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Political, Economic, and Social Determinants of the COVID-19 Vaccination Rate with Focus on Institutional Quality and Human Development: A Finite Mixture Approach

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Abstract

Introduction: Although immunization against COVID-19 is one of the most effective strategies to control the pandemic, political, economic, and social determinants play a vital role in improving vaccine access and vaccination rates across countries. The present study aimed to investigate the roles of political, economic, and social determinants in the performance of countries facing the COVID-19COVID-19 pandemic, focusing on institutional quality and human development.

Methods: The required data were gathered from international organizations' databases. After descriptive and correlation analysis, finite mixture model (FMM) was used for estimation of the effect of institutional quality (IQ), human development index (HDI), and other control variables (government health expenditure percentage of total health expenditure (GHE%THE), logarithmic gross domestic production (LGDP) and unemployment rate (UR)) on the covid-19 complete vaccination (CFV). The researchers' assumption in using FMM was that CFV had different dimensions and heterogeneity, and HDI had one observed dimension and several unobserved ones, which could better explain CFV heterogeneity than other explanatory variables. Stata 17 was used for model estimation.

Results: In the first class estimation of the FMM model, coefficients of IQ (γ_1=0.1458, P=0.000), GHE%THE ($\mu_{1,1}$=0.2761, P=0.009), and LGDP ($\mu_{1,2}$=0.0586, P=0.014) were significantly positive, and UR ($\mu_{1,3}$=-.0124, P=0.000) was significantly negative. Moreover, class-two estimation showed a significant effect of HDI on CFV (δ_2=63.0537, P=0.009). There is also a significant and positive relationship between CFV and IQ (γ_2=0.1199, P=0.000), GHE%HE ($\mu_{2,1}$=0.27085, P=0.002), and LGDP ($\mu_{2,2}$=0.0559, P=0.000) and UR ($\mu_{2,3}$=0.0169, P=0.000).

Conclusion: Countries with high human development and better institutional quality (voice and accountability, control of corruption, political stability and absence of violence/terrorism, rule of law, regulatory quality, and government effectiveness) reported higher vaccination rates. In other words, political, economic, and social determinants played a significant role in the performance of health systems amid critical conditions, such as the pandemic, particularly in access to vaccines and vaccination rates against COVID-19.

Keywords: COVID-19, Vaccination, Pandemic, Determinants of health, Institutional quality, Human development

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Introduction

On December 31, 2019, an unknown disease was identified and reported by the World Health Organization (WHO) office in Wuhan, China. On January 7, 2020, following preliminary studies and genomic analyses in that country, the disease was called Coronavirus Disease 2019 (COVID-19) (1). The leading cause (pneumonia) of the formation of COVID-19 was the SARS-CoV-2 virus, which had a very high transmission rate. Hence, the WHO declared it a pandemic on March 11, 2020 (2). From the onset of the pandemic to August 20, 2022, COVID-19 infected more than 545 million people worldwide, of whom more than 6 million died (3).

In the early days of the pandemic, the WHO recommended wearing a mask, washing hands, maintaining social distance, and observing cough and sneeze etiquette to prevent infection with COVID-19 (4). However, given the extremely rapid rate of virus transmission, especially among those without symptoms, vaccination was proposed as one of the most effective tools to control the pandemic and prevent an increase in the burden of the disease from infection and deaths (5, 6). According to the latest statistics available as of August 20, 2022, nearly 12 billion doses of vaccines produced by various countries and companies have been administered worldwide (3, 7).

Since the onset of the COVID-19 pandemic, the primary concern of the WHO, the United Nations (UN), and governments has been to provide public healthcare to communities and prevent the collapse of countries' health systems. In this regard, adequate access to vaccines and maximum vaccination coverage have been among the most important strategies of all countries. As part of the function of providing services, vaccination coverage is influenced by health system stewardship, and, as in other public sectors, this stewardship is affected by political, economic, and social determinants. One of the main political determinants affecting health system stewardship is institutional quality and performance. Thus, the study of institutional quality and its role in health system stewardship is of great importance.

