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**Review Article**

# Acceptance rate of COVID-19 vaccine among healthcare workers: A systematic review and meta-analysis

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ABSTRACT

**Background & Aim:** Vaccination is the most efficient strategy to tackle the COVID-19 epidemic, and it is important in many ways. Additionally, healthcare workers represent an important vaccine information source for the general population. This systematic review and meta-analysis aimed to evaluate the COVID-19 vaccine acceptance rate among healthcare workers.

**Methods & Materials:** This study was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline, and the protocol of this study was registered in PROSPERO with the registration number CRD42023402082. Searches were conducted up to 20 October 2023 in data resources, including PubMed, Scopus, Web of Science, and Google Scholar. The random-effects model was used for meta-analysis, and the $I^2$ index was used to evaluate heterogeneity among studies. The STATA software (version 14) was used for data analysis.

**Results:** During the initial search, 6132 articles were selected. After the screening, study selection, and quality assessment, 93 studies entered the meta-analysis process, and a total of 196235 healthcare workers were examined. The overall vaccine acceptance rate among healthcare workers was reported as 68.56% (95% confidence interval (CI) =18.7-99.7; $I^2 = 99.750\%$; $p< 0.001$).

**Conclusion:** The overall acceptance rate of the COVID-19 vaccine in healthcare workers was lower than expected. Also, some determining factors were identified. The analysis of the vaccine acceptance rate and the factors affecting it can help healthcare officials and policymakers with proper healthcare planning.

## Introduction

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) emerged as a major global healthcare threat at the end of 2019 (1, 2). To control this epidemic, besides public health measures, such as social distancing, wearing face masks, and educating people, effective vaccination is necessary to reduce the cases of SARS-CoV-2 and associated deaths (3, 4). Extensive research and development have been conducted worldwide for COVID-19 vaccination as the most efficient strategy to curb the pandemic (1). Receiving the COVID-19 vaccine is an important challenge that has to be addressed (5). Obtaining information on vaccine acceptance is crucial for the proper preparation of future vaccination strategies and immunization programs against COVID-19 (6). Vaccine acceptance is a measure of the public perception of the disease risk and the attitude towards vaccination (7).

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In fact, HCWs (Health Care Workers) are on the front line of fighting against epidemics, and some of them have to perform tasks with a high risk of exposure to pathogens (8). Furthermore, HCWs can be an important source of vaccine information for the general population. According to studies, people who received information from public health officials were more likely to vaccinate against COVID-19 (9). Also, people were more likely to get vaccinated if their HCWs would recommend them to receive a COVID-19 vaccine (10). Furthermore, people holding conspiracy beliefs identified HCWs as a trustworthy source that may influence their vaccine decisions. In addition, the vaccination of the largest number of HCWs is necessary both in terms of preventing the spread of infection and the loss of skilled workforce (11). Therefore, it is important to evaluate vaccine acceptance among HCWs (12). Some studies have found that vaccine acceptance among HCWs is less than desirable (13).

Moreover, the determining factors in vaccine acceptance among HCWs must be considered. Researchers studied vaccine acceptance among HCWs in the United States and showed that vaccine acceptance increases with increasing age, education, and income level (11). Accordingly, various factors affect the vaccine acceptance rate among HCWs. The analysis results of these factors are helpful for healthcare officials and policymakers for proper healthcare planning (14).

Several preliminary studies have been conducted on the COVID-19 vaccine acceptance rate and associated factors in different parts of the world. However, no comprehensive study has been conducted to evaluate and summarize the findings for HCWs. Studies that have been done so far have either been general or other populations (15). In addition, studies have been conducted in some continents and countries in particular, which are not universal (16, 17). A review has also been conducted in 2021, when vaccination is not yet widely available globally. Only nine articles have been included in this research (18). Separately, other studies have been conducted to examine the effective factors in which the acceptance rate was not calculated. The proportion of HCWs who intend to accept a COVID-19 vaccination has been reported with a wide range among studies from 27.7% to 90.1%, which has been attributed to various reasons, such as concerns raised about the vaccination of COVID-19, which are related to insufficient knowledge in The case of such new vaccines is related to long-term side effects, effectiveness, efficiency, etc. (17). Therefore, according to the above explanations and the need for a comprehensive investigation and more detailed information gathering, this study was conducted to determine the COVID-19 vaccine acceptance rate among HCWs in general and in subgroups by using systematic review and meta-analysis, as well as to summarize and analyze the factors associated with vaccine acceptance in various studies.

## Methods

In this systematic review and meta-analysis, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline was used (19). The protocol of the present study was registered in the International Prospective Register of Systematic Reviews (PROSPERO) with the registration number CRD42023402082. The PRISMA guideline was used to conduct the search strategy, screening, study selection, quality assessment, and data extraction.

### *Data resources and search strategy*

In the present study, related articles were searched and selected using the Data resources PubMed, Scopus, and Web of Science. Searches were conducted from 2020 up to 20 October 2023. The search engine Google Scholar and the references in the selected articles were manually reviewed to further identify the relevant studies. The process of obtaining appropriate keywords from medical subject headings (MeSH) involved utilizing the keywords from relevant studies. To determine the search strategies for all databases, the following valid keywords were used. "Health care provider," "COVID-19," and "vaccination acceptance." Search fields and operators were used, and searches were performed from the beginning of 2020 until 20 October 2023. Table 1 shows the search strategy for all databases.

