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The global inequity in COVID-19 vaccination coverage among health and care workers

Maria Sarah Nabaggala^{1†}, Tapas Sadasivan Nair^{1†}, Marta Gacic-Dobo², Amani Siyam¹, Khassoum Diallo¹ and Mathieu Boniol^{1*}

Abstract

Background: Health and care workers (HCWs) are at the forefront of COVID-19 response, at high risk of infection, and as a result they are a priority group for COVID-19 vaccination. This paper presents the global patterns in COVID-19 vaccination coverage among HCWs in 2021, how HCWs were prioritized, and identifies factors associated with the early vaccination coverage.

Methods: Using monthly data reported to the World Health Organization, the percentages of partially and fully vaccinated HCWs were computed. The rates of vaccination of HCWs for the first and second half of 2021 were compared in a stratified analysis using several factors. A multivariate analysis was used to investigate the independent associations of these factors with the percentage of HCWs fully vaccinated.

Results: Based on data from 139 Member States, as of end of 2021, 82% HCWs were reported as fully vaccinated with important variations by income groups: 33% for low income countries, 83% for lower-middle income countries, 79% for upper-middle income countries and 88% for high income countries. Overall 76% of countries did not achieve 70% vaccination coverage of their HCWs in the first half of 2021, and 38% of countries by end of 2021. Compared with the general population, the rate of HCWs full vaccination was 3.5 times higher, in particular for low income countries (RR = 5.9). Stratified analysis showed that beyond income group, the availability of vaccine doses was a critical factor of HCWs vaccination coverage with medians of 59.1% and 88.6% coverage in the first and second half of 2021, respectively for countries with enough doses to cover 70% of their population, compared with 0.8% and 47.5% coverage, respectively for countries with doses to cover 40% of their population. The multivariate analysis confirmed this observation with a 35.9% overall difference (95%CI 15.1%; 56.9%) between these two groups.

Conclusion: Despite being considered a priority group, more than a third of countries did not achieve 70% vaccination coverage of their HCWs at the end of 2021. Large inequities were observed with low income countries lagging behind. Additional efforts should be dedicated to ensure full protection of HCWs through vaccination.

Keywords: Health and care workers, Health inequity, COVID-19, Immunization

Background

Health and care workers (HCWs) face a higher risk of exposure to the SARS-Cov-2 virus and of getting infected at their workplace than the general population as a result of contact with potentially at-risk patients [1]. A population-based estimate indicates that around 115,500 HCWs (ranging between 80,000–160,000) out of the global 135 million HCWs may have lost their lives due to the novel coronavirus disease (COVID-19) between January 2020

[†]Maria Sarah Nabaggala and Tapas Sadasivan Nair equally contributed to this work.

*Correspondence: boniolm@who.int

¹ Health Workforce Department, World Health Organization, 20 Avenue Appia, CH-1211 Geneva 27, Switzerland
Full list of author information is available at the end of the article



and May 2021 [2]. A series of global pulse surveys on the continuity of essential health services during the COVID-19 pandemic has consistently indicated that the lack of sufficient health workers was the most common cause of disruptions to essential health services [3–5]. Thus, vaccinating HCWs against COVID-19 has a dual imperative – of not only minimizing their risk of deaths and disease burden from the pandemic, but also ensuring the continued functioning of health systems and the delivery of essential health services.

Accordingly, the World Health Organization (WHO) developed guidance for countries to support and protect their HCWs during the COVID-19 pandemic [6] and recommended that HCWs should be considered a high priority group for COVID-19 vaccination [7, 8]. In response, countries incorporated the vaccination of HCWs as a priority in their COVID-19 national deployment and vaccination plans (NDVPs) [9]. During the WHO's 148th Executive Board meeting, the WHO Director General (DG) issued a challenge to see the vaccination of HCWs and older people underway in all countries within the first 100 days of the year [10]. And at the 74th World Health Assembly, the DG called on all Member States to complete vaccinating their HCWs by September 2021 [11].

Since then, an unmissable global inequity has been observed in COVID-19 vaccines availability and distribution. High income countries initiated their vaccination campaigns in the first quarter of 2021, stockpiled vaccines over and above their population needs and even had to discard millions of vaccines doses which were expiring, while low income countries struggled to procure vaccines constraining their ability to initiate vaccination campaigns [12–14]. These potentially large inequalities in accessing vaccines to inoculate HCWs, could lead to prolonged disruptions of essential services due to illness and death among unprotected HCWs, thereby exacerbating the impact of the COVID-19 pandemic if left unaddressed [15].

