Preplanned Studies

Predictors of Global Disparities in COVID-19 Vaccination Coverage — 219 Countries and Territories, December 2020–July 2022

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Summary

What is already known about this topic?

The significant disparities in global coronavirus disease 2019 (COVID-19) vaccine coverage hamper the pace of epidemic control. There is a need to better understand the factors contributing to disparities in COVID-19 vaccination rates across countries.

What is added by this report?

This report revealed significant associations between vaccination coverage and various country-level indicators. Better pandemic preparedness, higher levels of trust, and a lower proportion of young population aged 0–14 were strongly correlated with higher COVID-19 vaccination coverage.

What are the implications for public health practices?

Our findings emphasize the need for enhanced pandemic preparedness and governance, coupled with building trust in government and healthcare systems. It also needs to address the hesitancy of vaccinating children and adolescents aged 0–14 as the vaccination campaign progresses.

Disparities in coronavirus disease 2019 (COVID-19) vaccination coverage among countries have been observed following the introduction of COVID-19 vaccines, which has hindered global efforts to control the pandemic. The 80% of the world's population only had access to approximately 5% of the total COVID-19 vaccines available (*1*), and vaccination rate per capita in high-income countries is approximately 7.8 times higher than that in low-income countries (*2*), leading to prolonged impacts of the pandemic (*1*,*3*). In addition to the financial status of individuals or countries, there could be additional factors that influence people's willingness to receive the vaccine, which public health agencies might consider or address. Gaining insights into the underlying reasons behind COVID-19 vaccine uptake would enhance global preparedness for the potential pandemics in the future.

There is a need to better understand the factors contributing to disparities in COVID-19 vaccination rates across countries. This goes beyond the economic reasons that have been previously studied (*4*–*5*). Therefore, our study aims to identify the country-level predictors that contribute to global disparities in COVID-19 vaccine coverage.

METHODS

Complete COVID-19 vaccination coverage data were collected for each country/territory as of July 2022 from a public database (https://ourworldindata.org/). COVID-19 vaccination coverage is measured by total number of people who received all doses prescribed by the initial vaccination protocol, divided by the total population of the country. Additionally, we gathered various country-level indicators including demographics, social development status, pandemic preparedness, governance, trust, COVID-19 Vaccines Global Access (COVAX) participation, and COVID-19 vaccine acceptance and delivery. COVAX is a global risk-sharing mechanism for pooled procurement and equitable distribution of COVID-19 vaccines, including two participating mechanisms — advance market commitment and self-financing. The role of advance market commitment is to leverage the scale assured by the participation of higher-income economies to ensure that lower-income ones are also able to participate. Countries with sufficient supply could opt out of getting COVAX doses, leaving more doses for others. For detailed information on each variable and its sources, please refer to Supplementary Table S1 (available at https://weekly.chinacdc.cn/).

To illustrate the global disparity in the percentage of people fully vaccinated against COVID-19, we utilized R (version 4.2.1, R Core Team, Murray Hill, NJ, USA) to create a scatter plots, along with linear