During the COVID-19 pandemic, studies were conducted across countries to examine the roles of political, economic, and social determinants in vaccine access and vaccination coverage. For example, Oshakbayev et al. investigated the role of Gross Domestic Product (GDP) in the COVID-19 vaccination rate (8). Ngo et al. examined the roles of education and GDP in COVID-19 vaccination rates (9). Lewkowicz also examined the role of democracy (rule of law and state democracy) during the COVID-19 pandemic (10). Similarly, Bayati et al. reviewed studies on the most important micro and macroeconomic, political, and social determinants affecting the fair distribution of COVID-19 vaccines conducted by other researchers (12).

The review of the mentioned studies showed that political, economic, and social determinants played a vital role in improving vaccine access and vaccination rates across countries. However, no studies were found on the role of institutional quality, as a cornerstone of other determinants, in the performance of health system stewardship and vaccination rates across countries. Therefore, the present study aimed to investigate the role of political, economic, and social determinants in the performance of countries dealing with the COVID-19 pandemic (adequate access to vaccines and maximum vaccination coverage) and to compensate for the lack of studies investigating the role of institutional quality in the performance of the health systems worldwide.

Methods

In this study, the latest data on vaccination rates, institutional quality, HDI, GDP, government participation in health-sector financing, and the unemployment rate were used. In the following, the studied variables, how their data are collected, and their roles in the proposed model are explained.

-Covid-19 full vaccination rate (CFV): According to the WHO's definition, complete vaccination refers to the injection of at least two doses of the vaccine and represents the percentage of the people receiving two doses of the Covid-19 vaccine compared to the target population. This index was entered into the model as a dependent variable, and its data were extracted from the 'Our World in Data' database for 138 countries from August 1, 2021, to August 1, 2022 (13).

-Institutional Quality (IQ): The World Bank considers governance as the traditions and quality of institutions implemented by power and for the public interest in the country. IQ is composed of six indices: "voice and accountability", "control of corruption", "political stability and absence of violence/terrorist", "rule of law", "regulatory quality", and "government effectiveness". The World Bank reports annual data. The numerical range of this index is -2.5 to +2.5, and the closer it is to +2.5, the higher the IQ (14). In the current study, the mentioned indices were combined using principal components analysis (PCA).

-Human Development Index (HDI): It summarizes three aspects of human development, which consist of a decent standard of living, long and healthy life, and knowledge. HDI is estimated using "Life Expectancy at birth", "Gross National Income per capita", "mean of years of schooling for adults aged 25 years ", and "expected years

of schooling for children of school entering age" variables. It ranged from 0 to 1 and was reported by the UN.

-Government health expenditure as a percentage of total health expenditure (GHE%THE): One of the main functions of the health systems is financing, and governments are among the primary sources of financing the health system. The government's share in financing the health sector plays a key role in supporting research and development (R&D) and the provision of COVID-19 vaccines. The latest World Bank data were used in this study (16).

-GDP: It is used to measure the production of goods and services and their market values in the economy, which are calculated annually. The latest GDP data at fixed prices in PPP (Purchasing Power Parities), reported by the World Bank, were used to control for differences in income across the studied countries. The GDP was entered into the model logarithmically (16).

-Unemployment Rate (UR): It is one of the most well-known measures of a country's labor market. In other words, it shows the economy's inability to create jobs for job seekers. The UR is an indicator of an economy's efficiency and effectiveness in attracting active labor and in labor market performance. The UR data are reported annually by the International Labor Organization (ILO), and the latest published report was used in this study (17).

Based on the types of variables and data structures, the Finite Mixture Model (FMM) was used to estimate the model. FMMs are distributions presented using basic mathematical methods for statistical modeling and that model a wide variety of stochastic phenomena. The main reason for using this approach is its strong ability to model with high flexibility. In the last decade, the use of this modeling approach has increased significantly due to its practical and theoretical nature. It is used across various fields, including spatial studies, biology, genetics, medicine, economics, and the social sciences (18).

FMM is used to classify observations so that unobserved heterogeneities can be clustered, regularized, and modeled. In FMM, the observed data are considered part of the unobservable data (classes), and modeling is achieved by calculating their probability density or by regression. After fitting the model, the probability of each observation's membership in the classes can be predicted. The central concept of modeling in FMM is that the observed data are a subset of the distinct and unobservable data. FMM is estimated using maximum likelihood estimation. The classification probability has been derived under the assumption that, within a given latent class, the response variable is independent and uniformly distributed across the estimated sample. The condition for this assumption is that hidden classes and exogenous variables have been observed. The probabilities are calculated by combining the conditional probabilities for each latent class weighted by the associated latent class probabilities (19).