This paper sheds light on the global patterns of COVID-19 vaccination coverage among HCWs and the inequity in vaccination uptake during 2021. It examines the extent to which countries prioritized the vaccination of HCWs vis-a-vis the general population, in particular in the first half of 2021. It also evaluates some key factors associated with the early vaccination of HCWs.

Methods

The analysis relies on cumulative COVID-19 vaccination coverage data reported by countries to WHO which included information on vaccination of HCWs and of the general population. A series of analyses were applied to this data to assess trends over time across regions, and

also to identify factors associated with higher vaccination coverage.

The primary source of COVID-19 vaccination coverage data was the WHO/UNICEF electronic Joint Reporting Form (eJRF) on immunization, used by countries to report vaccination data on a monthly basis [16]. The eJRF data were supplemented by region-specific data collection such as The European Surveillance System (TESSy), and the data collection frameworks used in African, South-East Asian, and Western Pacific regions. The data reported to the eJRF and region-specific sources included in this analysis were mutually exclusive. The aggregated monthly data contained cumulative information on the number of persons who received a first and last dose of primary series in the total population and among specific high-risk groups such as HCWs. The data analyzed and presented in this study cover the period February to December 2021 reported to WHO as at February 2022 and only data from the WHO Member States were included when available.

Denominators to compute vaccination coverage were not always reported and when reported showed potential differences in coverage and targets (Additional file 1 section 1.2). Hence to harmonize the denominators necessary to compute the vaccination rate among HCWs and in the general population, the ILOStat estimates of the size of the health and care sector [17], and the total population data from the United Nations' World Population Prospects 2019 [18] were used. Also, some reporting gaps arose for some countries where no statistics on "not vaccinated HCWs" were indicated, and where some countries defined a specific vaccination target lower than their HCWs size. To correct for these reporting gaps, the vaccination rate in the general population was applied to the stock of HCWs for which the vaccination status is unknown (see appendix for further details). To assess the inequality in HCWs vaccination coverage between countries, the percentage of partially and fully vaccinated HCWs up to December 2021 were compared across World Bank income groups [19]. The definition of "fully vaccinated" HCWs was the completion of the primary series of COVID-19 vaccination, which was indicated according to the vaccines regimens, i.e. either as single or 2-dose vaccines. Our analysis did not include booster doses.

To assess the prioritization of HCWs for vaccination by countries, the proportion of full vaccination coverage was compared between HCWs and the general population. These proportions of full vaccination coverage were compared by computing the rate ratio (RR) between HCWs and the general population, with a RR above 1 indicating higher vaccination of HCWs than the general population, and vice versa. Because vaccination coverage varied

overtime, with an initial prioritization of high-risk groups in several countries, two distinct periods were used to analyze the vaccination coverage of HCWs and the RRs: February to June 2021, and, July to December 2021.

The analysis of vaccination coverage was further stratified by a series of factors, by calculating median values of full vaccination coverage among HCWs across stratified groups. Firstly, vaccination-specific factors were considered such as the existence of a COVID-19 NDVP reported to WHO, the presence of a defined HCWs target to be vaccinated, and the availability of COVID-19 vaccines. Secondly, a health and care workforce-specific factor was included, namely the density of nursing personnel (per 10,000 population) based on the latest available data for each country in the National Health Workforce Accounts (NHWA) portal [20]. Lastly, a series of macro-economic factors were also considered: the human development index (HDI), out-of-pocket health expenditure (OPHE) per capita, domestic general government health expenditure (GGHE-D) as a share of gross domestic product (% of GDP), and the proportion of urban population. The broad domains of these factors were selected during the conceptualization of the study. While the vaccination-specific factors were identified from a rapid review of WHO publications on COVID-19 vaccination [8, 9, 21], health workforce-specific and macro-economic factors were already used in previous publications [22, 23]. Specific information on each of these factors are presented in the Supplementary Material (Additional file 1 Table S1). Indicators measured on a continuous scale were systematically categorized into three broad groups. These included vaccines doses availability (% of the vaccination-eligible population) [less than 40%, 40%–69%, 70% and higher]; nursing personnel density (per 10,000 population) [less than 30, 30–60, greater than 60]; the human development index (HDI) [0–0.5, 0.5–0.74, 0.75 – 1]; out-of-pocket health expenditure (OPHE) per capita (US\$) [less than 100, 100–499, 500 and higher]; domestic general government health expenditure (GGHE-D) as percentage of gross domestic product (GDP) [less than 3%, 3%–5.9%, 6% and higher]; and the percentage of urban population [Less than 50%, 50%–74%, 75% and higher].