**Table 1.** Search strategy in databases

| Databases | Search strategy | N |
|---|---|---|
| **PubMed** | ("Vaccine resistant*" [TI] OR "Vaccination Hesitanc*" [TI] OR "Vaccine Delay*" [TI] OR "Vaccination Delay*" [TI] OR "Autogenous Vaccine*" [TI] OR "vaccine acceptance" [TI] OR "Vaccine refusal" [TI] OR "COVID-19 vaccine" [TI] OR "vaccination campaign" [TI] OR "Vaccination trust" [TI]) AND ("Health Personnel" OR "Health Care Provider*" OR "Healthcare Provider*" OR "Healthcare Worker*" OR "Health Care Professional*" OR "healthcare personnel" OR "health care personnel" OR "Medical Staff" OR "Medical worker") AND (COVID 19 OR "SARS-CoV-2 Infection" OR "SARS CoV 2 Infection*" OR "2019 Novel Coronavirus Disease" OR "2019 Novel Coronavirus Infection" OR "2019-nCoV Disease*" OR "COVID-19 Virus Infection*" OR "Coronavirus Disease 2019" OR "Coronavirus Disease-19" OR "Coronavirus Disease 19" OR "Severe Acute Respiratory Syndrome Coronavirus 2 Infection" OR "SARS Coronavirus 2 Infection" OR "COVID-19 Virus Disease*" OR "2019-nCoV Infection*" OR COVID19 OR "COVID-19 Pandemic*" OR "COVID 19 Pandemic") | 753 |
| **Scopus** | ((TITLE-ABS-KEY("Vaccine resistant*") OR TITLE-ABS-KEY("Vaccination Hesitanc*") OR TITLE-ABS-KEY("Vaccine Delay*") OR TITLE-ABS-KEY("Vaccination Delay*") OR TITLE-ABS-KEY ("Autogenous Vaccine*") OR TITLE-ABS-KEY("vaccine acceptance") OR TITLE-ABS-KEY("Vaccine refusal") OR TITLE-ABS-KEY("COVID-19 vaccine*") OR TITLE-ABS-KEY("vaccination campaign") OR TITLE-ABS-KEY("Vaccination trust")) AND (TITLE-ABS-KEY(COVID 19) OR TITLE-ABS-KEY("SARS-CoV-2 Infection") OR TITLE-ABS-KEY("SARS CoV 2 Infection*") OR TITLE-ABS-KEY("2019 Novel Coronavirus Disease") OR TITLE-ABS-KEY("2019 Novel Coronavirus Infection") OR TITLE-ABS-KEY("2019-nCoV Disease*") OR TITLE-ABS-KEY("COVID-19 Virus Infection*") OR TITLE-ABS-KEY("Coronavirus Disease 2019") OR TITLE-ABS-KEY("Coronavirus Disease-19") OR TITLE-ABS-KEY("Coronavirus Disease 19") OR TITLE-ABS-KEY("Severe Acute Respiratory Syndrome Coronavirus 2 Infection") OR TITLE-ABS-KEY("SARS Coronavirus 2 Infection") OR TITLE-ABS-KEY("COVID-19 Virus Disease*") OR TITLE-ABS-KEY("2019-nCoV Infection*") OR TITLE-ABS-KEY(COVID19) OR TITLE-ABS-KEY("COVID-19 Pandemic*") OR TITLE-ABS-KEY("COVID 19 Pandemic")) AND (TITLE-ABS-KEY("Health Personnel") OR TITLE-ABS-KEY("Health Care Provider*") OR TITLE-ABS-KEY("Healthcare Provider*") OR TITLE-ABS-KEY("Healthcare Worker*") OR TITLE-ABS-KEY("Health Care Professional*") OR TITLE-ABS-KEY("healthcare personnel") OR TITLE-ABS-KEY("health care personnel") OR TITLE-ABS-KEY("Medical Staff") OR TITLE-ABS-KEY("Medical worker"))) | 3,783 |
| **Web of Science** | ((TS=("Vaccine resistant*") OR TS= ("Vaccination Hesitanc*") OR TS= ("Vaccine Delay*") OR TS=("Vaccination Delay*") OR TS=("Autogenous Vaccine*") OR TS=("vaccine acceptance") OR TS=("Vaccine refusal") OR TS=("COVID-19 vaccine*") OR TS=("vaccination campaign") OR TS=("Vaccination trust")) AND (TS= (COVID 19) OR TS= ("SARS-CoV-2 Infection") OR TS= ("SARS CoV 2 Infection*") OR TS= ("2019 Novel Coronavirus Disease") OR TS= ("2019 Novel Coronavirus Infection") OR TS= ("2019-nCoV Disease*") OR TS= ("COVID-19 Virus Infection*") OR TS= ("Coronavirus Disease 2019") OR TS= ("Coronavirus Disease-19") OR TS= ("Coronavirus Disease 19") OR TS= ("Severe Acute Respiratory Syndrome Coronavirus 2 Infection") OR TS= ("SARS Coronavirus 2 Infection") OR TS= ("COVID-19 Virus Disease*") OR TS= ("2019-nCoV Infection*") OR TS= (COVID19) OR TS= ("COVID-19 Pandemic*") OR TS= ("COVID 19 Pandemic")) AND (TS= ("Health Personnel") OR TS= ("Health Care Provider*") OR TS= ("Healthcare Provider*") OR TS= ("Healthcare Worker*") OR TS= ("Health Care Professional*") OR TS= ("healthcare personnel") OR TS= ("health care personnel") OR TS= ("Medical Staff") OR TS= ("Medical worker" ))) | 1596 |

### *Inclusion criteria*

All the English articles that evaluated the COVID-19 vaccine acceptance rate among HCWs from 2020 until 20 October 2023 were included. The target population in this study was the healthcare workers who provided medical services to COVID-19 victims.

### *Exclusion criteria*

The studies that had evaluated the COVID-19 vaccine acceptance rate among groups other than HCWs were excluded. Additionally, systematic review studies, intervention studies, case reports, theses/dissertations, letters to editors, and conference papers were excluded. Also, studies that did not obtain the necessary data based on the purpose of the study were excluded.

### *Study selection*

Following the initial search, all articles were imported into EndNote X8 to handle the search results. After removing duplicates, the titles and abstracts of other articles were

screened based on the eligibility criteria. Then, the initial possible relevant articles were identified. Next, two researchers independently read the full texts of the initial possible relevant articles in detail. Finally, the eligible articles were selected. In case of disagreement between the two researchers, a decision was made via group discussion.

### *Quality assessment and data extraction*

In this step, the quality assessment of the selected studies was independently carried out by two researchers. A third individual resolved any disagreement between the two evaluators. Accordingly, the Appraisal tool for Cross-Sectional Studies (AXIS) was used (20). This tool has a score range of 0-20, and the articles with a score of 12 or higher were selected for meta-analysis (21, 22). Data extraction was also carried out by the two researchers independently. The third reviewer resolved any disagreement between the reviewers. According to the consensus, a decision was made and agreed upon. At this stage, items such as the first author's name, sample size, tools, number of men and women, and vaccine acceptance rate were extracted for each study, and then the extracted items were counted in the prepared checklist.

### *Ethical consideration*

The present study was approved by the Ethics Council of Research Ethics Committees (Ethical code: IR.SBMU.RETECH.REC.1402.074).

### *Statistical analysis*

The $I^2$ index was used to evaluate the between-study heterogeneity. $I^2$ index <25%, 25–50%, 50–75%, and more than 75% showed no heterogeneity, moderate, high, and very high heterogeneity, respectively (23). In order to minimize the heterogeneity between studies, a random effects model was employed for conducting the meta-analysis. Begg test was used to evaluate the publication bias. Data analysis was carried out using STATA software ver. 14.