In the current study, the following FMM model was used.

$$z(CFV_i \mid IQ_i, C_i, HDI_i)=\Sigma^{G}_{i}=1\pi g\ (HDI_i, \delta g)\ zg\ (Fv_i \mid IQ_i, C_i, \gamma_g, \mu_g, \sigma_g)$$

Where G is the unknown number of classes, $\pi g(HDI_i, \delta g)$ represents the posterior probability of a country belonging to the latent class g; HDIi and δg are, respectively, the classification variable and the coefficient of the former. zg ($CFV_i \mid IQ_i, C_i; \gamma_m, \mu_m, \sigma_m$) denotes the conditional distribution of the CFV_i coefficient on IQ_i, characterized by the explained variable CFV_i, the key explanatory variable IQ_i, and other control variables C_i. Furthermore, the Parameters γg, μg, and σg indicate the coefficient of the key explanatory variable IQ_i in class g, the coefficient of the control variables in class g, and the standard deviation of the error term in class g, respectively.

The possibility of being assigned to a latent class is estimated using the following multinomial logit model:

$$\pi_g\ (HDI_i\ ,\ \delta_m)=\frac{exp\ (\delta_m+HDI_i\ ,\delta g)}{\sum_{i=1}^{G} exp(\delta g+HDI_i\ ,\delta g)}$$

In the present study, CFV was the dependent variable, and log GDP (LGDP), IQ, and GHE%HE were the explanatory variables. Furthermore, HDI was considered the independent classifying variable. The researchers' assumption in estimating the model was that CFV had multiple dimensions and heterogeneity, and HDI had one observed dimension and several unobserved ones, which could better explain CFV heterogeneity than other explanatory variables. Hence, HDI was considered the explanatory variable of classification.

The number of classes, G, is a priori unknown. Because there is no uniform standard for choosing the classing number of G, this paper thus considers

the approach of class selection following the previous literature. More specifically, two kinds of information criteria (i.e., Akaike information criteria (AIC), Bayesian information criteria (BIC) are chosen to endogenously ensure the correct selection of the number of groups (19).

Stata 17 was used to test and estimate the model.

Results

The mean full vaccination rate among the 138 studied countries was 57%. Sudan and the United Arab Emirates had the lowest and highest vaccination rates. Descriptive statistics for the other variables are presented in Table 1.

Correlation analysis showed that the full vaccination rate was positively associated with HCI, LGDP, IQ, and GHE%HE and negatively correlated with UR (Figure 1).

According to the Bayesian information criterion (BIC), the two-class FMM was selected for estimation, as shown in Table 2.

In the first-class estimation of the FMM model, the classification variable (HDI) is not estimated, and a linear regression model is used to estimate the other explanatory variables. In this class estimation, the coefficients for IQ, GHE%HE, and LGDP were significantly positive, and the coefficient for UR was significantly negative. Moreover, class-two estimation, which estimates the classification variable using the maximum likelihood estimator, showed a remarkable effect of HDI on CFV. There is also a significant and positive relationship between COVID-19 vaccination and all explanatory factors. FMM results are shown in Table 3.

Table 1: Descriptive statistics of studied variables for 138 counties of the world, 2021-22

Variables	Mean	Standard Deviation	Min	Max
FV	57%	0.241	10% Sudan	105% United Arab Emirates
HDI	0.75	0.15	0.394 Nigeria	0.957 Norway
IQ	0.08	0.88	-1.55 Central African Republic	1.87 Finland
GDP (PPP)	9.41e+11	2.90e+12	7.79e+08 Dominica	2.43e+13 China
UR	8.123 %	5.855283	0.258% Qatar	33.55% Southern Africa
GHE%THE	54 %	0.20	11% Central African Republic	94% Brunei