Multivariate regression was used to investigate the independent associations of vaccination-specific, health and care workforce-specific, and macro-economic factors on the percentage of HCWs fully vaccinated during the first period (February to June 2021) which had the maximum prioritization for HCWs vaccination. Accounting for within-country variance in the percentage of HCWs vaccinated yielded almost systematic statistically significant results for every factor, and countries were used as the unit of analysis. The selection of explanatory

variables was conducted in a forward stepwise approach, to include at least one adjustment factor for each domain (vaccination-specific, health workforce-specific, macro-economic). Because the unit of analysis was the country, the degrees of freedom were limited and required minimizing the number of explanatory variables and their respective categories included in the model. This was also done to avoid any bias resulting from overfitting the model by multiple factors. Explanatory variables retained (World Bank income groups, vaccines doses availability (% of the vaccination-eligible population), OPHE per capita (US\$), and nursing personnel density (per 10,000 population)) were those resulting in the lowest Akaike Information Criterion (AIC) value. The final best-fit parsimonious model selected met the criteria of having the lowest AIC value, and explains the greatest amount of variation in the dependent variable (the share of HCWs vaccinated) using the fewest possible independent variables. All the analyses were conducted using STATA v16.

Results

The situation of HCWs vaccination as of the end of December 2021

Based on data reported by 139 Member States as at December 2021, 45.8 million (81.9%) HCWs were fully vaccinated and 5.3 million (9.6%) were partially vaccinated. In contrast, 23.4% of the general population of these countries were fully vaccinated and 19.5% were partially vaccinated. The proportion of fully vaccinated HCWs varied considerably by World Bank income group, ranging from 88% among high income countries (HICs), 79.4% among upper middle income countries (UMICs), 82.7% among lower middle income countries (LMICs), and 32.6% among low income countries (LICs). It was observed that the rate of HCWs full vaccination was 3.5 times higher than the general population overall, with LICs having the highest rate (5.9 times higher), followed by LMICs (3.5 times higher), UMICs (2.6 times higher) and HICs (1.9 times higher) (Table 1).

Time trend of reporting and coverage of COVID-19 vaccination among HCWs throughout 2021

Countries started reporting COVID-19 vaccination coverage data to WHO in February 2021. The reporting rapidly picked up pace during the initial period, with data from 115 countries (59%) available by June 2021, and improved steadily to 139 countries (72%) by the end of December 2021. Overall, 733 datapoints were received, with an average of 5 monthly reports per country in the period February to December 2021. Analysis of the reporting pattern by income group revealed good coverage across countries in all income groups (Table 1). No major difference in the overall population vaccination

Table 1 COVID-19 vaccination coverage among HCWs and the general population by World Bank income groups (as of December 2021)

World Bank income group [Number of countries reporting (% of stratum total)]	Estimated size of health and care sector ^a (millions)	Vaccination coverage among HCWs			Estimated size of the general population ^b (millions)	Vaccination Coverage among the general population		
		Fully vaccinated [million (%)]	Partially vaccinated [million (%)]	Not vaccinated [million (%)]		Fully vaccinated [million (%)]	Partially vaccinated [million (%)]	Not vaccinated [million (%)]
HIC [n=34(60%)]	25.0	22.0 (88.0)	1.7 (6.9)	1.3 (5.1)	439.2	208.4 (47.5) ^c	25.3 (5.8) ^c	205.5 (46.8) ^c
UMIC [n=37(70%)]	11.4	9.1 (79.4) ^c	2.1 (18.3) ^c	0.3 (2.4) ^c	583.3	175.6 (30.1)	308.1 (52.8)	99.5 (17.1)
LMIC [n=43(80%)]	16.7	13.8 (82.7)	1.2 (7.4)	1.7 (9.9)	2917.7	691.1 (23.7)	536.2 (18.4)	1690.3 (57.9)
LIC [n=25(93%)]	2.8	0.9 (32.6)	0.3 (11.2)	1.7 (56.2)	619.8	34.2 (5.5)	19.6 (3.2)	566.0 (91.3)
Total [n=139(72%)]	55.9	45.8 (81.9)	5.3 (9.6)	4.8 (8.5)	4560.0	1109.4 (24.3)	889.3 (19.5)	2561.3 (56.2)

Source: Data reported to WHO as at December 2021; 10 countries reporting data on HCWs did not report data for the general population

^a Estimated size of health and care sector was extracted from ILOStat 2021

^b Estimated size of general population was extracted from United Nations' World Population Prospects 2019

^c Percentage summations exceeding 100 due to rounding off

coverage was observed between countries included and not included in the present analysis (Additional file 1 Table S2).

