



## Review Article

**Acceptance rate of COVID-19 vaccine among healthcare workers: A systematic review and meta-analysis**Ali Sahebi<sup>1,2</sup>, Zohreh Ghomian<sup>3,4\*</sup>, Azadeh Tahernejad<sup>4</sup>, Mahdi Sadeghi<sup>4</sup><sup>1</sup>Department of Medical Emergencies and Health in Disasters and Emergencies, Ilam University of Medical Sciences, Ilam, Iran<sup>2</sup>Non-Communicable Diseases Research Center, Ilam University of Medical Sciences, Ilam, Iran<sup>3</sup>Safety Promotion and Injury Prevention Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran<sup>4</sup>Department of Health in Emergencies and Disasters, School of Public Health and Safety, Shahid Beheshti University of Medical Sciences, Tehran, Iran

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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).



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.

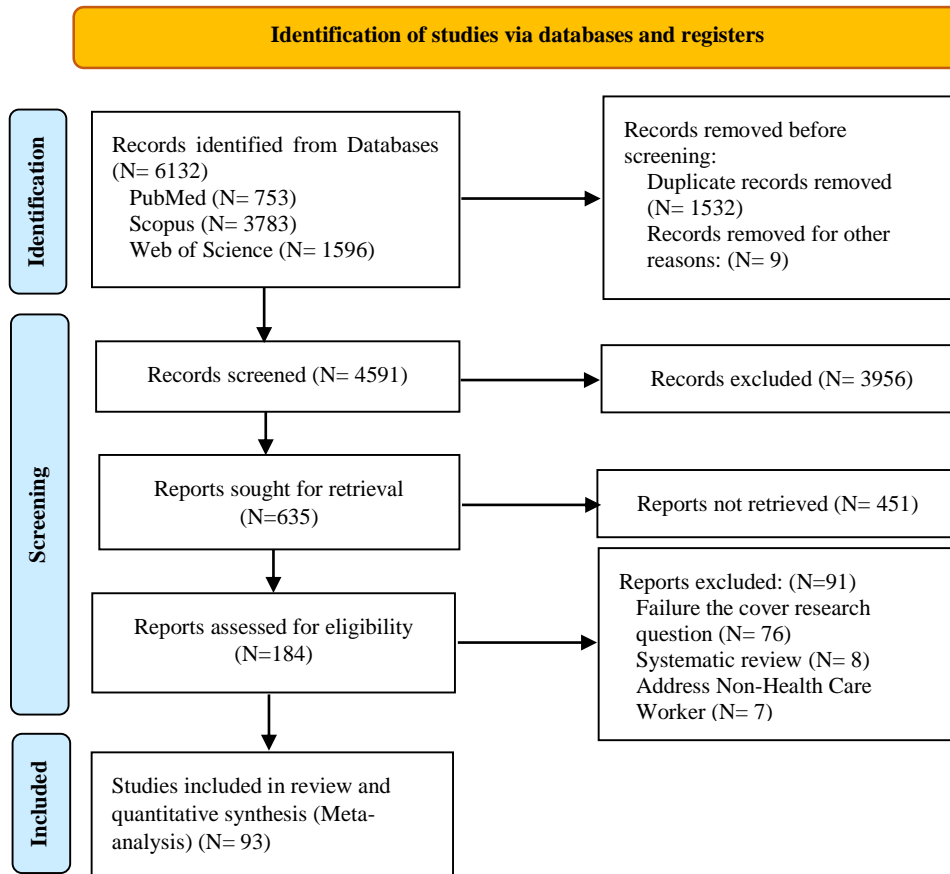


Figure 1. Flow diagram of the Selection of Studies Based on PRISMA 2020

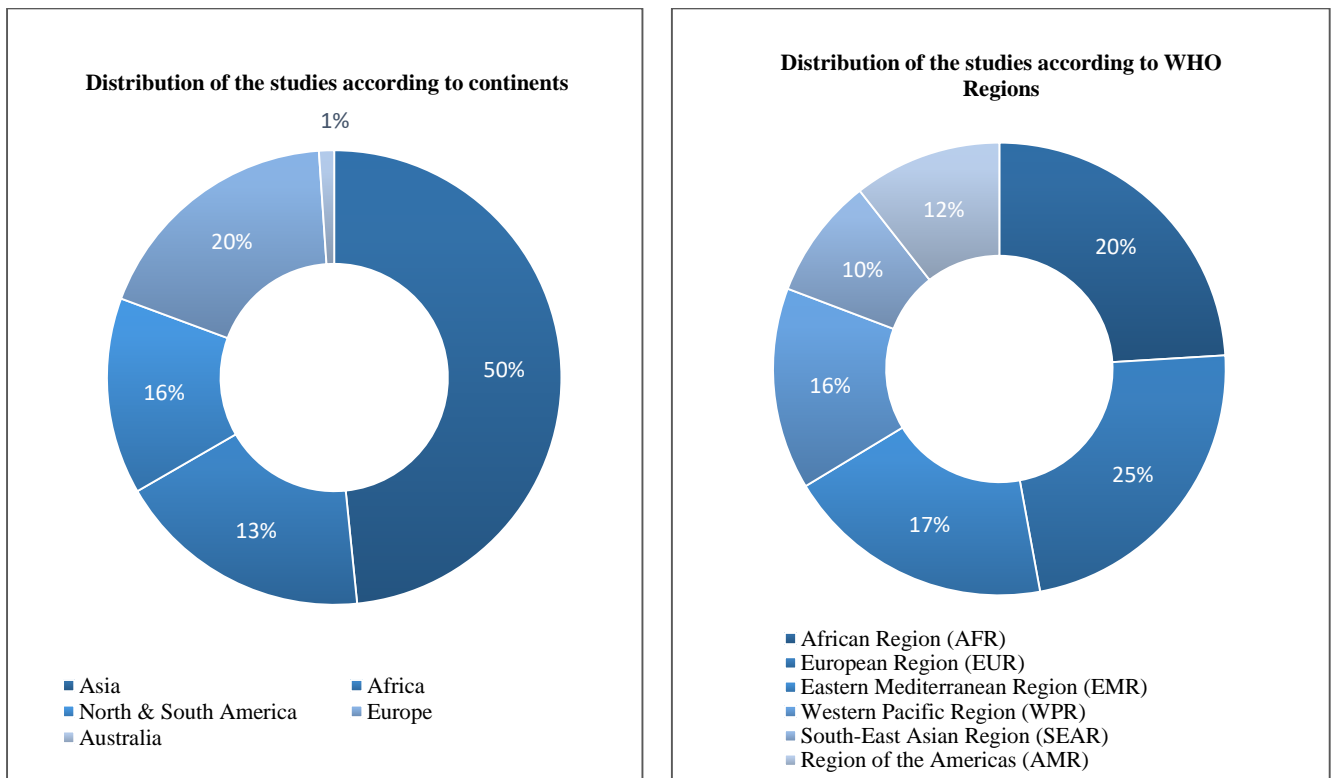


Figure 2. Characteristics of studies included in the systematic review and meta-analysis

