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Research article

The acceptance of COVID-19 vaccine at early stage of development and approval: A global systematic review and meta-analysis

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ABSTRACT

Background: Vaccination seems to be the most effective way to prevent and control the spread of COVID-19, a disease that has adversely impacted the lives of over 7 billion people across the globe. Vaccine hesitancy represents an important threat to combat infectious diseases worldwide. This study aims to inspect the COVID-19 vaccine acceptance rate worldwide and the regional variation of the acceptance rates among the general population and healthcare workers across different territories of the world. In addition, it compares the vaccine acceptance rates between the pre- and post-vaccine approval periods.
Method: A comprehensive systematic review was conducted using PRISMA statements. After quality evaluation, the data from eligible studies were analyzed using the random effect model. Q-test and I^2 statistics were used to search for heterogeneity. The publication bias was assessed by using Egger's test and funnel plot.
Results: The combined COVID-19 vaccine acceptance rate among the general population and healthcare workers (n = 1,581,562) was estimated at 62.79% (95% CI: 58.98–66.60). The acceptance rate substantially decreased from 66.29% (95% CI: 61.24–71.35) to 56.69% (95% CI: 48.68–64.71) among the general population from the pre-to post-vaccine approval periods but remained almost constant at 58.25% (95% CI: 46.52–69.97) among healthcare workers. The acceptance rates also varied in different regions of the world. The highest acceptance rate was found in the South-East Asia region at 70.18% (95% CI: 58.12–82.25) and the lowest was found in African Region at 39.51% (95% CI: 23.42–55.59).
Conclusion: Low COVID-19 vaccine acceptance rate might be a massive barrier to controlling the pandemic. More research is needed to address the responsible factors influencing the low global rate of COVID-19 vaccine acceptance. Integrated global efforts are required to remove the barriers.

1. Introduction

1.1. Background

At the end of the year 2019, the world experienced a new global threat posed by a novel coronavirus in Wuhan, China that spread rapidly around the world within a month [1, 2]. Afterward, this threat was labeled a pandemic by WHO [3]. As of now, this virus infected at least 543, 972, 975 and killed at least 6,340,008 people worldwide [4]. The pandemic also has had a disastrous impact on the mental health of people throughout the world due to fear, uncertainty, isolation, school closure, etc [5, 6]. Along with the public health crisis, the pandemic has had a devastating effect on the global economy. This pandemic resulted in at least a 2.9 percent loss of gross domestic product (GDP) in most of the major economies over 2020 [7]. Unfortunately, the virus continues to evolve [8]. Since no globally acceptable treatment has been developed to fight off the lethal infectious disease, vaccines are touted to be the most effective approach to prevent and control COVID-19. Before introducing a vaccine, people's knowledge, perception, and attitude toward vaccines come first to mind as it impacts vaccination efforts. After the clinical development of a vaccine, probably the most significant challenge is the acceptance and distribution of the vaccine. Vaccine acceptance study helps governments make immunization programs successful by mass distributing the vaccine. Therefore, many studies have been carried out to understand the knowledge about the COVID-19 vaccines, the prevalence of the vaccines' acceptance, or vaccination intention which help to implement effective strategies to improve the vaccine coverage rate. Per the studies already conducted it has been observed that vaccine hesitancy

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has become a serious and growing concern worldwide despite overwhelming evidence of the importance of vaccines [9, 10]. This is remarkably influencing the rate at which immunization was expected to go through. Due to an alarming figure of vaccine hesitancy across the world, WHO announced this as one of the top ten threats to global health [9].

Several studies observed low vaccine acceptance rates (less than 40%) in the UK [11, 12], USA [13, 14], Jordan [15, 16], Kuwait [15], Hong Kong [17], Turkey [18], Congo [19], and Egypt [20]. Multiple pieces of research also reported high acceptance rates in several countries. For instance, a narrative review by Sallam et al. (2022) found that in 42 countries/territories across the world COVID-19 vaccine acceptance rates ranged between 13% and 59% [21]. A study in China reported that 91.30% of people would accept COVID-19 vaccination after the vaccine becomes available [22]. Another study in China showed that 64.01% of university students indicated their willingness to participate in COVID-19 vaccine trials [23]. A high level of acceptance for COVID-19 vaccines was found in Greece among health professionals [24]. A high intention to take vaccines among nurses and general people (60% and 66% respectively) has been observed in the USA [25, 26]. Although 61.16% of people in Bangladesh are willing to take COVID-19 vaccines, a large proportion of them (64.86%) would delay the vaccination until the vaccine's efficacy and safety are substantiated [27]. Therefore, it is obvious that vaccine hesitancy is a common phenomenon globally with high variability.