The coverage of COVID-19 vaccination among HCWs also improved during 2021. By June 2021, 24% of the reporting countries (28 out of 115) had fully vaccinated at least 70% of their HCWs; this proportion more than doubled to reach 62% (87 out of 139) by the end of the

year. The achievement of 70% full vaccination coverage among HCWs was least among LICs (28%) and highest among HICs (97%) as of December 2021 (Fig. 1). The trend in achievement of 70% coverage was almost similar for LMICs and UMICs initially, the progress in HICs appears to start slowly and rapidly surpassing other regions from June, and LICs showed slow progress and

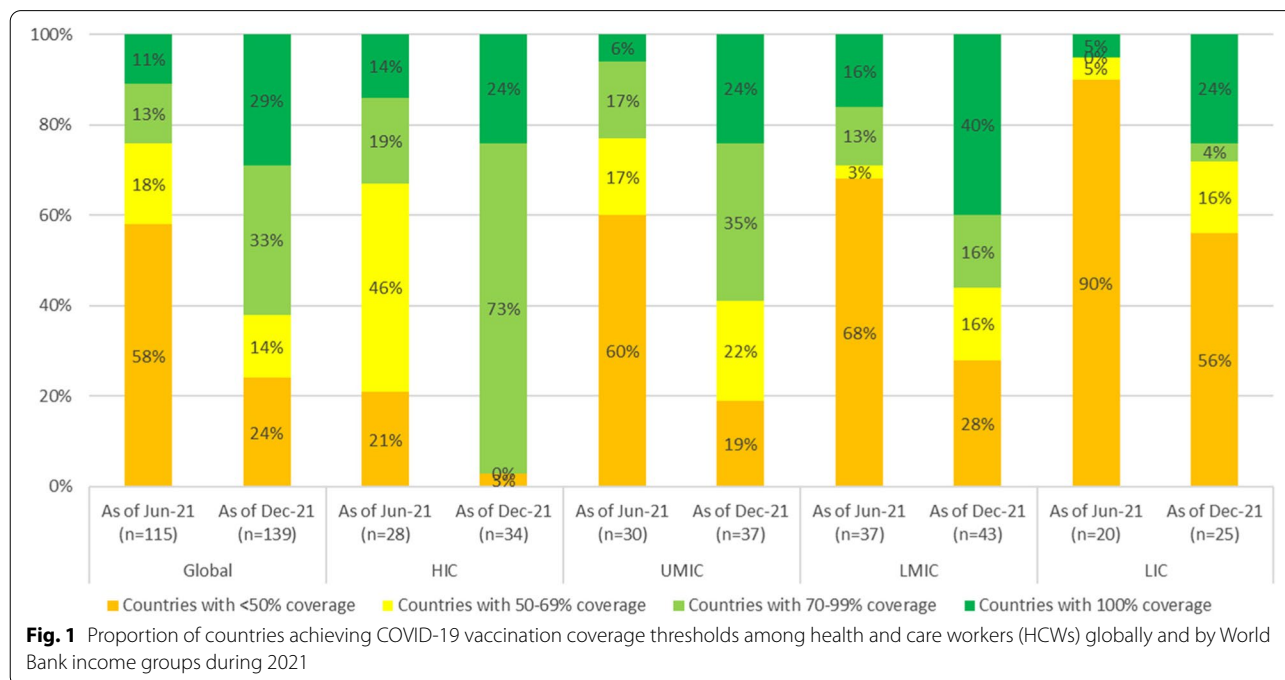


Fig. 1 Proportion of countries achieving COVID-19 vaccination coverage thresholds among health and care workers (HCWs) globally and by World Bank income groups during 2021

remained low by end of December 2021 (Additional file 1 Figure S1).

The prioritization of HCWs vaccination compared to the general population during 2021

Comparing the full vaccination coverage rate ratios (RRs) of the initial period (February-June 2021) with the later period (July-December 2021) shows that HCWs were several times more vaccinated than the general population across countries regardless of income group, with maximum RR in LICs ($RR \geq 100$) and minimum among HICs ($1 < RR < 100$) (Fig. 2). In LICs and middle income countries (MICs), the vaccination of HCWs occurred at a relatively higher pace than that of the general population in the first period, which then levelled in the second period. The same pattern was observed in HICs, where the vaccination of HCWs was prioritized over the general population in the initial period and then not as much during the later period (Fig. 2).

Assessing factors associated with higher COVID-19 vaccination coverage among HCWs

Table 2 presents the stratified analysis of HCWs full vaccination coverage in 115 countries that reported data up to June 2021 and in 139 countries up to December 2021, relative to a series of comparative factors.