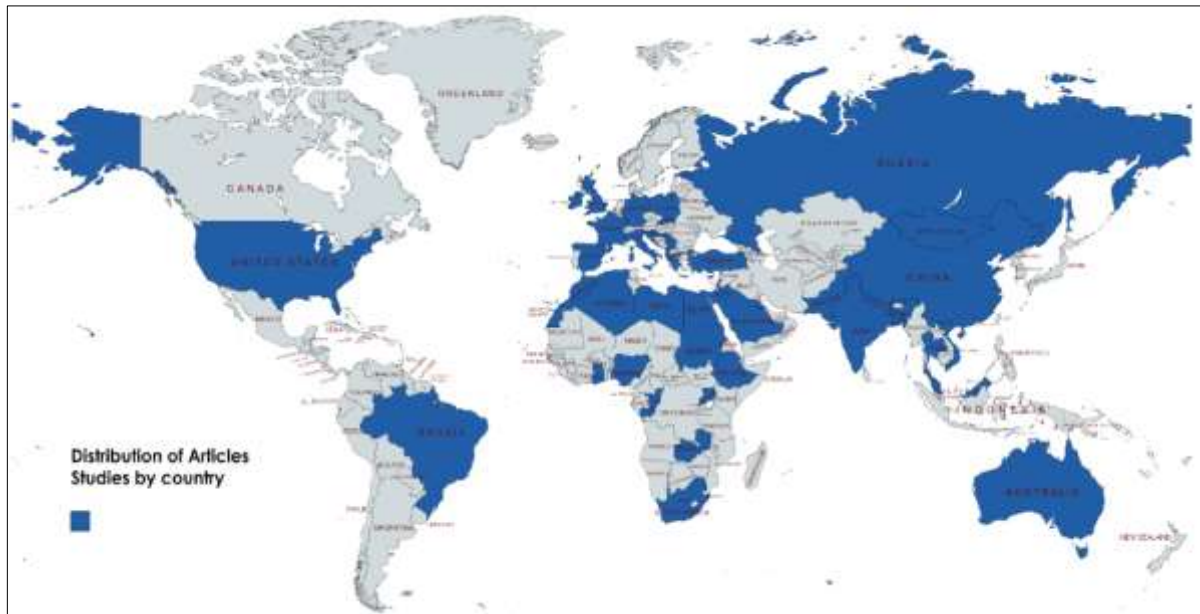


Figure 3. Geographical world distribution of countries according to article studies

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	Turkey	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	Wysonge [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

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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	İkiİşik [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	Elkhatay [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



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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	Maraqqa [95]	2021	Palestine	Eastern Mediterranean Region (EMR)	Asia	1159	430	729	37.8

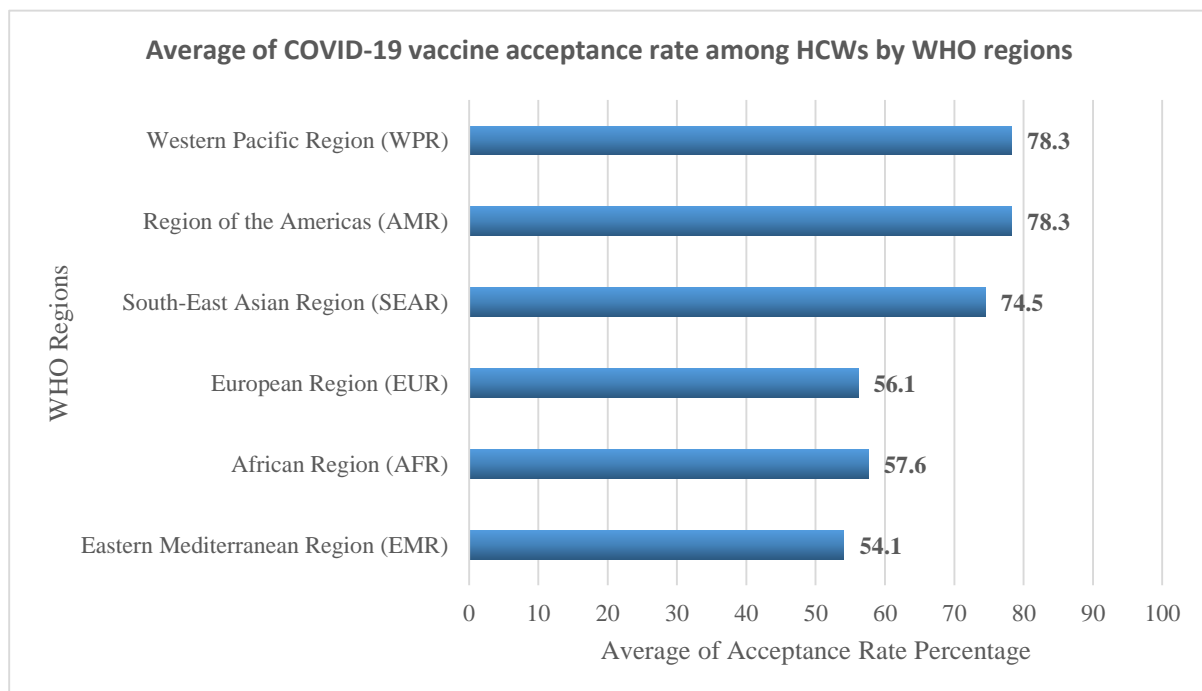
- Top 10 Vaccination Rate Percentage: Cells with green fill and dark green text