## Results

### *Systematic review*

In the initial search, 6132 articles were identified. Of these articles, 1532 were duplicates, and nine were removed for other reasons, so they were excluded. A total of 4591 studies were included in the screening process, and 3956 were excluded, according to the inclusion and exclusion criteria, respectively.

Then, the full texts of the remaining 635 studies were read, and 451 studies were excluded due to their irrelevant subjects. After assessing for eligibility of studies, 91 studies were excluded. Finally, 93 relevant articles were selected for quality assessment, all of which were included in the meta-analysis (Figure 1).

The total sample size of the studies was 196235. First, the studies were categorized based on the continent. However, there was significant heterogeneity in the distribution of studies. Therefore, according to the WHO classification, we considered six regions for the distribution of studies. The distribution of studies in the classification of WHO regions is more homogeneous.

Figure 2 shows the distribution of studies in different continents and six WHO regions separately. Each WHO Regional Office has a "Regional Committee" consisting of the Ministries of Health of the member countries. Most studies were conducted in the European Region (EUR) and 18 countries. Also distribution of countries according to article studies was shown on Geographical world (Figure 3).

Additionally, two studies have been jointly conducted in several regions with 91 and 37 countries. Table 2 presents the other characteristics of the reviewed studies in the systematic review and meta-analysis.