Vaccination-specific factors

The reporting of a NVDP to WHO was not associated with an increase vaccination coverage, probably because it was mainly carried-out by low income countries. Initially countries that reported targets for HCWs vaccination showed a higher full vaccination coverage in comparison to those that did not, however that advantage narrowed down to less than 5% by the end of 2021. Although countries with high vaccines doses availability (vaccines available for $\geq 70\%$ of the vaccination-eligible population) had a sizeable HCWs median full vaccination coverage (59.1%) in mid-2021, countries with moderate vaccine availability (40–69%) levelled the difference by December 2021.

Health and care workforce specific factor

Countries in the group with the highest density of nursing personnel (> 60 nurses per 10,000 population) had a higher HCWs full vaccination coverage throughout the study period compared to those with lower densities achieved.

Macro-economic factors

The lowest HCW median full vaccination coverage was consistently in countries with the lowest HDI. Comparisons using other macro-economic factors showed an initial variability in the HCW full vaccination coverage between countries, yet again the differential advantage between strata narrowed down by the end of the year.

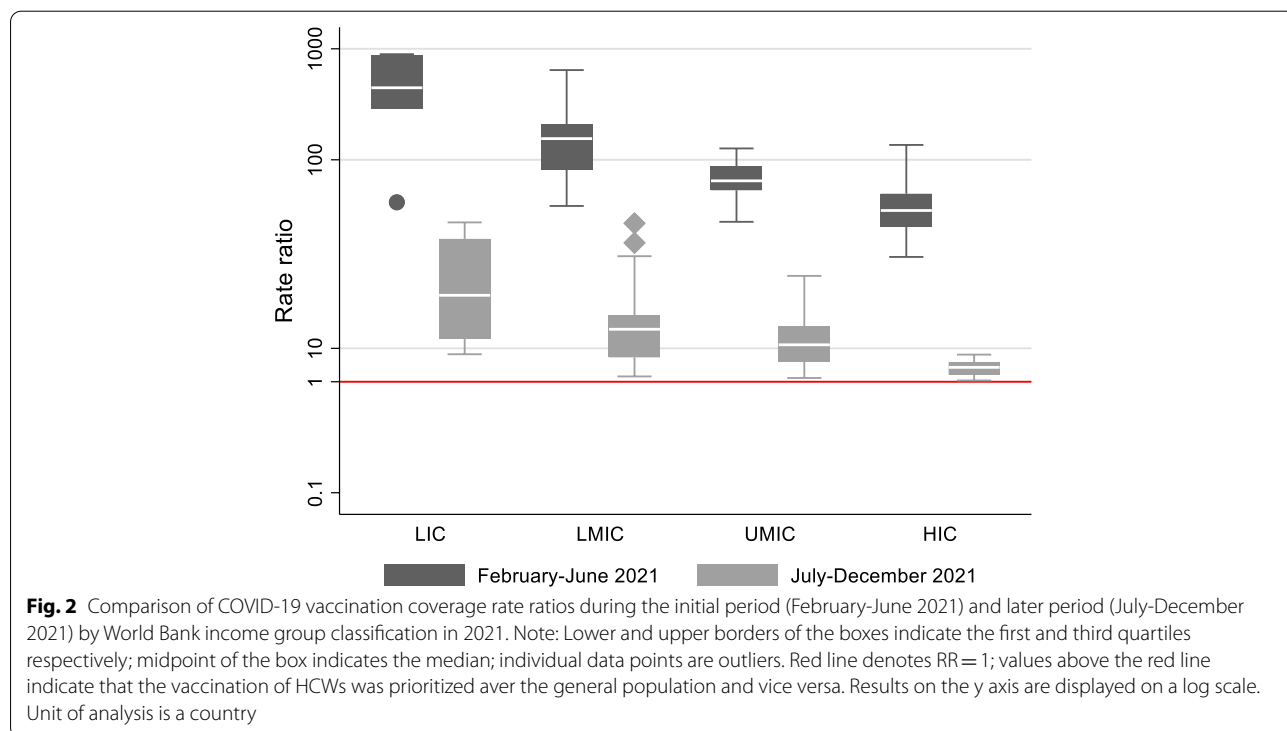


Table 2 Analysis of COVID-19 vaccination coverage among HCWs by vaccination-specific factors, health workforce-specific factors and macro-economic factors