1.2. Theoretical framework

It is obvious that the COVID-19 pandemic is not a crisis for a specific region or country, this is a global disaster. There is no alternative to combined global efforts to fight off the calamity. This is such a global challenge that nobody wins until everyone wins [28]. COVID-19 vaccines are proven to be effective and safe [29]. So, a significant portion of people across the globe must get vaccinated against COVID-19 to achieve so-called herd immunity. The WHO is working relentlessly to make sure every nation in the world gets the COVID-19 vaccines equitably through its COVAX program [28]. However, according to numerous surveys, a considerable section of the population worldwide would refuse or be unsure about receiving a COVID-19 vaccine if it were made available to them [30, 31, 32]. Fake news and misreporting on the safety and efficacy of vaccinations can spread quickly in the age of social media and online information, causing an "infodemic" and increasing both anti-vax movements and vaccine reluctance [33]. We have seen a deluge of misinformation disseminated even from political leaders and celebrities during the pandemic, which is also fueling the infodemic flame [34]. COVID-19 vaccination hesitancy is especially common among marginalized communities, which have been adversely impacted by the pandemic [35]. To increase COVID-19 vaccine uptake globally, it is of paramount importance to identify the people who are not willing to accept COVID-19 vaccines, inspect trends in vaccine hesitancy (regional/racial/ethnic), and report them to national and global leaders. A systematic review (meta-analysis) is one of the best ways to synthesize global data and investigate global phenomena. Such a study on the COVID-19 vaccine acceptance/hesitancy would be a great step forward to increase vaccine uptake. This motivated us to conduct a global meta-analysis on COVID-19 vaccine acceptance.

Prior to this study, only a few systematic reviews had been done related to vaccine acceptance with limited coverage. A meta-analysis of 46 studies inspected gender-wise differences in vaccination intention [36]. Another meta-analysis of 30 studies observed country-wise vaccination intention [37]. It was a remarkable success for medical science when the U.S Food and Drug Administration (FDA) approved the first COVID-19 vaccine for emergency use. On December 11, 2020, the Pfizer-BioNTech COVID-19 Vaccine was made available for 16 years or older individuals under Emergency Use Authorization (EUA) [38]. A COVID-19 vaccine approval by FDA might affect the vaccine acceptance rate. This study seeks answers to the following questions by conducting a systematic review of the existing studies on vaccine acceptance:

(a) What is the rate of COVID-19 vaccine acceptance (willing to take) globally?
(b) What are the acceptance rates across different regions of the world and do the rates differ by region?
(c) Is there any difference in the acceptance rate between healthcare workers and general people?
(d) Is there any difference in the acceptance rate between pre-time (before Dec. 11, 2020) and post-time (from Dec. 11, 2020, onward) of vaccine approval?

We are optimistic that the findings will help policymakers and global healthcare administrations in understanding COVID-19 vaccine hesitancy across different countries or territories. They can then design special intervention programs to make marginalized people aware of the severity of COVID-19 and the safety and efficacy of the COVID-19 vaccines. Thus this study can contribute to increasing COVID-19 vaccine acceptance and uptake of vaccines. The subsequent sections of the article will provide details of the methods (search strategy and selection criteria, inclusion/exclusion criteria, statistical analysis), results, discussion, and limitations of the study.

2. Methods

This systematic review and meta-analysis followed the Systematic Reviews and Meta-Analysis (PRISMA) statements [39] and Meta-analysis Of Observational Studies in Epidemiology (MOOSE) checklists [40].