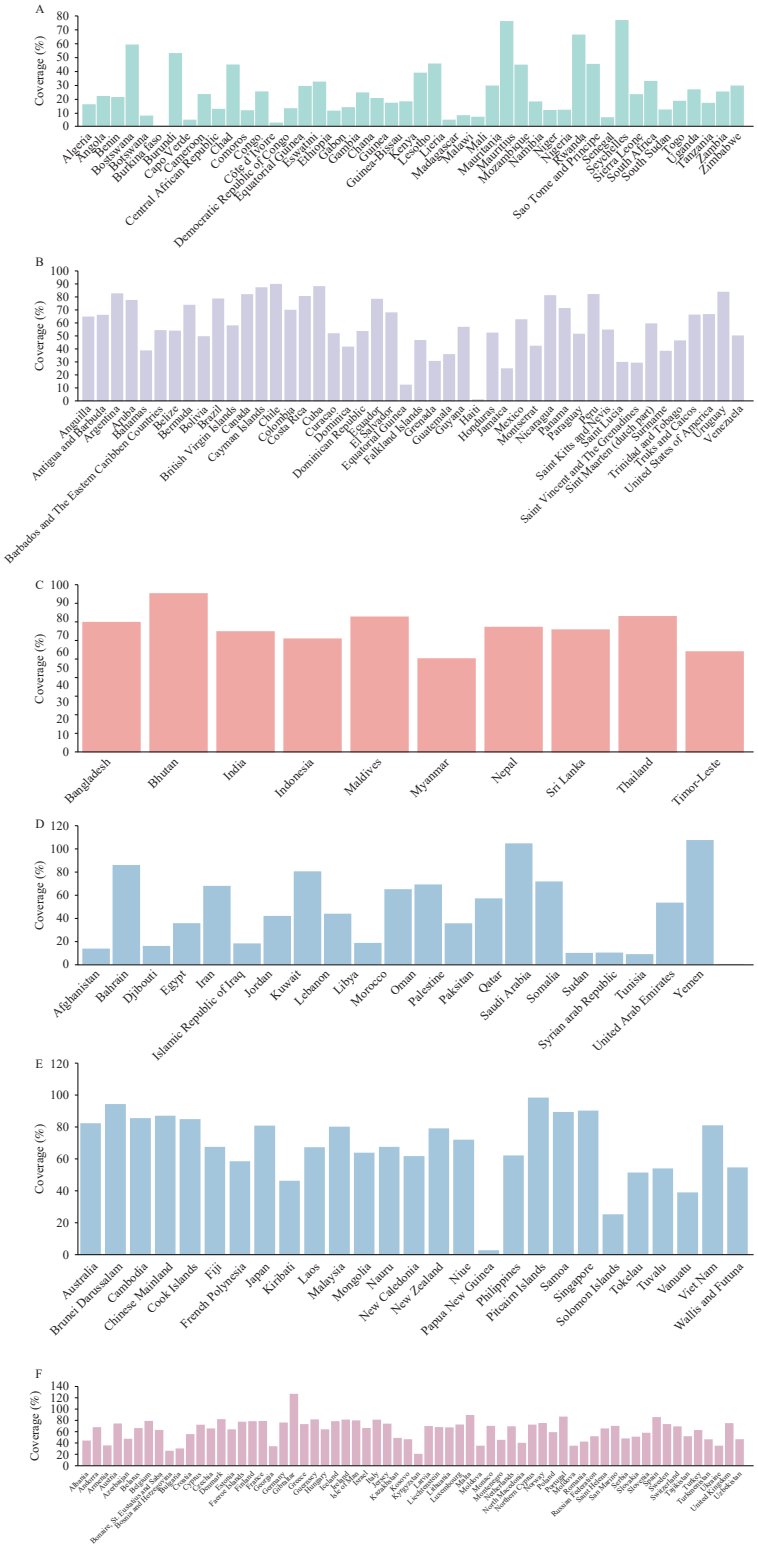

FIGURE 1. Full COVID-19 vaccination coverage in six WHO regions as of July 19, 2022. (A) Africa; (B) Americas; (C) South-east Asia; (D) Eastern mediterranean; (E) Western Pacific; (F) Europe.
Note: Since vaccination is available to both residents and non-residents such as tourists and foreign workers, vaccination coverage in some countries or territories may exceed 100%. Tonga (vaccine coverage rate of 91.64%) is not shown separately due to its location in Oceania. Full COVID-19 vaccination coverage rates in the regions of Hong Kong SAR, Macau SAR, and Taiwan, China are 86.61%, 85.51%, and 83.16%, respectively
Abbreviation: WHO=World Health Organization; COVID-19=coronavirus disease 2019; SAR=Special Administrative Region.

regression lines, visualized the association between COVID-19 vaccination coverage and vaccine delivery or acceptance.