- 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

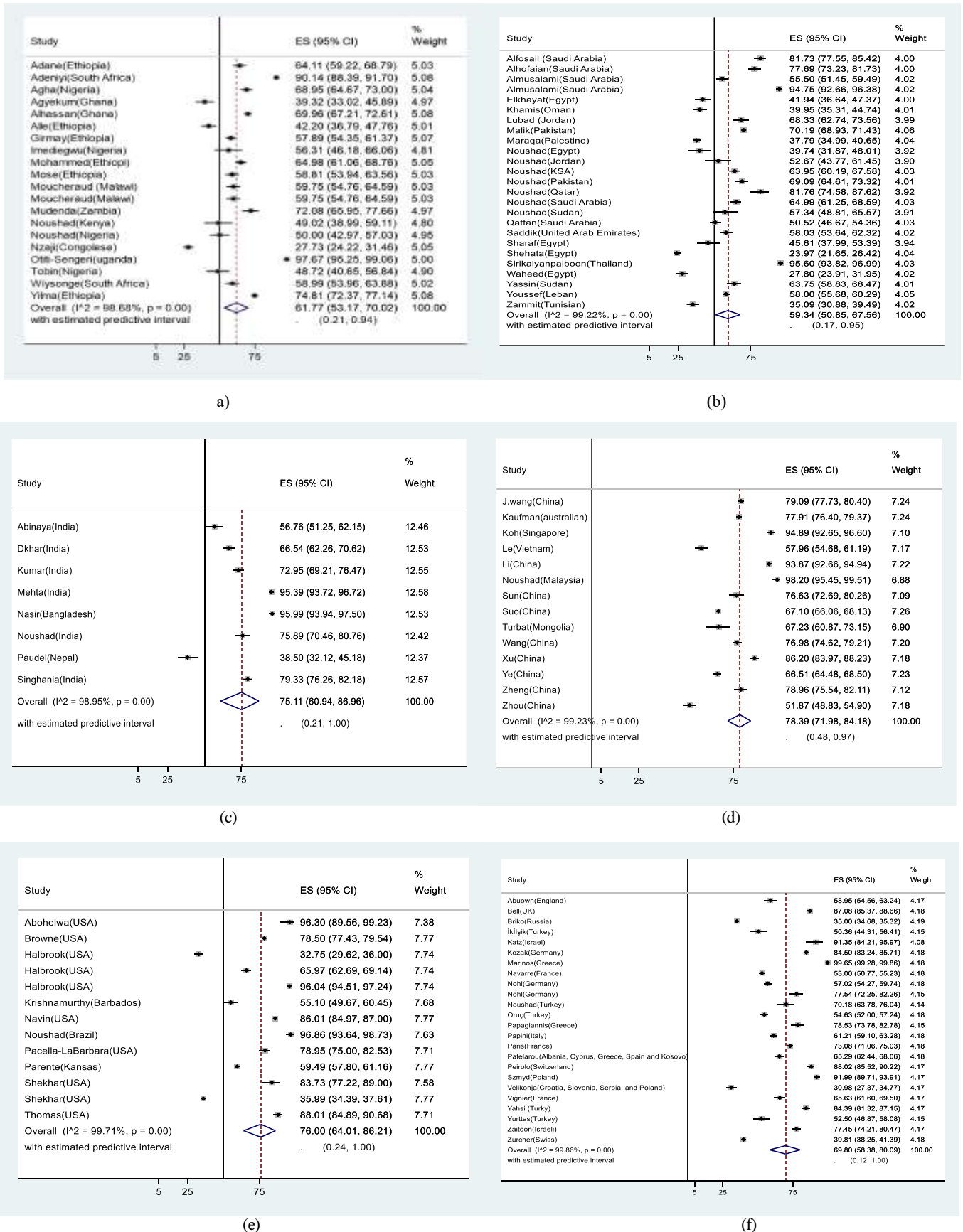


Figure 5: Forest plot of the vaccination rate among HCWs with 95% confidence interval. (a) Africa; (b) Eastern Mediterranean; (c) South-East Asia; (d) Western Pacific; (e) America; (f) Europe.

## **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.

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### **Conflicts of interest**

The authors declare that they have no conflict of interest.

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