Factor	Categories	Full vaccination coverage of HCWs			
		As at June 2021		As at December 2021	
		No of countries (n = 115)	Coverage [median (quartiles 1 and 3)]	No of countries (n = 139)	Coverage [median (quartiles 1 and 3)]
Vaccination-specific factors					
Existence of NDVP reported to WHO ^a	Presence	58	2.5 (0.2 – 42.4)	68	61.3 (38.6 – 100.0)
	Absence	57	56.9 (17.4 – 80.5)	71	85.6 (71.5 – 100.0)
HCWs vaccination target set ^a	Target not set or not reported	47	1.9 (0.2 – 35.4)	59	75.2 (44.6 – 100.0)
	Target set	68	57.4 (14.6 – 82.9)	80	78.6 (57.4 – 100.0)
Vaccines doses availability (% of the vaccination-eligible population) ^a	< 40%	31	0.8 (0.1 – 8.0)	41	47.5 (31.1 – 98.8)
	40%—69%	28	18.7 (2.0 – 57.1)	30	70.3 (54.4 – 100.0)
	≥ 70%	56	59.1 (31.0 – 83.7)	68	88.6 (73.5 – 100.0)
Health workforce-specific factor					
Nursing personnel density (per 10,000 population) ^a	< 30	58	3.0 (0.2 – 59.5)	68	67.5 (37.5 – 100.0)
	30—60	29	38.8 (10.4 – 72.8)	35	77.2 (56.7 – 100.0)
	> 60	28	58.6 (39.2 – 74.3)	36	85.5 (71.5 – 95.3)
Macro-economic factors					
Human Development Index (HDI) ^a	0—0.49	15	0.2 (0.0 – 17.5)	18	35.5 (16.8 – 69.0)
	0.5—0.74	54	5.5 (0.9 – 58.0)	63	69.2 (44.6 – 100.0)
	0.75—1	44	59.1 (38.9 – 82.1)	51	86.2 (73.1 – 98.6)
Out-of-pocket health expenditure (OPHE) per capita (US\$) ^a	< 100	64	3.0 (0.3 – 44.9)	78	70.3 (40.6 – 100.0)
	100—499	30	54.8 (14.2 – 78.5)	33	78.9 (67.3 – 96.4)
	≥ 500	15	67.2 (51.7 – 89.7)	17	89.9 (76.4 – 94.3)
Domestic general government health expenditure (GGHE-D) (% of GDP) ^a	< 3%	51	5.2 (0.3 – 38.8)	61	68.0 (38.6 – 100.0)
	3%—5.9%	41	56.8 (17.2 – 82.0)	45	78.4 (71.2 – 98.8)
	≥ 6%	14	57.4 (5.7 – 68.0)	18	91.2 (80.5 – 100.0)
Proportion of urban population (%) ^a	< 50%	39	2.5 (0.1 – 35.4)	46	66.9 (38.6 – 100.0)
	50%—74%	44	44.7 (4.5 – 75.3)	47	73.8 (55.1 – 96.3)
	≥ 75%	22	58.6 (37.3 – 87.0)	29	90.5 (76.4 – 100.0)

Source: Data reported to WHO as at December 2021

^a Detailed information about these factors is available in Table S1

A similar analysis of 87 countries that reported data at least over three periods is presented in the Supplementary Material (Additional file 1 Table S3) and has no discernable differences in interpretation to those presented in Table 2.

One could speculate that “Zero-COVID” strategies could have led to a delay in vaccination rollout hence a lower HCWs vaccination coverage. However, comparing the results of countries that implemented such strategies with others in the same income group for which data were available, did not support that notion in indicating a lower vaccination coverage.

A multiple linear regression was used to assess the multivariate effects of various explanatory variables on the HCWs full vaccination coverage during the initial period (February-June 2021). Out of 115 countries which reported data for the first period, 109 had

complete data for all co-variables and were included in the analysis (Table 3). It was observed that the availability of vaccines doses had a positive correlation with HCW full vaccination coverage. It was statistically significant for the highest category—countries with vaccines available for ≥ 70% of the vaccination-eligible population had an adjusted average HCW full vaccination coverage 35.9 percentage points higher than countries with less than 40% vaccine available. Country’s income group and density of nursing personnel had no adjusted impact on HCW full vaccination coverage. For OPHE, no statistical association was identified but the trend from lowest to highest category can be noted. These correlations and their directions were observed in intermediate models with and without adjusting for income group or other factors, hence not the result of collinearity. A similar model-based analysis

Table 3 Multiple linear regression for HCWs full vaccination coverage during the period February to June 2021 ($n=115$ countries)