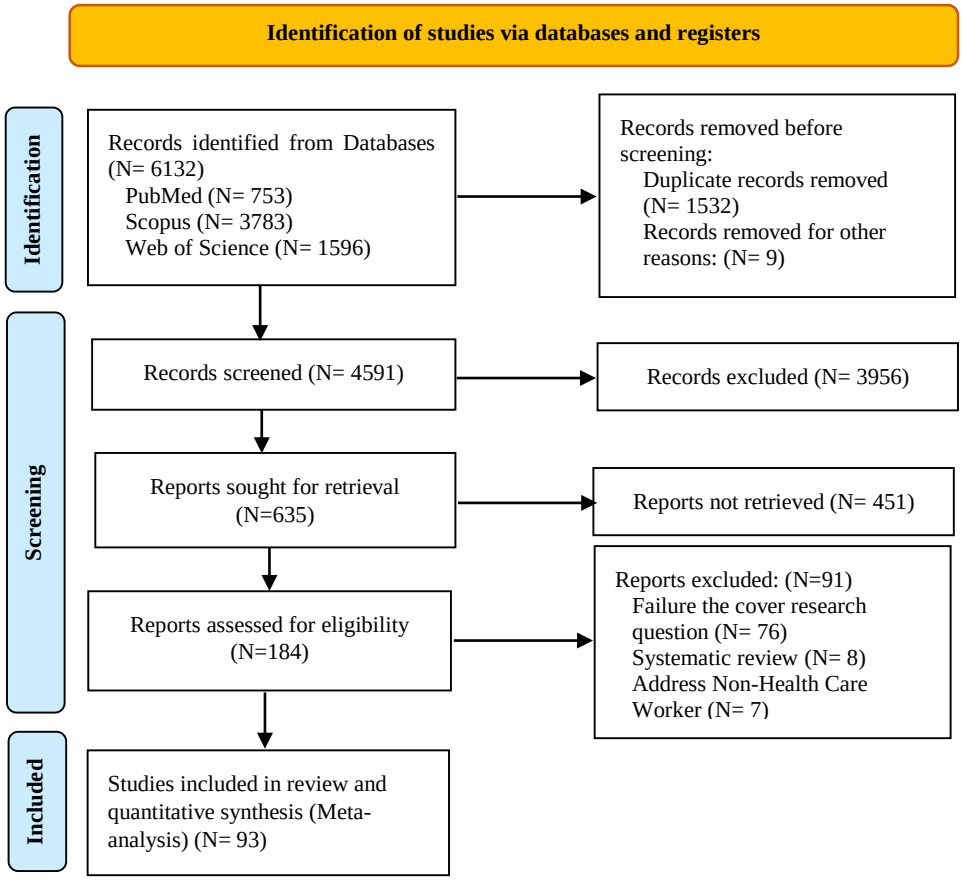



**Figure 1.** Flow diagram of the Selection of Studies Based on PRISMA 2020

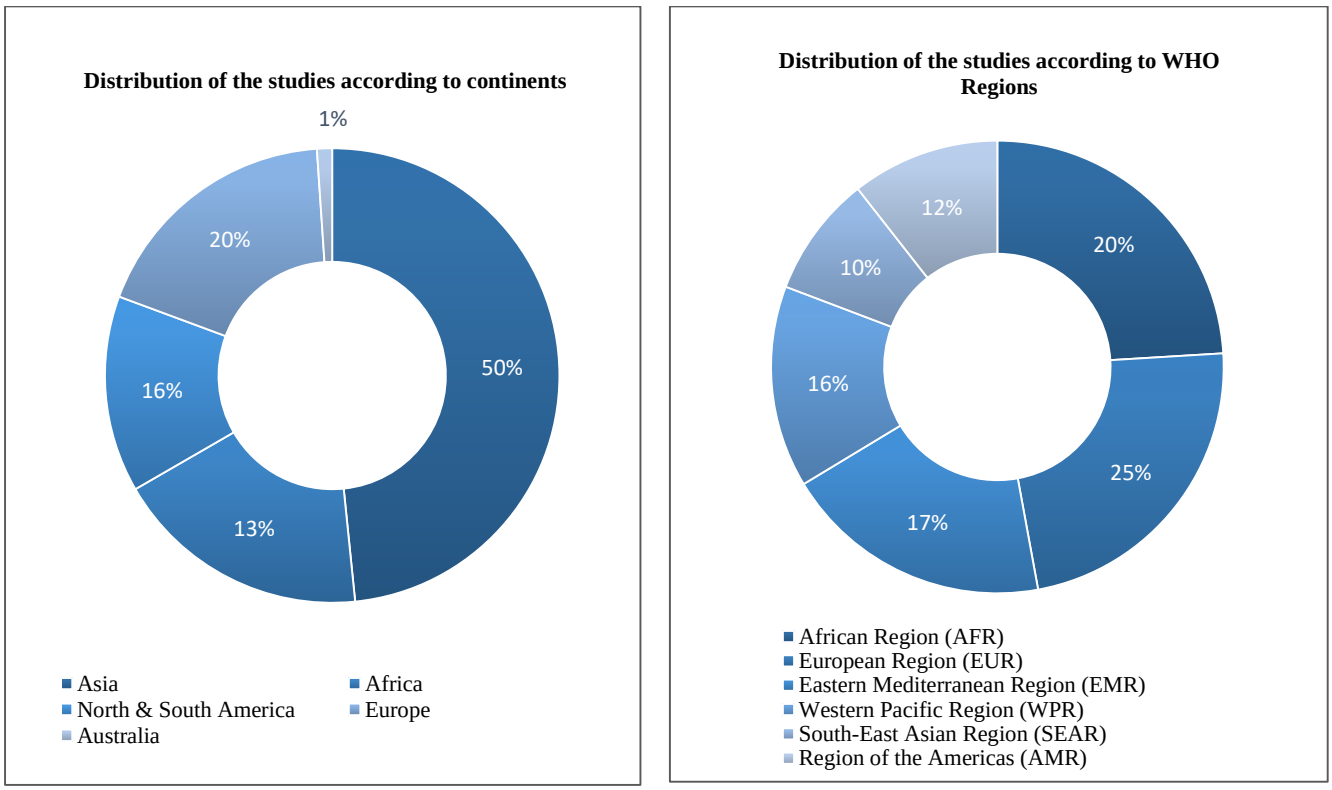



**Figure 2.** Characteristics of studies included in the systematic review and meta-analysis


**Figure 3.** Geographical world distribution of countries according to article studies

**Table 2.** Characteristics of studies included in the systematic review and meta-analysis

| No | First Author | Year | Country | WHO Regions | Continent | N | Male | Female | Acceptance rate % |
|---|---|---|---|---|---|---|---|---|---|
| 1 | Moucheraud (24) | 2023 | Malawi | African Region (AFR) | Africa | 400 | 221 | 179 | 59.8 |
| 2 | Mudenda (25) | 2023 | Zambia | African Region (AFR) | Africa | 240 | 110 | 130 | 72.1 |
| 3 | Lubad (26) | 2023 | Jordan | Eastern Mediterranean Region (EMR) | Asia | 300 | 112 | 188 | 68.4 |
| 4 | Imediegwu (27) | 2023 | Nigeria | African Region (AFR) | Africa | 103 | 46 | 57 | 56.2 |
| 5 | Girmay (28) | 2023 | Ethiopia | African Region (AFR) | Africa | 786 | 285 | 501 | 57.9 |
| 6 | Almusalami (29) | 2020 | Saudi Arabia | Eastern Mediterranean Region (EMR) | Asia | 609 | 80 | 529 | 55.5 |
| | Almusalami (29) | 2021 | Saudi Arabia | Eastern Mediterranean Region (EMR) | Asia | 609 | 80 | 529 | 94.7 |
| 7 | Alfosail (30) | 2023 | Saudi Arabia | Eastern Mediterranean Region (EMR) | Asia | 394 | 108 | 286 | 81.64 |
| 8 | Yahsi (31) | 2022 | Turky | European Region (EUR) | Asia | 628 | 161 | 467 | 84.3 |
| 9 | Waheed (32) | 2022 | Egypt | Eastern Mediterranean Region (EMR) | Africa | 500 | 150 | 350 | 27.8 |
| 10 | Zammit [14] | 2022 | Tunisian | African Region (AFR) | Africa | 493 | 131 | 346 | 35 |
| 11 | Zaitoon [15] | 2022 | Palestine | European Region (EUR) | Asia | 714 | 267 | 447 | 77.4 |
| 12 | Youssef [16] | 2022 | Lebanon | Eastern Mediterranean Region (EMR) | Asia | 1800 | 591 | 1209 | 58 |
| 13 | Yilma [17] | 2022 | Ethiopia | African Region (AFR) | Africa | 1314 | 759 | 555 | 74.8 |
| 14 | Yassin [18] | 2022 | Sudan | African Region (AFR) | Africa | 400 | 156 | 244 | 63.8 |
| 15 | Wiysonge [19] | 2022 | South Africa | African Region (AFR) | Africa | 395 | 143 | 252 | 59 |
| 16 | Velikonja [20] | 2022 | Croatia, Slovenia, Serbia, Poland | European Region (EUR) | Europe | 623 | 56 | 567 | 31 |
| 17 | Turbat [21] | 2022 | Mongoli | Western Pacific Region (WPR) | Asia | 238 | 43 | 195 | 67.2 |
| 18 | Thomas [22] | 2022 | United States | Region of the Americas (AMR) | America | 517 | 86 | 431 | 88 |
| 19 | Shekhar [23] | 2022 | United States | Region of the Americas (AMR) | America | 166 | 102 | 64 | 84 |
| 20 | Shehata [24] | 2022 | Egypt | Eastern Mediterranean Region (EMR) | Africa | 1268 | 514 | 754 | 24 |
| 21 | Sharaf [25] | 2022 | Egypt | Eastern Mediterranean Region (EMR) | Africa | 171 | 26 | 145 | 45.6 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 22 | Saddik [26] | 2022 | United Arab Emirates | Eastern Mediterranean Region (EMR) | Asia | 517 | 187 | 330 | 58 |
| 23 | Peirolo [27] | 2022 | Switzerland | European Region (EUR) | Europe | 776 | 125 | 651 | 88 |
| 24 | Patelarou [28] | 2022 | Albania, Cyprus, Greece, Spain,Kosovo | European Region (EUR) | Europe | 1135 | 175 | 960 | 65.3 |
| 25 | Papini [29] | 2022 | Italy | European Region (EUR) | Europe | 2137 | 609 | 1528 | 61.22 |
| 26 | Otiti-Sengeri [30] | 2022 | Uganda | African Region (AFR) | Africa | 300 | 182 | 118 | 97.6 |
| 27 | Noushad [31] | 2022 | Egypt | Eastern Mediterranean Region (EMR) | Africa | 2963 | 151 | 1185 | 40 |
| | | | India | South-East Asian Region (SEAR) | America | | 282 | | 76 |
| | | | Kenya | African Region (AFR) | Asia | | 102 | | 49 |