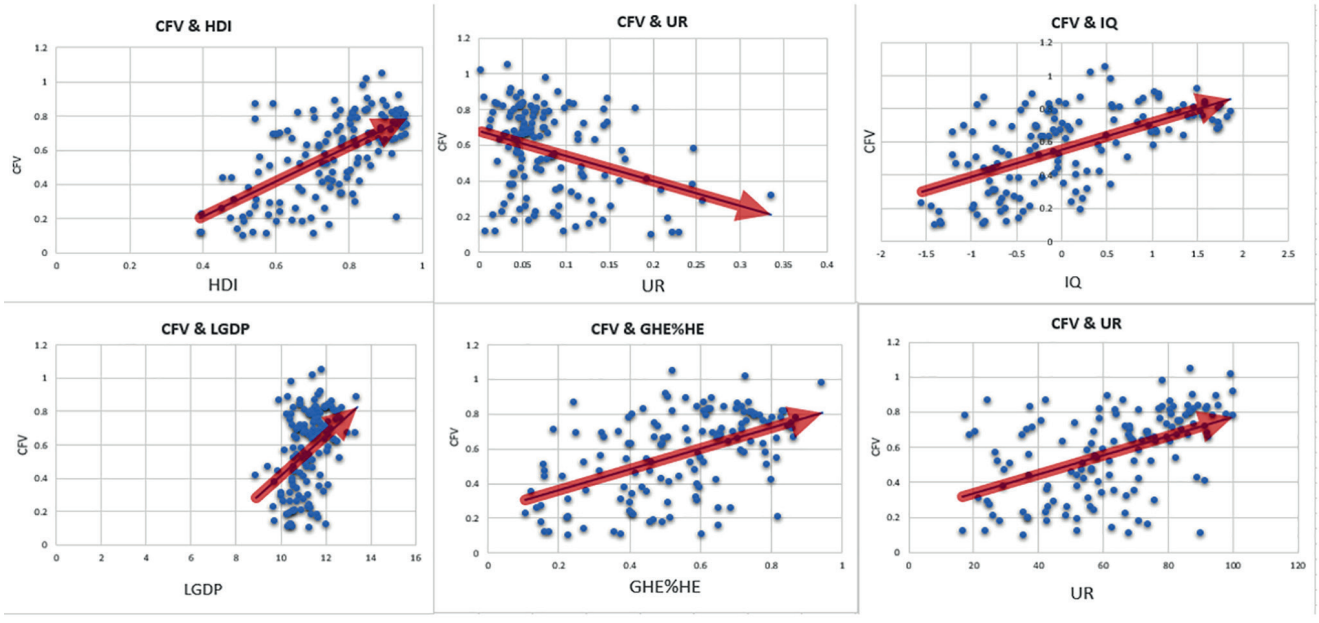

Figure 1: Correlation between CFV and HDI, L GDP, IQ, and GHE%THE

Table 2: AIC & BIC test for model selection

Model	N	II (null)	II (model)	DF	AIC	BIC
1 Classes	138	0	47.89348	6	-83.78697	-65.26708
2 Classes	138	0	67.37634	14	-106.7527	-66.87295
3 Classes	138	0	83.91439	22	-123.8288	-59.5892

Table 3: FMM estimates of determinants of the COVID-19 vaccination rate using HDI as a classification variable

Explanatory variables		Coefficient	Std. error	P value	[95% conf. interval]
Class 1: FMM without HDI (base outcomes)					
CFV	IQ	0.1457478	0.031246	0.000	0.0845068, 0.2069888
	GHE%THE	0.2761344	0.1063667	0.009	0.0676595, 0.4846093
	L GDP	0.0586041	0.0237544	0.014	0.0120463, 0.1051619
	UR	-0.0124139	0.0028234	0.000	-0.0179677, -0.0068801
Class 2: FMM with HDI					
CFV	HDI	63.0537	24.14791	0.009	15.72465, 110.3872
	IQ	0.1198979	0.0289788	0.000	0.0631005, 0.1766952
	GHE%THE	0.2708543	0.0873264	0.002	0.996977, 0.4420108
	L GDP	0.0558636	0.0159045	0.000	0.0246914, 0.0870358
	UR	0.0168988	0.0036444	0.000	0.0097558, 0.0240417

Discussion

According to the WHO and the UN, the main challenge in controlling the COVID-19 pandemic was ensuring fair access to adequate and affordable vaccines across countries. Comparing vaccination rates in middle- and low-income countries with those in high-income countries revealed an unfair distribution of vaccines at the international level. Various studies have shown that countries' political, economic, and social power is the main guarantee of their access to vaccines (7, 12). Given the key role of countries' access to adequate and affordable vaccines in controlling the COVID-19 pandemic, the present study aimed to examine the influence of IQ, HDI, and other political and socioeconomic determinants on vaccination rates across countries (as an indicator of countries' access to vaccines).