2.1. Search strategy and selection criteria

In this study, an Endnote (version X.8) library was created to list articles and remove replicas. A comprehensive systematic review was conducted using a systematic methodology (Figure 1) for the assessment of global acceptance rates of COVID-19 vaccination through the searches of PubMed/MEDLINE, Web of Science and GOOGLE SCHOLAR databases. The keywords used in the systematic searches were: "COVID-19 vaccine", "Vaccination against SARS-CoV-2" "intention", "general population, "healthcare workers", "refusal", "hesitancy", "hesitance", "hesitation'", "acceptance", "willingness", "motivation", "confidence", "uptake", "attitude", "emotion", "opinion', "belief", "trust", "doubts", "rejection", "disapproval". More specifically, we have used different combinations of those keywords, for instance:

(((COVID-19*vaccine*general*population [Title/Abstract]) OR (COVID-19*vaccine* hesitancy [Title/Abstract]) OR (COVID-19* vaccine acceptance [Title/Abstract])) OR (COVID-19* vaccine* attitude* [Title/Abstract])) OR (COVID-19*Vaccine* refusal* [Title/Abstract]) OR (COVID-19* vaccine* willingness*[Title/Abstract])).

The search was conducted on April 25, 2021. The studies that were published only in English and met the predefined inclusion criteria were considered. The reference list of the included articles was inspected and cross-checked for maximizing the articles that met the specified inclusion criteria. The preprint articles published on Medrxiv, PsyArXiv, bioRxiv, arXiv, and SSRN servers were also incorporated into the study.

2.2. Inclusion/exclusion criteria

Studies were considered for final analysis if they met the following inclusion criteria: (1) studies measured the COVID-19 vaccine acceptance rate for the general population or healthcare workers; (2) studies published in English; (3) study design such as study site, the sample size must be reported; (4) studies with available full text. Studies were removed from the list if followed the following criteria: (1) studies did not specify the target population, the study site, as well as sample size; (2) studies did not use original data; (3) articles did not report valid estimates of the