| | | | Nigeria | African Region (AFR) | Asia | | 206 | | 50 |
| | | | Pakistan | Eastern Mediterranean Region (EMR) | Africa | | 453 | | 69 |
| | | | Sudan | African Region (AFR) | Asia | | 143 | | 57 |
| | | | Brazil | Region of the Americas (AMR) | Africa | | 223 | | 97 |
| | | | Jordan | Eastern Mediterranean Region (EMR) | Asia | | 131 | | 53 |
| | | | Saudi Arabia | Eastern Mediterranean Region (EMR) | Asia | | 674 | | 64 |
| | | | Malaysia | Western Pacific Region (WPR) | Asia | | 222 | | 98 |
| | | | Qatar | Eastern Mediterranean Region (EMR) | Africa | | 148 | | 82 |
| | | | Turkey | European Region (EUR) | Asia | | 228 | | 70 |
| 28 | Moucheraud [32] | 2022 | Malawi | African Region (AFR) | Africa | 400 | 221 | 179 | 59.8 |
| 29 | Mose [33] | 2022 | Ethiopia | African Region (AFR) | Africa | 420 | 249 | 171 | 58.8 |
| 30 | Mehta [34] | 2022 | India | South-East Asian Region (SEAR) | Asia | 824 | 470 | 354 | 95.38 |
| 31 | Le[35] | 2022 | Vietnam | Western Pacific Region (WPR) | Asia | 911 | 224 | 687 | 58 |
| 32 | Koh [36] | 2022 | Singapore | Western Pacific Region (WPR) | Asia | 528 | 65 | 463 | 94.9 |
| 33 | Khamis [37] | 2022 | Oman | Eastern Mediterranean Region (EMR) | Asia | 433 | 136 | 297 | 40 |
| 34 | Kaufman [38] | 2022 | Australia | Western Pacific Region (WPR) | Australia | 3074 | 392 | 2532 | 77.9 |
| 35 | Katz [39] | 2022 | Palestine | European Region (EUR) | Asia | 104 | 64 | 40 | 91.3 |
| 36 | İkİlşik [40] | 2022 | Turkey | European Region (EUR) | Asia | 276 | 55 | 221 | 50.4 |
| 37 | Halbrook [41] | 2022 | United States | Region of the Americas (AMR) | America | 858 | 256 | 602 | 64.9 |
| 38 | Elkhayat [42] | 2022 | Egypt | Eastern Mediterranean Region (EMR) | Africa | 341 | 211 | 130 | 42 |
| 39 | Dkhar [43] | 2022 | India | South-East Asian Region (SEAR) | Asia | 511 | 196 | 315 | 66.53 |
| 40 | Chudasama [44] | 2022 | 37 Countries | MixContinent | MixContinent | 275 | 113 | 162 | 93 |
| 41 | Briko [45] | 2022 | Russia | European Region (EUR) | Asia | 85216 | 8351 | 76865 | 35 |
| 42 | Bell [46] | 2022 | United Kingdom | European Region (EUR) | Europe | 1656 | 593 | 1249 | 87.1 |
| 43 | Askarian [47] | 2022 | 91 Countries | MixContinent | MixContinent | 4630 | 1537 | 3093 | 63 |
| 44 | Adane [48] | 2022 | Ethiopia | African Region (AFR) | Africa | 404 | 204 | 201 | 64 |
| 45 | Zurcher [49] | 2021 | Switzerland | European Region (EUR) | Europe | 3793 | 952 | 2841 | 39.8 |
| 46 | Zhou [50] | 2021 | China | Western Pacific Region (WPR) | Asia | 1070 | 192 | 878 | 51.9 |
| 47 | Zheng [51] | 2021 | China | Western Pacific Region (WPR) | Asia | 618 | 37 | 581 | 79 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 48 | Yurttas [52] | 2021 | Turkey | European Region (EUR) | Asia | 320 | 88 | 232 | 52.5 |
| 49 | Ye [7] | 2021 | China | Western Pacific Region (WPR) | Asia | 2156 | 261 | 1895 | 66.5 |
| 50 | Xu [53] | 2021 | China | Western Pacific Region (WPR) | Asia | 1051 | 111 | 940 | 86.2 |
| 51 | Vignier [54] | 2021 | France | European Region (EUR) | Europe | 579 | 186 | 393 | 65.6 |
| 52 | Tobin [55] | 2020 | Nigeria | African Region (AFR) | Africa | 156 | 74 | 82 | 48.7 |
| 53 | Szmyd [56] | 2020 | Poland | European Region (EUR) | Europe | 687 | 242 | 445 | 91.99 |
| 54 | Suo [57] | 2020 | China | Western Pacific Region (WPR) | Asia | 8040 | 1576 | 6464 | 67.1 |
| 55 | Sun [58] | 2021 | China | Western Pacific Region (WPR) | Asia | 505 | 114 | 391 | 76.63 |
| 56 | Singhania [59] | 2021 | India | South-East Asian Region (SEAR) | Asia | 750 | 439 | 311 | 79.3 |
| 57 | Sirikalyanpaiboon [60] | 2021 | Thailand | South-East Asian Region (SEAR) | Asia | 705 | 346 | 359 | 95.6 |