	Coefficient (95% Confidence Intervals)
World Bank income groups	
LIC	ref
LMIC	12.4 (-8.2; 33.0)
UMIC	9.3 (-18.2; 36.9)
HIC	9.6 (-28.3; 47.4)
Vaccines doses availability (% of the vaccination-eligible population)^a	
<40%	ref
40% to 69%	15.5 (-3.9; 34.9)
≥70%	35.9 (15.1; 56.9)
Out-of-pocket health expenditure (OPHE) per capita (US\$)^a	
<100	ref
100 to 499	12.6 (-9.4; 34.5)
≥500	25.0 (-6.4; 56.4)
Nursing personnel density (per 10,000 population)^a	
<30	ref
30 to 60	-10.4 (-29.6; 8.6)
>60	-9.4 (-32.2; 13.4)

^a Detailed information about these factors is available in Additional file 1 Table S1

using the data reported as of the end of 2021 by 121 countries which had complete data for all co-variables is presented in the Supplementary Material (Additional file 1 Table S4), and shows similar findings to those of Table 3. An attenuated effect of the vaccines dose availability variable and a statistically significant association with income group can be noted, which could be due to including the full period and better identification of the differences observed in Fig. 1. Further, a log-linear regression was used to assess the multivariate effects of various explanatory variables on the HCWs full vaccination coverage during the initial period (February-June 2021) with results expressed as rate ratios (Additional file 1 Table S5) and similar findings were shown.

Discussion

After one year of COVID-19 vaccine deployment, the latest available data from 139 countries as at December 2021 suggests that overall 8 in 10 of their HCWs have been fully vaccinated. This achievement is higher than that found among the general population (about 1 in 3) and highlights that countries have made substantial efforts to prioritize the vaccination of HCWs, particularly during the initial months of vaccines availability. While there was a global call for prioritizing HCWs during the

first 100 days of 2021 [10], the vaccination coverage rate started at a relatively slow pace and gradually accelerated. However, this uptake is heterogeneous, with more than half of the HCWs (56.2%) belonging to the reporting LICs still not having received even a single dose of COVID-19 vaccination by the end of 2021.

The availability of COVID-19 vaccines doses was identified as a major contributing factor of the vaccination coverage among HCWs. While the analysis showed that countries reporting having set targets for HCWs vaccination were able to quickly ramp up their full vaccination coverage during the initial period, whether or not a NDVP existed or was reported to WHO was not associated with a rapid uptake in HCWs vaccination coverage. The results of this analysis underscores that HICs were able to achieve higher vaccination coverage of HCWs, since they were able to procure surplus doses of COVID-19 vaccines [12–15, 24].

By and large, the *Strategy to achieve Global COVID-19 Vaccination by mid-2022* [25] outlined a series of steps for the global community to achieve 70% coverage in all countries by mid-2022, in which the first interim target was 10% coverage by September 2021 through the completion of vaccination of older adults and high-risk populations (including HCWs). It is therefore disconcerting to note in this study that more than a third of countries (49 of 139) were not able to achieve the general population target of 70% vaccination coverage for their HCWs by the end of 2021 and that only 29% (40 of 139) were able to fully vaccinate all their HCWs.

It is important to recall that the *Global Strategy on human resources for health: workforce 2030* (GSHRH) [26] identified inequities in the availability of HCWs between and within countries, and the persisting HCWs shortages in relation to health systems and population needs. More recent evidence has further highlighted the gravity of the inequitable distribution of specific HCW occupations [23, 27, 28]. Despite the reasonable progress presented by this study, the universal protection of HCWs with COVID-19 vaccination uptake is yet to be achieved and inequity remains high particularly in LICs, where more than half of HCWs were not fully vaccinated by end of 2021. As such, LICs are facing a double jeopardy – of not having adequate HCWs, and of them not being adequately protected by vaccination against COVID-19. Vaccine inequity could therefore exacerbate the inequitable access to HCWs, to essential health services, and to services required during the pandemic, such as creating surge capacities and delivering COVID-19 vaccinations. Low and middle income countries have already suffered unequivocal disruptions to essential health services [3–5], hence ensuring the protection of their HCWs by vaccination against COVID-19 is critical to safeguard their health systems from collapse.

Another cause for concern is that out of the 194 countries reporting vaccination coverage data to WHO, only 139 (72%) provided data on HCWs vaccination coverage and 55 countries (28%) have not. In the case of the latter, this could partly be attributable to how the health information system in these countries integrates HCWs vaccination data in the national immunization surveillance system.