The role of IQ in the vaccination rates of the studied countries was positive and significant. In other words, countries with higher IQs achieved higher vaccination rates and were more successful in controlling the pandemic. Lewkowicz showed that countries with better political and IQ conditions were more resistant to various shocks, including the COVID-19 pandemic (10). Ngo et al. suggested that countries with democratic political regimes and higher levels of education and employment experienced faster vaccination rates than other countries (9). Another study found that controlling corruption and increasing government effectiveness played an important and significant role in improving vaccination rates across countries (20). In general, IQ, as the most important political and economic infrastructure of countries, has had a significant impact on access to vaccines and vaccination coverage by affecting other socioeconomic determinants.

Based on the findings, HDI played a significant positive role in the vaccination rates of the studied countries. Rughiniș C. et al. showed that human development had a positive effect on vaccination coverage. Among the dimensions of the indicator mentioned, life expectancy had the most significant effect on countries' vaccination rates (21). Nabaggala. et al. also showed that HDI was effective in CFV (22).

The role of GDP in the vaccination rates of the studied countries was positive and significant. In fact, GDP reflected countries' ability to finance vaccine access (through production or purchase). Other studies also confirmed this relationship (8, 22), but the important point was that greater vaccine access did not necessarily translate into higher vaccination rates. The statistical results of the research by Oshakbayev et al. showed that countries with the highest GDP, such as the United States and China, had vaccination rates that were either equal to or lower than those of countries with lower GDP, including Bhutan and Malta (8). Although higher GDP played a positive and significant role in access to COVID-19 vaccines, it did not guarantee greater vaccination coverage, as other factors also influenced vaccination coverage (23). Khubchandani et al. found that uncertainty about vaccination and vaccine effectiveness in the United States had a positive, direct relationship with income, education, and employment levels. Vaccination rates were higher among educated populations, those with full-time jobs, and those with medium to high income levels (11).

Governments' participation in financing the health sector (GHE%THE) positively affected COVID-19 vaccination rates. In other words, the higher the share of governments in financing the health sector, the greater the access to vaccines in countries, and, finally, the higher the

vaccination rates. No study was found on the role of government participation in financing the health sector to provide COVID-19 vaccination. However, some studies, including those by M. Onofrei et al. and Nabaggala, suggested that increasing government participation in the health sector, along with improvements in governance and service delivery quality, would increase life expectancy and reduce mortality (22, 24).

The role of the unemployment rate in the vaccination rate was negative when the FMM model did not include the HDI variable in the first class. However, the HDI variable was positively associated with the second class. The types of unemployment in countries with higher HDI differed from those in countries with lower HDI. In other words, countries with higher HDI had better life expectancy, education, and national income per capita, and direct and indirect government and non-government support reduced the pressure caused by temporary unemployment, increased resilience during the pandemic, and ultimately made the vaccination program more popular. On the other hand, the countries with lower HDI benefited from neither direct nor indirect government nor non-government support. Therefore, the impact of chronic unemployment was much greater and more profound for them, and the vaccination program was not well-received. It has been less. Khubchandani et al. indicated that uncertainty about vaccination and its effectiveness in the United States had a positive, direct relationship with employment, and that vaccination rates were higher among educated populations, as well as those with full-time jobs and medium to high income (11).

Conclusion

Countries that focused on improving the components of human development in previous years (long life with health, education, and the standards necessary for life) and IQ (rule of law, government effectiveness, the right to comment, responsiveness, and the quality of laws and regulations) not only had more access to vaccines, but also reported better vaccination rates. In other words, political, economic, and social determinants played a significant role in the performance of health systems amid critical conditions, such as the pandemic, particularly in access to vaccines and vaccination rates against COVID-19.

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Ethics Approval and Consent to Participate

The project was found to be in accordance with the ethical principles and the national norms and standards for conducting medical research. The study protocol was approved by the Ethics Committee of Shiraz University of Medical Sciences under code IR.SUMS.NUMIMG.REC.1401.096.

Authors' Contribution

AH, MB, and MJ conceptualized the study. AH conducted data management. AH and MJ conducted data analysis. All authors contributed to editing the manuscript. All authors read and approved the final manuscript.

Availability of Data and Materials

The data used in this study are publicly available in international organizations' databases.

Conflict of Interest

There are no conflicts of interest.

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