| 58 | Shekhar [10] | 2021 | United States | Region of the Americas (AMR) | America | 3479 | 881 | 2598 | 36 |
| 59 | Wang [61] | 2021 | China | Western Pacific Region (WPR) | Asia | 1329 | 858 | 471 | 76.98 |
| 60 | J.Wang [62] | 2021 | China | Western Pacific Region (WPR) | Asia | 3634 | 820 | 2814 | 79.09 |
| 61 | Turbat [63] | 2021 | Mongolia | Western Pacific Region (WPR) | Asia | 238 | 43 | 195 | 67.2 |
| 62 | Qattan [64] | 2021 | Saudi Arabia | Eastern Mediterranean Region (EMR) | Asia | 673 | 372 | 301 | 50.52 |
| 63 | Paudel [65] | 2021 | Nepal | South-East Asian Region (SEAR) | Asia | 266 | 76 | 190 | 38.3 |
| 64 | Parente [66] | 2020 | Kansas | Region of the Americas (AMR) | America | 3347 | 726 | 2601 | 59.5 |
| 65 | Papagiannis [67] | 2020 | Greece | European Region (EUR) | Europe | 340 | 173 | 167 | 78.5 |
| 66 | Pacella-LaBarbara [68] | 2021 | United States | Region of the Americas (AMR) | America | 45 | 241 | 229 | 79 |
| 67 | Paris [69] | 2021 | France | European Region (EUR) | Europe | 1965 | - | - | 73.1 |
| 68 | Noushad [70] | 2021 | Saudi Arabia | Eastern Mediterranean Region (EMR) | Asia | 674 | 350 | 324 | 65 |
| 69 | Oruc [71] | 2021 | Turkey | European Region (EUR) | Asia | 1426 | 509 | 917 | 54.6 |
| 70 | Nohl [72] | 2021 | Germany | European Region (EUR) | Europe | 1296 | 1013 | 283 | 57 |
| 71 | Nasir [73] | 2021 | Bangladesh | South-East Asian Region (SEAR) | Asia | 524 | 201 | 323 | 95.99 |
| 72 | Navarre [74] | 2020 | France | European Region (EUR) | Europe | 1964 | 432 | 1532 | 53 |
| 73 | Mohammed [75] | 2021 | Ethiopia | African Region (AFR) | Africa | 614 | 298 | 316 | 65 |
| 74 | Marinos [76] | 2021 | Greece | European Region (EUR) | Europe | 1993 | 1192 | 801 | 99.64 |
| 75 | Nohl [77] | 2021 | Germany | European Region (EUR) | Europe | 285 | 89 | 196 | 77.4 |
| 76 | Browne [78] | 2021 | United States | Region of the Americas (AMR) | America | 5929 | 1276 | 4571 | 78.5 |
| 77 | Navin [79] | 2021 | United States | Region of the Americas (AMR) | America | 4603 | 771 | 3666 | 86 |
| 78 | Nzaji [80] | 2020 | Congo | African Region (AFR) | Africa | 613 | 312 | 301 | 27.7 |
| 79 | Abinaya [81] | 2021 | India | South-East Asian Region (SEAR) | Asia | 333 | 118 | 215 | 56.7 |
| 80 | Abohelwa [82] | 2021 | United States | Region of the Americas (AMR) | America | 81 | 41 | 40 | 96.3 |
| 81 | Abuown [83] | 2020 | England | European Region (EUR) | Europe | 514 | - | - | 59 |
| 82 | Adeniyi [84] | 2020 | South Africa | African Region (AFR) | Africa | 1308 | 242 | 1066 | 90.1 |
| 83 | Agha [85] | 2021 | Nigeria | African Region (AFR) | Africa | 496 | 237 | 237 | 69 |
| 84 | Agyekum [86] | 2021 | Ghana | African Region (AFR) | Africa | 234 | 86 | 148 | 39.3 |
| 85 | Alhassan [87] | 2021 | Ghana | African Region (AFR) | Africa | 1142 | 436 | 706 | 70 |
| 86 | Alhofaian [88] | 2021 | Saudi Arabia | Eastern Mediterranean Region (EMR) | Asia | 390 | 117 | 266 | 77.8 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 87 | Alle[89] | 2021 | Ethiopia | African Region (AFR) | Africa | 327 | 208 | 119 | 42.3 |
| 88 | Kozak [90] | 2021 | Germany | European Region (EUR) | Europe | 3401 | 997 | 2371 | 84.5 |
| 89 | Krishnamurthy [91] | 2021 | Barbados | Region of the Americas (AMR) | America | 343 | 83 | 260 | 55.1 |
| 90 | Kumar [92] | 2021 | India | South-East Asian Region (SEAR) | Asia | 599 | 293 | 306 | 73 |
| 91 | Li [93] | 2021 | China | Western Pacific Region (WPR) | Asia | 1779 | 210 | 1569 | 93.9 |
| 92 | Malik [94] | 2021 | Pakistan | Eastern Mediterranean Region (EMR) | Asia | 5237 | 1922 | 3315 | 70.2 |
| 93 | Maraqa [95] | 2021 | Palestine | Eastern Mediterranean Region (EMR) | Asia | 1159 | 430 | 729 | 37.8 |

