, S. (2020). Evolution of the COVID-19 vaccine development landscape. *Nature Reviews Drug Discovery*, *19*(10), 667-668.

The Council on Foreign Relations. (2021, February 5). *A guide to global COVID-19 vaccine efforts*. (C. Felter, Ed.). CFR. https://www.cfr.org/backgrounder/guide-global-covid-19-vaccine-efforts.

Thorne, E. (2020, June). *Towards a global Covid-19 vaccine strategy*. London, UK. https://institute.global/sites/default/files/202006/Tony%20Blair%20Institute%2C%20Towards%20a%20Global%20Covid-19%20Vaccine%20Strategy.pdf.

Transparency International. (2021, January 28). *2020 corruptıon perceptıons ındex reveals wıdespread corruptıon ıs weakenıng covıd-19 response, threatenıng global recovery.* Transparency International. https://www.transparency.org/en/press/2020-corruption-perceptions-index-reveals-widespread-corruption-is-weakening-covid-19-response-threatening-global-recovery#.

United Nations. Country Profile Data. *UN Data*. https://www.kaggle.com/sudalairajkumar/undata-country profiles?select=country_profile_variables.csv.

UN (2021, September 19). *COVID vaccines: Widening inequality and millions vulnerable*. UN News: https://news.un.org/en/story/2021/09/1100192.

Velavan, T. P., & Meyer, C. (2020). The COVID-19 epidemic. *Tropical Medicine & International Health, 25*(3), 278-280.

Vetter, V., Denizer, G., Friedland, L., Krishnan , J., & Shapiro, M. (2017). Understanding modern-day vaccines: what you need to know. *Annals of Medicine, 50*(2), 110-120.

WHO (2018). *A72/17: Access to medicines and vaccines.* Seventy-Second World Health Assembly. https://www.who.int/publications/m/item/a72-17.

WHO (2020a, March 11). *Coronavirus disease 2019 (COVID-19) situation report-51*. World Health Organization. https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200311-sitrep-51-covid-19.pdf.

WHO (2020b, April 27). *WHO timeline-COVID-19.* WHO International. https://www.who.int/news/item/27-04-2020-who-timeline---covid-19.

WHO (2021a, February 19). *COVID-19 vaccine tracker and landscape*. WHO International. https://www.who.int/publications/m/item/draft-landscape-of-covid-19-candidate-vaccines.

WHO (2021b, January 18). *WHO Director-General's opening remarks at 148th session of the Executive Board*. WHO International. https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-148th-session-of-the-executive-board.

WHO. *COVAX: Working for global equitable access to COVID-19 vaccines*. WHO International. https://www.who.int/initiatives/act-accelerator/covax.