Univariate linear regressions were conducted to assess the relationship between various country-level indicators and COVID-19 vaccination coverage at the country level. Considering the possible multicollinearity among country-level indicators, we employed the Least Absolute Shrinkage and Selection Operator (LASSO) regression for variable selection. The selected country-level indicators were then included in a multifactorial regression to identify predictors of COVID-19 vaccination coverage. Note that the categorical variable (COVAX participation) was not part of the LASSO regression but included in the multifactorial regression. All statistical analyses were performed using Stata (version 16; Stata Corp., TX, USA) with a significance level of 0.05.

RESULTS

As of July 2022, COVID-19 vaccination coverage varied widely among the 219 countries and territories, ranging from 0.13% to 126.79% (Figure 1). COVID-19 vaccination coverage was positively correlated with delivered doses per capita and vaccine acceptance (Figure 2). Note that despite some countries having high vaccine delivery per capita (e.g., Austria, Liechtenstein, Hungary, Dominica, Saint Vincent and the Grenadines, and Djibouti) or high vaccine acceptance rates (e.g., Somalia, Bosnia and Herzegovina, Paraguay, Iran, Nepal, Indonesia, and Brazil), they still experienced low COVID-19 vaccination coverage.

Univariate linear regressions showed that significant correlations (P<0.05) were found between COVID-19 vaccination coverage and all country-level indicators analyzed (Table 1). When examining demographic characteristics, a positive association was observed between vaccination coverage and the proportion of urban population (R^2=24.3%), and the proportion of population aged 65 and above (R^2=27.2%). In contrast, a negative association was observed with the proportion of population aged 0–14 (R^2=51.4%). In terms of social development indicators, vaccination coverage showed positive associations with the socio-demographic index (R^2=44.2%) and GDP per capita (R^2=49.9%). Positive associations were also found with indicators measuring preparedness for pandemics, including the epidemic ready score (R^2=55.8%), global health security index (R^2=33.3%), number of medical doctors per 1,000 people (R^2=30.2%), and vaccine manufacturing capability (R^2=4.8%). Among indicators related to governance and trust, vaccination coverage displayed positive correlations with government effectiveness (R^2=52.4%), control of corruption (R^2=39.6%), trust in government