- Top 10 Vaccination Rate Percentage: Cells with green fill and dark green text

- Top 10 Numbers of Population: Cells with light red fill and dark red text

### *Meta-analysis*

The meta-analysis results indicated that the COVID-19 vaccine acceptance rate among HCWs was 68.56% (95% CI=18.7-99.7; $I^2$= 99.750%; p<0.001). The $I^2$ test results showed a very high degree of heterogeneity among the studies ($I^2$ = 99.75), as shown in Figure 5. None of the studies changed our results and, in fact, did not have much impact on our results. Subgroup analysis was performed for the six WHO regions (Africa, Americas, Eastern Mediterranean, Europe, South-East Asia, and Western Pacific) to find the source of heterogeneity. The highest percentage was related to the Western Pacific region, with 78.39% and 95% CI (Figure 4). Acceptance rates of other WHO regions were 76%, 75.11%, 69.80%, 61.77%, and 59.34% (95% CI) for the Americas, South-East Asia, Europe, Africa, and Eastern Mediterranean, respectively. Marinos et al. reported the highest vaccine acceptance rate, which was 99.64% for 1993 HCWs.

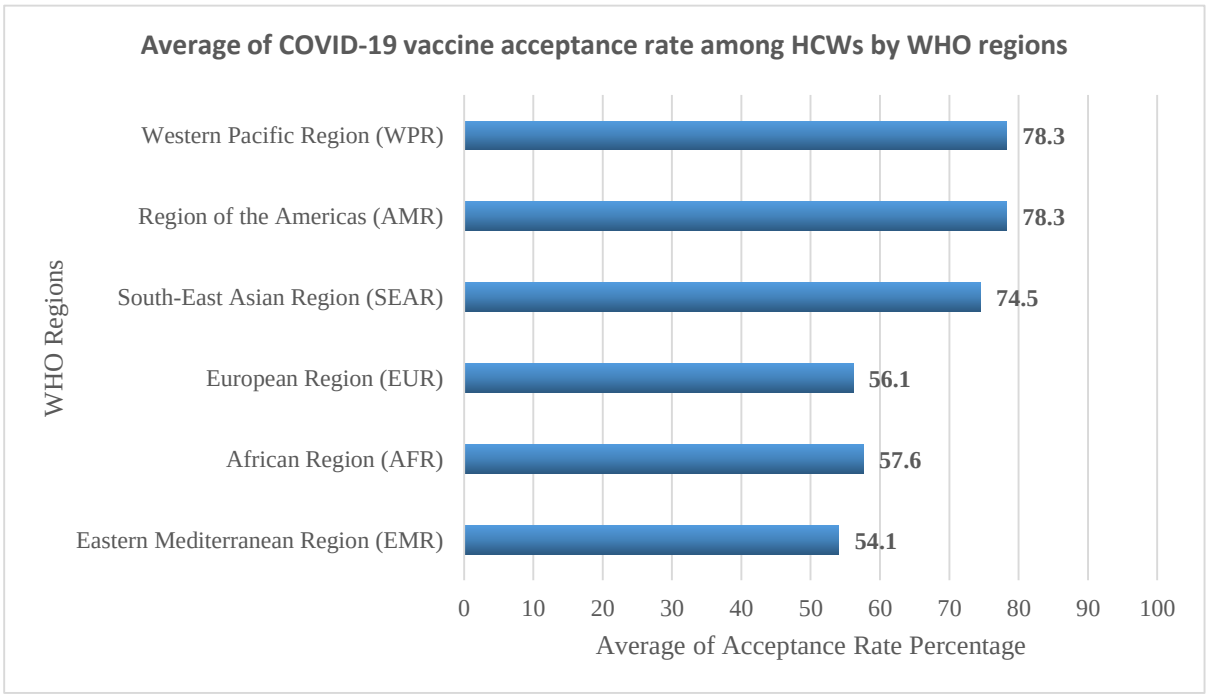
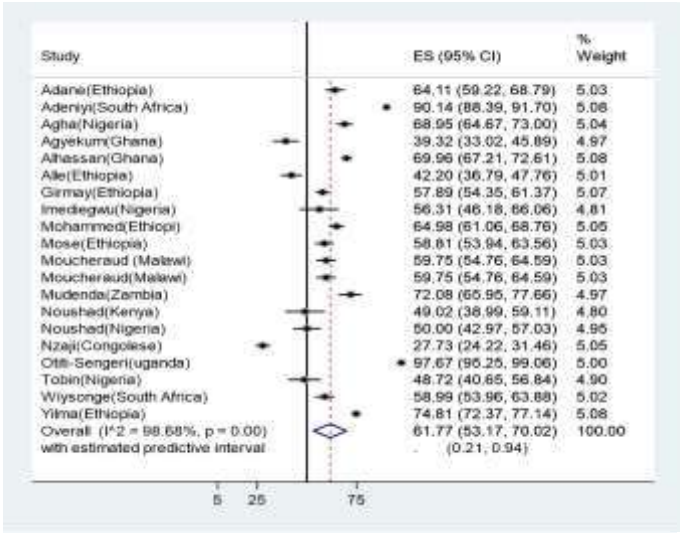
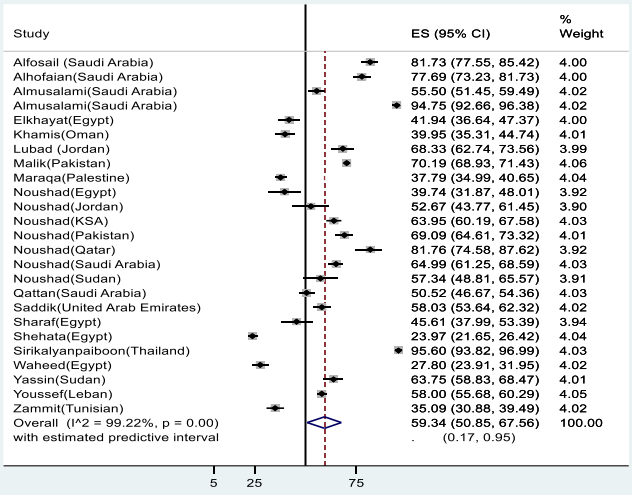


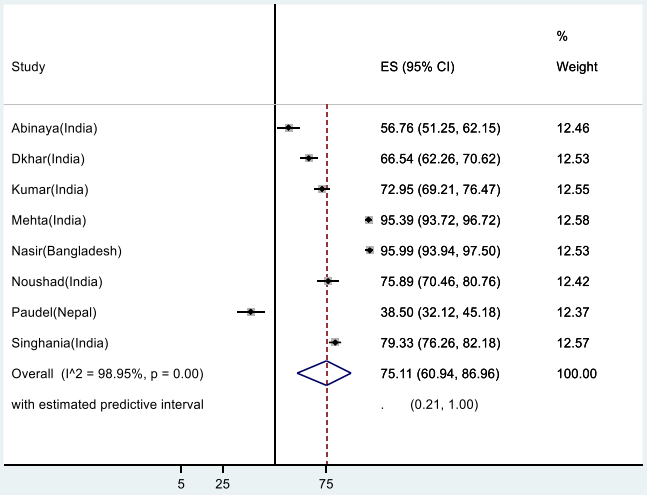

**Figure 4**. Vaccination rates in different WHO Regional Offices



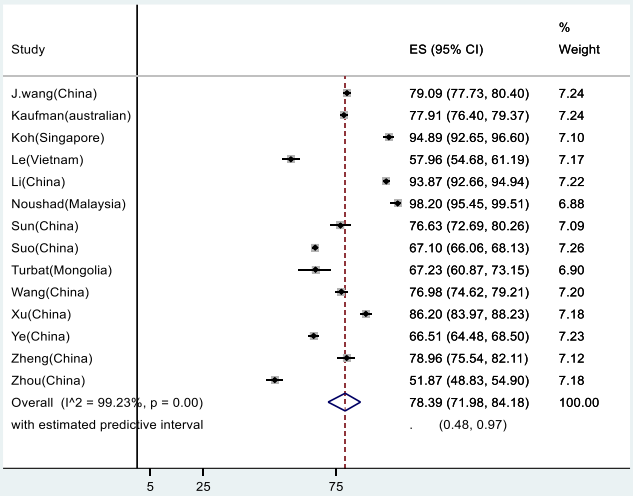

a)



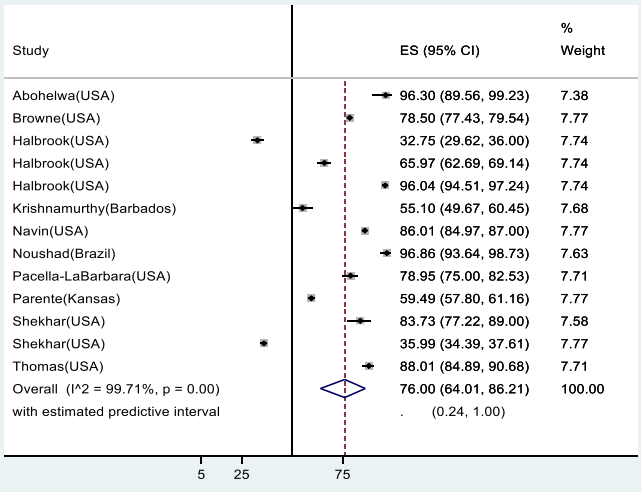

(b)