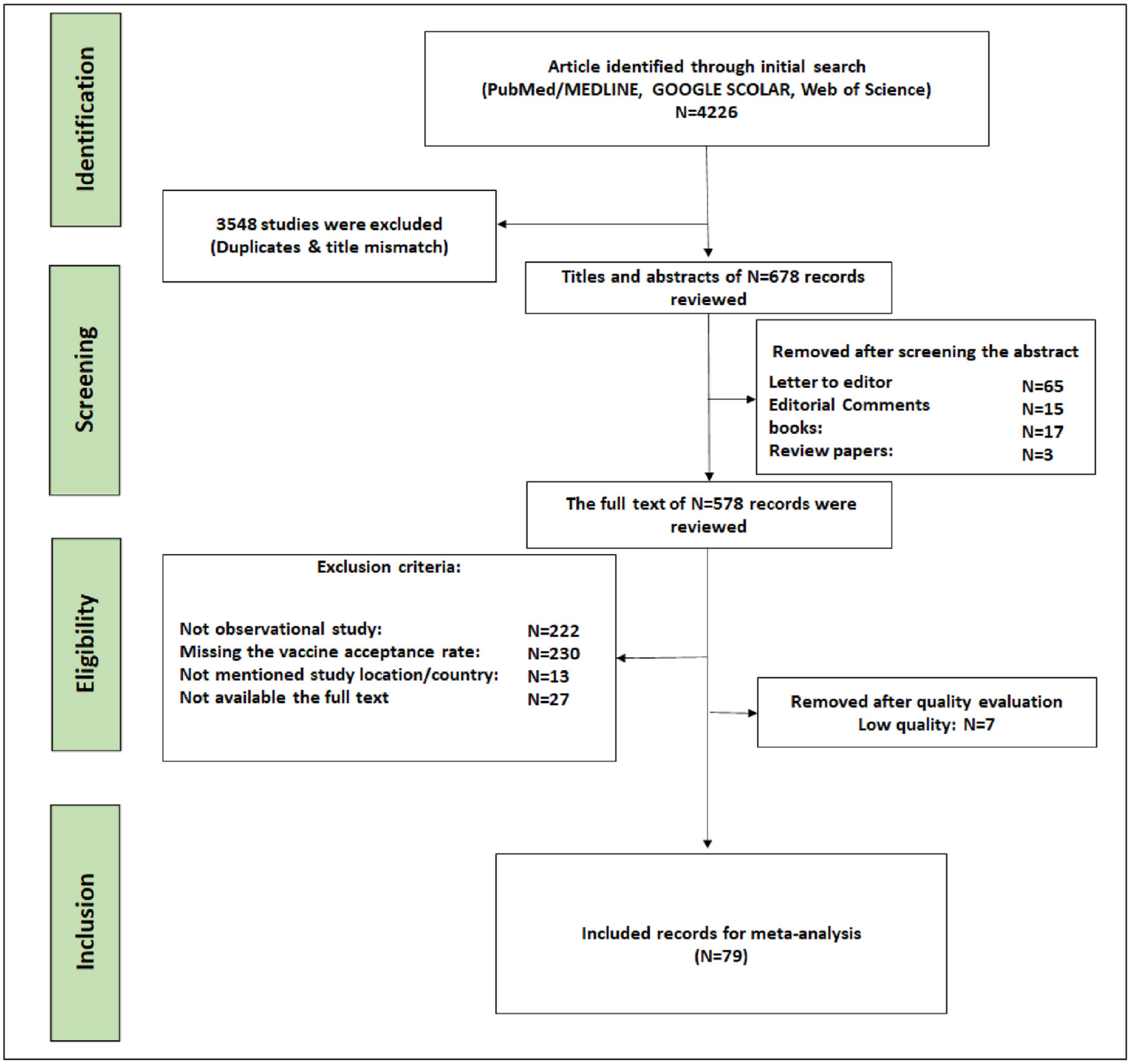

Figure 1. Flow diagram describing the selection of the studies by following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA 2009) guidelines.

acceptance rates of the COVID-19 vaccines; (4) duplicate sources; (5) studies with unclear methods; (6) articles that their full text was not available; (7) not observational study; (8) Low-quality articles; (9) interventional studies, case reports, reviews articles, letters to the editor, correspondences, opinions, and comments.

2.3. Quality evaluation

The quality of the included studies needs to be evaluated before analysis. We evaluated the quality of included studies using the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) [5,42] statements by two independent researchers (AM and SM) along with the help of a third one (SH) in case of any disagreement. With a total of 32 sections/scales, the STROBE checklist can be constructed into six general sections such as title, abstract, introduction, methods, results, and discussion. Those checklists are usually used to assess the study quality in a sense of methodological aspects including sampling and data collection approaches, study population, study design, statistical methods, and so on. The study quality evaluation scores varied between 1 to 32. The cut-off point was considered 14, which means studies with STROBE-score below 14 were removed from the list [5].

2.4. Screening and extraction

The data were extracted by three independent authors (SH, SM, and AM), with the presence of fourth reviews if necessary (MM). The first three authors screened all the articles that met the inclusion criteria and extracted data using a standardized form. The information that was extracted from the chosen articles included the title of the article, name of the first author, year of publication, study location (country), name of the authors, sampling method, study duration, study sample size, and COVID-19 vaccine acceptance rate.

2.5. Statistical analysis

The meta-analysis of COVID-19 vaccine acceptance rates was carried out using the statistical software STATA 16. The significance of the hypothesis was tested using the z statistic (level of significance $p < 0.05$). The heterogeneity tests were considered with a 5% level of significance to measure the homogeneity of studies. Due to significant heterogeneity, the random-effects model was used to estimate the pooled acceptance rates of the COVID-19 vaccine with 95% confidence intervals and the relative weight for each study. All the results of the meta-analysis were displayed in forest plots. The potential publication bias was inspected by using the funnel plot/Egger's test. The subgroup analysis based on study location/territory, target population, study duration, and estimation methods was conducted to observe the COVID-19 vaccine acceptance rates from different stratifications and identify the source of heterogeneity. The study was divided into two different groups based on the target population: (i) the general population, and (ii) Healthcare workers. Here, university students were considered in the general population and medical students/Nurses were considered healthcare workers. The studies were also further classified into two groups: studies during the pre-time of COVID-19 vaccine approval (before 11 December 2020) and studies during the post-time of COVID-19 vaccine approval (from 11 December 2020). All the countries in the world which are members of the UN were classified into six territories namely the African Region, Eastern Mediterranean Region, European Region, Region of the Americas, South-East Asia Region, and Western Pacific Region by following the WHO's regional classifications [43] to examine the regional disparities of COVID-19 vaccine acceptance. The significance of the difference between pre-time and post-time of COVID-19 vaccine approval was tested using a t-test.