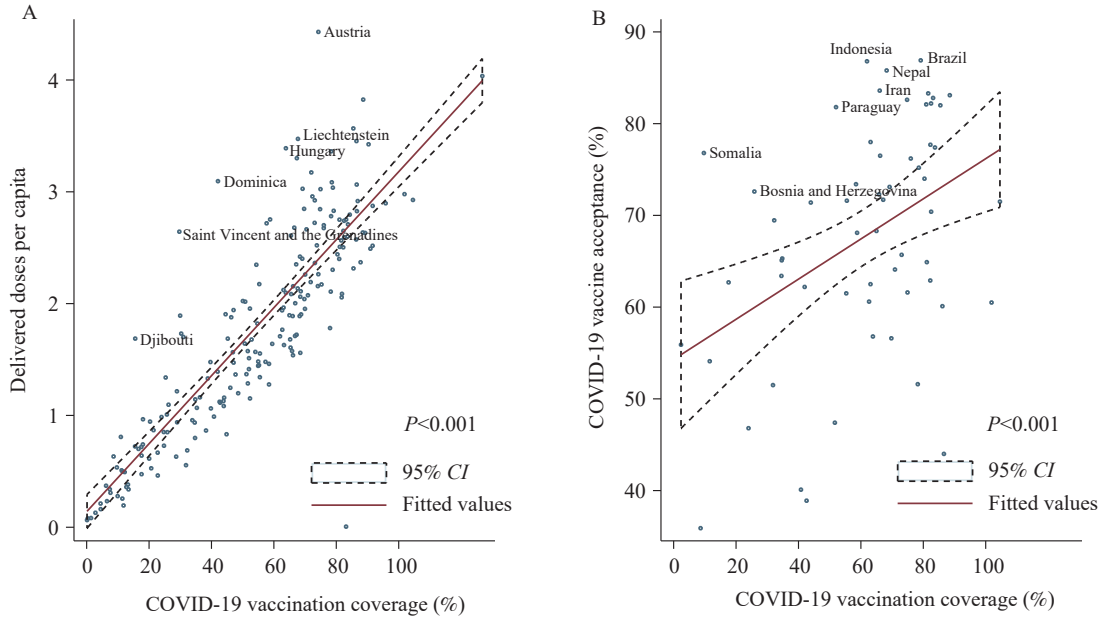

FIGURE 2. Correlations between COVID-19 vaccination coverage and vaccine delivery/acceptance as of July 19, 2022. (A) vaccine delivery; (B) vaccine acceptance.
Abbreviation: COVID-19=coronavirus disease 2019; *CI*=confidence interval.

TABLE 1. Associations between country-level characteristics and COVID-19 vaccination coverage by univariate and multifactorial regression.

Variables	*N*	Univariate linear regressions			Multifactorial regressions	
		Coefficient, 95% *CI*	*P*-value	R^2	Coefficient, 95% *CI*	*P*–value
Demographics						
Urban population, %	196	0.57 (0.43, 0.71)	<0.001	24.3%		
Population aged 65 and above, %	181	2.12 (1.61, 2.63)	<0.001	27.2%	−0.88 (−2.30, 0.53)	0.214
Population aged 0–14, %	181	−1.89 (−2.16, −1.62)	<0.001	51.4%	−2.22 (−3.10, −1.34)	<0.001
Social development status						
Socio-Demographic Index	188	99.01 (82.91, 115.10)	<0.001	44.2%		
Ln (GDP per capita)	175	12.90 (10.96, 14.83)	<0.001	49.9%		
Pandemic preparedness						
Epidemic Ready Score	94	1.09 (0.89, 1.29)	<0.001	55.8%	0.50 (0.12, 0.88)	0.011
Global Health Security Index	181	1.12 (0.88, 1.35)	<0.001	33.3%		
Doctors per 1,000 people	189	0.83 (0.65, 1.01)	<0.001	30.2%	−0.04 (−0.46, 0.37)	0.831
Vaccine manufacturing capability	219	14.46 (5.86, 23.07)	0.001	4.8%	−1.39 (−10.74, 7.95)	0.765
Governance						
Government effectiveness	196	19.16 (16.57, 21.74)	<0.001	52.4%		
Control of corruption	196	16.60 (13.70, 19.50)	<0.001	39.6%		
State fragility	176	−7.79 (−8.87, -6.71)	<0.001	53.8%		
Trust						
Trust in government, %	106	0.41 (0.18, 0.65)	0.001	10.4%	0.25 (0.03, 0.46)	0.024
Trust in science, %	112	1.22 (0.91, 1.54)	<0.001	35.1%		
Interpersonal trust, %	56	0.72 (0.36, 1.08)	<0.001	22.6%		
COVAX participation						
Participation in COVAX through advance market commitment	219	−28.09 (−35.95, −20.23)	<0.001	28.9%	10.03 (−4.36, 24.41)	0.167
Self-financing participation in COVAX	219	1.20 (−0.66, 9.06)	0.764	28.9%	−1.69 (−17.60, 14.22)	0.831

Abbreviation: COVID-19=coronavirus disease 2019; *CI*=confidence interval; GDP=gross domestic product; COVAX=COVID-19 vaccines global access.

(R^2=10.4%), trust in science (R^2=35.1%), and interpersonal trust (R^2=22.6%). Conversely, state fragility (R^2=53.8%) showed a negative correlation. Regarding COVAX, vaccination coverage was negatively associated with participation in COVAX through advance market commitment (R^2=28.9%), but not significantly associated with self-financing participation in COVAX.