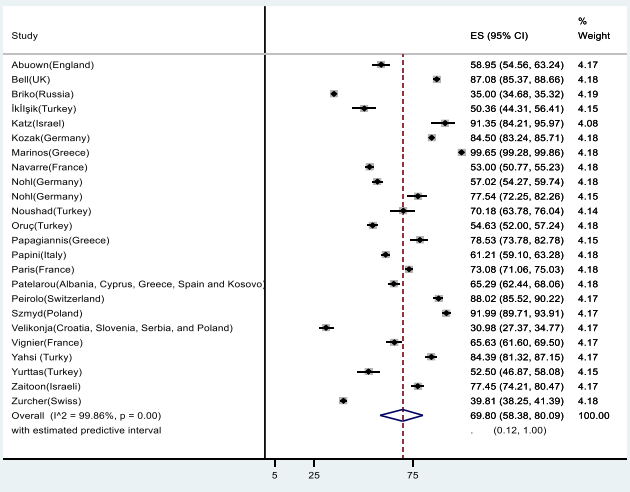

(c)




(d)




(e)




(f)

**Figure 5:** Forest plot of the vaccination rate among HCWs with 95% confidence interval. (a) Africa; (b) Eastern Mediterranean; (c) South-East Asia; (d) Western Pacific; (e) America; (f) Europe.

## Discussion

The present study was a systematic review and meta-analysis, which showed that the COVID-19 vaccine acceptance rate among 196235 HCWs was 68.56% (95% CI). The results of the $I^2$ test showed very high heterogeneity among the studies. The sensitivity analysis test also showed that none of the studies changed our results and, in fact, did not have a large effect on our results. Acceptance rates of other WHO regions were 78.39%, 76%, 75.11%, 69.80%, 61.77%, and 59.34% (95% CI) for the Western Pacific, Americas, South-East Asia, Europe, Africa, and Eastern Mediterranean, respectively.

The result of vaccine acceptance in an observational study among HCWs in the United States was 36% (11), and in another study in the United Kingdom was 59% (102). These results are lower than the results of the present study. Furthermore, several cross-sectional studies conducted in China with more than 2000 participants showed a relatively high acceptance rate (78%) among HCWs (7, 8, 12). The vaccine acceptance rates among HCWs were 84.5% and 99.64%, respectively, in Germany (109) and Greece (95), which are higher than the vaccine acceptance rate in the present study. In accordance with the results of the present study, the findings of the mentioned studies confirm the heterogeneity in the results of different studies. The studies conducted in different countries confirm different vaccination intentions among HCWs (17). Determining the factors that reduce the vaccine acceptance rate among HCWs (11). Various reasons can justify the differences in vaccine acceptance among HCWs. However, in contrast to the results of primary studies, in the present study, which was published in 2022, such differences can be attributed to the increased awareness of the complications of COVID-19 and its ability to cause more severe conditions and complications (115). Moreover, the vaccine information that has been published at an increasing rate during the COVID-19 pandemic has affected vaccine acceptance among HCWs (17). Actually, the scientific evidence about the COVID-19 vaccine became more comprehensive over time, so HCWs became more aware of its efficacy and safety (116).

Additionally, the COVID-19 vaccine mandates implemented by different countries may have increased the COVID-19 vaccine acceptance rate among HCWs (117). A report after implementing mandatory vaccination in Italy showed that only one in 10,000 HCWs refused vaccination (118). Furthermore, the free vaccination policy may also help increase vaccine acceptance (18). In a study, researchers showed that the Chinese National Health Commission's voluntary and free vaccination policy significantly impacted increasing vaccine uptake (17).

In the study population, different influential factors that have caused heterogeneity in the results of the studies should be analyzed. In 57.65% of the studies, gender was considered a factor affecting COVID-19 vaccine acceptance, and 91.84% of these studies showed that the vaccine acceptance rate was higher in men than in women. In agreement with the results of the present study, several studies showed that male HCWs are more likely to accept the COVID-19 vaccine (35). The reason for This assertion can be attributed to the relatively better health behaviors in men and their more positive attitudes toward the recommendation of COVID-19 vaccination. These claims have been supported and proven by various behavioral approaches, such as the theories of planned behavior and reasoned action (119). Moreover, women-specific factors, such as menstruation, pregnancy, and breastfeeding, may adversely affect women's attitudes about vaccination against COVID-19 (17).

In 34.11% of the studies, vaccine acceptance was higher in older age groups. The higher vaccine acceptance with increasing age can be attributed to the higher perceived vulnerability to the COVID-19 disease (120). Accordingly, researchers showed that older HCWs have a positive attitude towards the COVID-19 vaccination (121). This may be because unvaccinated older people are more likely to be hospitalized or die from COVID-19 (121). Therefore, targeted COVID-19 vaccination strategies

should be implemented for younger HCWs to address vaccine hesitancy among this group of HCWs.

Out of 18 articles that evaluated the level of education as a factor related to the acceptance of the COVID-19 vaccine, 17 studies reported a positive correlation between the level of education and the acceptance of the vaccine. In many studies, it has been proven that there is a relationship between positive attitude and higher education levels (11). However, in contrast to these results, in a study, it was shown that with increasing education levels, the willingness of HCWs to be vaccinated against COVID-19 decreased. This can be related to more unfavorable information received by HCWs with higher education levels (17). Several studies have reported that the COVID-19 vaccine acceptance rate among nurses is lower than among other HCWs (78). Therefore, to improve the COVID-19 vaccine acceptance among HCWs, targeted information dissemination, supportive strategies, and established institutional rules are needed.

### *Strengths and limitations*

The main strength of the present study was the large sample size of HCWs and a large number of the reviewed studies. A limitation of this study was the high heterogeneity of studies in different continents. However, to improve this heterogeneity, we categorized the studies according to WHO regions. Moreover, gender-based analysis was impossible since the numbers of male and female HCWs participating in many studies were not mentioned. Also, considering only English-published papers, some relevant articles may be missed.

## Conclusion

The collected evidence indicated that the overall COVID-19 vaccine acceptance rate among HCWs was 68.56%. The vaccine acceptance rate among HCWs depends on various factors. Increasing awareness about the safety and efficacy of vaccines is necessary to improve HCWs' perception of the COVID-19 vaccines and to increase their confidence in the vaccines. Additionally, HCWs' concerns about possible side effects of COVID-19 vaccines should be reduced to increase their willingness to be vaccinated.

## Acknowledgments

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## Conflicts of interest

The authors declare that they have no conflict of interest.

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