Since this analysis depends on the self-reported data by countries to WHO, it has certain inherent limitations – one being that all countries may not have reported their data, and that countries may not have reported their most up-to-date data. Even though 139 countries (of 194) have reported HCWs vaccination data, there is good coverage across geographical regions and income groups, with even the least reporting group (HICs) having a majority of countries reporting (60%). Also, the vaccination coverage in the total population in reporting and non reporting countries were not divergent, and not showing a particular selection of countries with better performance in full vaccination coverage (Additional file 1 Table S2). Another limitation was that the target population was not reported by all countries and for those that did report, there were several inconsistencies due to varying definitions used by countries. We accounted for this by using the estimated size of the health and care sector from ILO Stats [17] instead. Even if the analysis was adjusted for the workers with status unknown by applying the rate of vaccination of the general population, this might have led to a potential underestimation of the actual HCW vaccination coverage. A third limitation was that some countries did not report HCW vaccination data for all months, thus creating gaps in the time series data. Hence, the status as of December is likely to be underestimating the actual HCW vaccination coverage at the end of 2021.

The present analysis did not consider the levels of vaccine hesitancy among HCWs [29, 30], and country-specific policies on mandatory vaccination among HCWs could have had positive, but also probable negative, role on the vaccination coverage. It should be noted however that even in countries with no national level mandatory policies, some of these practices and policies were implemented at facility service delivery level.

Finally, the ongoing measurement of vaccination coverage and comparisons across countries will become more challenging, as more countries incorporate booster doses for HCWs in their vaccination programs. The analysis presented in this study could only consider vaccination coverage data up to December 2021, and hence the definition of “fully vaccinated” measures the status of completion of the primary series of vaccination (without booster doses) for HCWs. More crucially, the continuing occurrence of new variants heighten SARS-CoV-2

incidence rates which act to increase the risk of vaccines escape [31]. This creates additional concerns especially for countries that have not achieved the primary series of vaccination of all their HCWs. Even for countries who achieved it, strategies for mitigating the vaccine escape risk should be explored such as strengthening infection prevention and control measures and access to vaccine booster doses.

Conclusions

HCWs are the cornerstone of the COVID-19 vaccination roll-out in the general population. While countries across the world have made progress in prioritizing their HCWs for COVID-19 vaccination, the target of achieving universal protection of HCWs against COVID-19 by September 2021 was unmet by the end of 2021. By missing this target, the broader target of reaching 70% vaccination coverage of the total population in all countries by June 2022 appears to be least likely. Ensuring all countries have adequate availability of COVID-19 vaccines doses is critical to rapidly accelerate their HCWs vaccination coverage. The results presented in this study underscore the importance of multilateral mechanisms such as COVAX in ensuring vaccine equity, and the need for countries to act beyond merely prioritizing their own citizens' vaccinations, as “no one is safe until everyone is safe” [32, 33]. Countries need to reinforce the prioritization of HCWs for COVID-19 vaccination by defining a target number of HCWs to vaccinate and to undertake strategic and operational actions to ensure that this high-risk group is universally protected. Provision of vaccines free of charge to HCWs would be another route to improve their access to vaccination.

Countries also need to engage with HCWs as active agents and partners in shaping the overall vaccination efforts and address the underlying factors of vaccine hesitancy. Undoubtedly, the pandemic response pushed all health systems to create multipronged surge capacities and it is therefore imperative to include maximal protection of HCWs in broader policies aimed at improving access to personal protective equipments, decent working conditions and mental health and well-being support.

Abbreviations

AIC: Akaike Information Criterion; COVID-19: Coronavirus disease 2019; DG: Director-General; eJRF: WHO/UNICEF electronic Joint Reporting Form on Immunization; GDP: Gross domestic product; GGHE-D: Domestic general government health expenditure; GSHRH: Global Strategy on human resources for health: workforce 2030; HCW: Health and care workers; HDI: Human Development Index; HIC: High income countries; LIC: Low income countries; LMIC: Lower middle income countries; MIC: Middle income countries; NDVP: National Deployment and Vaccination Plan for COVID-19 vaccines; NHWA: National Health Workforce Accounts; OPHE: Out-of-pocket health expenditure; RR: Rate ratio; SARS-CoV-2: Severe acute respiratory syndrome coronavirus 2;

TESSy: The European Surveillance System; UMIC: Upper middle income countries; UNICEF: United Nations Children's Fund; WHO: World Health Organization; US\$: United States dollar.

Supplementary Information

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Additional file 1.

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Authors' contributions

MB and KD conceptualized the study. MSN and MGD conducted data management. MSN, MB and TSN conducted data analysis. TSN and MSN drafted the first manuscript. All authors contributed to editing the manuscript. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Author details

¹Health Workforce Department, World Health Organization, 20 Avenue Appia, CH-1211 Geneva 27, Switzerland. ²Immunization, Vaccines & Biologicals Department, World Health Organization, Geneva, Switzerland.

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