Following variable selection through LASSO regression, the final variables retained for the multifactorial regression analysis were population aged 65 and above, population aged 0–14, epidemic readiness score, doctors per 1,000 people, vaccine manufacturing capability, trust in government, participation in COVAX through advance market commitment, and self-financing participation in COVAX. In the multifactorial regression, population aged 0–14 [coefficient −2.22, 95% confidence interval (*CI*): −3.10, −1.34], epidemic readiness score (coefficient 0.50, 95% *CI*: 0.12, 0.88), and trust in government (coefficient 0.25, 95% *CI*: 0.03, 0.46) were found to be significant predictors of vaccination coverage when accounting for other factors. However, population aged 65 and above, doctors per 1,000 people, vaccine manufacturing capability, and COVAX index were not found to be significant predictors (Table 1).

DISCUSSION

This study examined the factors influencing the differences in COVID-19 vaccination coverage across countries. Our findings indicated that a lower proportion of the population aged 0–14, improved pandemic preparedness, and increased levels of trust were strongly associated with higher COVID-19

vaccination coverage.

Policy responses implemented globally in response to the COVID-19 pandemic have the potential to disrupt the plans and routines of populations, highlighting the importance of high trust and compliance (*6*). Past research has demonstrated that confidence in both the government and healthcare systems leads to increased vaccination rates and sustained support for pandemic control measures (*7*). The findings of this study underscore the critical role of establishing trust in the government, not only in terms of its ability to detect, contain, and prevent epidemics, but also in terms of ensuring transparency, openness, and reliability. These factors are essential in safeguarding individuals from the spread of misinformation and conspiracy theories, particularly in the era of the internet and the prevailing sense of uncertainty surrounding emerging pandemics.

The demographic characteristics of a country are important factors in determining its vaccine requirements. A higher proportion of urban population may be associated with a greater perceived risk of COVID-19 infection, leading to higher promotion of COVID-19 vaccination. This perception of higher risk may also explain why countries with more older adults or a lower proportion of children have higher vaccination coverage. Also, older adults are given priority in global vaccination campaigns. However, it is also crucial to focus on improving vaccine coverage among children and adolescents aged 0–14 years.

Differences in COVID-19 vaccination coverage among countries can be partly attributed to their social development status, indicating unequal distribution and uptake of vaccines. The high cost and monopolization of vaccine technology have resulted in limited supply and access for low-income countries. It is recommended that vaccine-producing countries, particularly low-income nations, enhance their emergency vaccine production and ultracold storage capacity. Additionally, cross-country vaccine distribution mechanisms such as the Global Alliance for Vaccines and Immunizations (GAVI) should play a more active role in addressing inequality issues in COVID-19 and future pandemics (*8*). As an example, GAVI has launched the African Manufacturing Vaccine Accelerator (AMVA) program to promote self-sufficiency in the future supply of essential immunization and life-saving vaccines for African countries (*9*).

Sufficient preparedness for pandemics is crucial for enhancing vaccine coverage in countries. It has been proposed by researchers that essential elements of pandemic preparedness should cover robust surge capacities in health systems, including an adequate personnel, medical supplies, and intensive care beds. Additionally, global cooperation should not be underestimated. Participation in international collaborative initiatives like COVAX can strengthen global response systems and vaccine supply chains (*10*).

We also identified countries that deviate from the expected relationship between vaccine acceptance/delivery rates and COVID-19 vaccination coverage. In countries where vaccine delivery is high but coverage is low, there may be a lack of willingness to receive vaccines, indicating the need for improved health communication to enhance vaccine acceptance. Building trust is a crucial step in addressing this issue, with a focus on engaging healthcare systems to provide accurate vaccine safety information to the public through local authorities and religious leaders (*11*–*12*). On the other hand, countries with high vaccine acceptance but low coverage require efforts to improve COVID-19 vaccine supplies and ensure equity, both at the national and global levels.

Conflicts of interest: No conflicts of interest.

Funding: Supported by the National Natural Science Foundation of China [No. 71874034 (Dr Hou)] and the Soft Science Research Project of Shanghai "Science and Technology Innovation Action Plan" [No.22692107600 (Dr Hou)].

doi: 10.46234/ccdcw2024.062

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Submitted: December 14, 2023; Accepted: March 22, 2024

REFERENCES

1. Tatar M, Shoorekchali JM, Faraji MR, Wilson FA. International COVID-19 vaccine inequality amid the pandemic: perpetuating a global crisis? J Glob Health 2021;11:03086. http://dx.doi.org/10.7189/jogh.11.03086.
2. Chen ZY, Zheng W, Wu QH, Chen XH, Peng C, Tian YY, et al. Global diversity of policy, coverage, and demand of COVID-19 vaccines: a descriptive study. BMC Med 2022;20(1):130. https://doi.org/10.1186/s12916-022-02333-0.
3. Liu F, Zhao ZB, Ma CF, Nie XW, Wu AD, Li X. Return to normal pre-COVID-19 life is delayed by inequitable vaccine allocation and SARS-CoV-2 variants. Epidemiol Infect 2022;150:e46. https://doi.org/10.1017/S0950268822000139.

4. Wouters OJ, Shadlen KC, Salcher-Konrad M, Pollard AJ, Larson HJ, Teerawattananon Y, et al. Challenges in ensuring global access to COVID-19 vaccines: production, affordability, allocation, and deployment. Lancet 2021;397(10278):1023 – 34. https://doi.org/10.1016/S0140-6736(21)00306-8.
5. Ning CL, Wang H, Wu J, Chen QW, Pei HC, Gao H. The COVID-19 vaccination and vaccine inequity worldwide: an empirical study based on global data. Int J Environ Res Public Health 2022;19(9):5267. https://doi.org/10.3390/ijerph19095267.
6. Bargain O, Aminjonov U. Trust and compliance to public health policies in times of COVID-19. J Public Econ 2020;192:104316. https://doi.org/10.1016/j.jpubeco.2020.104316.
7. Falkenbach M, Willison C. Resources or trust: what matters more in the vaccination strategies of high-income liberal democracies? Health Policy Technol 2022;11(2):100618. http://dx.doi.org/10.1016/j.hlpt.2022.100618.
8. Sachs JD, Karim SSA, Aknin L, Allen J, Brosbøl K, Colombo F, et al. The *lancet* commission on lessons for the future from the COVID-19 pandemic. Lancet 2022;400(10359):1224 – 80. https://doi.org/10.1016/S0140-6736(22)01585-9.
9. Momeni Y. Gavi's strategy to support African regional manufacturing. 2023. https://www.unicef.org/supply/media/19216/file/UNICEF-VIC2023-Session12-AVMAUpdate-Gavi-2023.pdf. [2023-11-15].
10. Nuzzo JB, Gostin LO. The first 2 years of COVID-19: lessons to improve preparedness for the next pandemic. JAMA 2022;327(3):217 – 8. https://doi.org/10.1001/jama.2021.24394.
11. Hatala A, Pervaiz MC, Handley R, Vijayan T. Faith based dialogue can tackle vaccine hesitancy and build trust. BMJ 2022;376:o823. https://doi.org/10.1136/bmj.o823.
12. Anakpo G, Mishi S. Hesitancy of COVID-19 vaccines: rapid systematic review of the measurement, predictors, and preventive strategies. Hum Vaccin Immunother 2022;18(5):2074716. https://doi.org/10.1080/21645515.2022.2074716.

SUPPLEMENTARY MATERIAL

SUPPLEMENTARY TABLE S1. Data descriptions of country-level indicators.

Indicators	Description	Data source	Period	Data range
COVID-19 vaccine coverage, acceptance, and delivery				
COVID-19 vaccination coverage, %	Total number of people who received all doses prescribed by the initial vaccination protocol, divided by the total population of the country	Our World in Data	Jul 19, 2022	0.13–126.79*
COVID-19 vaccination acceptance, %	The percentage of adults who intend to be vaccinated or have been vaccinated in the total sample in each studied country	A systematic review and meta-analysis†	Dec 1, 2019 to Feb 27, 2022	35.90–86.90
Delivered dose per capita	The number of COVID-19 vaccine doses delivered according to COVAX and AVAT shipment data, publicly reported deliveries, and donations, divided by total population of the country	UNICEF COVID-19 Vaccine Market Dashboard; World Bank	Jun 2022	0.01–4.43
Demographics				
Urban population, %	Percentage of urban population in the total population	World Bank	2021	13.46–100.00
Population ages 65 and above, %	Percentage of population aged 65 and above in the total population	World Bank	2021	1.45–28.70
Population ages 0–14, %	Percentage of population aged 0–14 in total population	World Bank	2021	12.27–49.54
Social development status				
Socio-demographic index	An index used to evaluate social development. The geometric mean of 0 to 1 indices of TFU25, EDU15+, and LDI per capita	Global Burden of Disease	2019	0.08–0.93
Ln (GDP per capita)	Natural logarithm of GDP per capita (constant US $)	World Bank	2021	5.47–11.82
Pandemic preparedness				
Epidemic ready score	The ready score determines whether a country is prepared to find, stop, and prevent epidemics, using data from the WHO's Joint External Evaluation. It is the average score of 19 areas of preparedness and response capacity on a scale from 0 to 100, with 0 representing a country that is not ready and 100 representing a country that is better prepared.	Prevent Epidemics	Latest	26.00–93.00
Global health security index	The GHS index is an assessment and benchmarking of health security and related capabilities on a score scale from 0 to 100 across countries, including six categories: prevention, detection and reporting, rapid response, health systems, compliance with international norms, and risk environment.	GHS Index	2021	16.00–75.90
Doctors per 1,000 people	Health systems resources.	The Global Health Observatory indicators	Latest	0.23–84.20
Vaccine manufacturing capability	A country was defined as having the capacity for vaccine production if it contained at least one documented manufacturing facility with prior/current vaccine production activity.	Knowledge Ecology International	Mar 1, 2022	0, 1
Governance				
Government effectiveness	Perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies.	World Bank	2020	−2.34–2.34
Control of corruption	Perceptions of the extent to which public power is exercised for private gain, including both petty and grand forms of corruption, as well as "capture" of the state by elites and private interests.	World Bank	2020	−1.91–2.27
State fragility	Incapacity to provide essential public goods and services and cope with shocks.	Fragility States Index	2022	0.90–10.00
Trust				
Trust in government, %	Trust coded as "A great deal" or "Quite a lot" on Q71 asking about confidence in government.	Wellcome Global Monitor 2020	2020	10.93–95.16
Trust in science, %	Trust coded as "A lot" or "Some" on W6 asking about trust in science.	Wellcome Global Monitor 2020	2020	49.45–96.70

Continued

Indicators	Description	Data source	Period	Data range
Interpersonal trust, %	Trust coded as “most people can be trusted” on Q57 asking about interpersonal trust.	World Values Survey wave 7	2021	2.14–64.86
COVAX participation				
Participation in COVAX through advanced market commitment	Leverage the scale assured by the participation of higher-income economies to ensure that lower-income ones are also able to participate.	GAVI	May 12, 2021	0, 1
Self-financing participation in COVAX	Countries with sufficient supply could opt out of getting COVAX doses, leaving more doses for others.	GAVI	May 12, 2021	0, 1

Abbreviation: COVID-19=coronavirus disease 2019; UNICEF=United Nations International Children's Emergency Fund; COVAX=COVID-19 Vaccines Global Access; AVAT=African Vaccine Acquisition Trust; TFU25=total fertility rate under the age of 25; EDU15+=mean education for those ages 15 and older; LDI=lag distributed income; GDP=gross domestic product; GHS=global health security; GAVI=Global Alliancefor Vaccines and Immunizations.

* In some countries or territories, vaccination coverage may exceed 100% since vaccination is available to both residents and non-residents such as tourists and foreign workers.

† 2022; 2:113. Wang Q, Hu S, Du F, Zang S, Xing Y, Qu Z, et al. Mapping global acceptance and uptake of COVID-19 vaccination: A systematic review and meta-analysis. Commun Med (Lond). 2022;2:113. doi: 10.1038/s43856-022-00177-6.