3. Results

During the systematic review and meta-analysis, the PRISMA guidelines were followed for collecting and reviewing the articles in this study. In the beginning, 3548 articles were removed from initially identified 4226 articles that were unrelated to the topics or duplicate records after screening the titles and abstracts. Then, 578 articles were identified for examining the full texts and 494 records were skipped because of not having the relevant information. The rest of the articles were reviewed or checked for quality and 7 studies were excluded due to their low quality. After the quality evaluation, 79 studies were selected for the meta-synthesis. The Flow Diagram shows the article searching and selecting processes (Figure 1).

3.1. Study characteristics

The characteristics of the selected 79 studies [1, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104] are presented in Table 1. Among them, 742 studies were single-country studies while four studies were conducted in two different countries, providing eight prevalence estimates. Besides, one study was conducted in five different countries and provided five estimates. Therefore, a total of 87 prevalence estimates of vaccine acceptance were used in the final analysis. In addition, this research covers studies from 31 countries. Of them, 13 studies were taken from the USA, nine from the UK, six from China, four from each of the countries: Saudi Arabia, Italy, and France, and three from each of the countries: Bangladesh, Spain, Turkey, Hong Kong, and two from each of the countries: Australia, Brazil, Canada, Egypt, Greece, Jordan, and Nigeria. One study was taken from each of the countries: Cameroon, Ecuador, England, Europe (whole), Indonesia, Ireland, Israel, Japan, Kuwait, Portugal, and Qatar. Most of the studies were cross-sectional and did not mention any sampling method. However, only 12 studies described the sampling procedure. Among them 4 studies used "Snowball sampling", 2 studies "Stratified random sampling", another two studies applied "Quota sampling", one study used "Bootstrap resampling", another one used "Commercial survey sampling", another one applied "Multistage stratified sampling" and another one "PPS sampling". One-third (33%) of the studies applied the "Dichotomy scale" for estimating the prevalence estimates of COVID-19 vaccine acceptance, while 28% used the "Trichotomy scale", 15% used the "4-point Likert scale", and another 15% used "5-point Likert scale". Also, the "6-point Likert scale" appeared in only 5% of studies and the rest 5% of studies did not mention any measurement scale. Healthcare workers were the target population for 20.51% (16/78) of studies and for the rest of 79.49% (62/78) studies general population was the target population. The average study quality score or STROBE score was 21.74 (median: 21, range 15–30).

3.2. Statistical heterogeneity and publication bias

To search for the heterogeneity of the included studies, Q-test and I^2 (%) statistical tools were used. Here, we obtained for overall COVID-19 vaccine acceptance rate (Q (87) = 101492, $P < 0.05$) I^2= 99.94% (Figure 2) which indicates there is a significant heterogeneity among the selected studies. The subgroup analysis and Q-test with significant p-values indicates that target population type (healthcare worker: Q (16) = 3814, $P < 0.05$; and general population: Q (69) = 85841, $P < 0.05$) (Figure 3), study duration (Pre-vaccine approval: Q (53) = 22048, $P < 0.05$; post-vaccine approval: Q (26) = 9780, $P < 0.05$) (Figure 4) are two of the sources of heterogeneity. The Q-test also reveals that the study's attributes "region" (Figure 5) and "prevalence estimation method" (Figure 6) are also the source of heterogeneity. Due to significant heterogeneity among the selected studies, the random-effect model was applied to data analysis. The Funnel plot and Eggers's test indicate the presence of significant publication bias (Z = -2.95, P = 0.003) in all the included studies (Figure 7a). Although, the Funnel plot and Eggers's test indicate the presence of significant publication bias (Z = -2.89, P = 0.002) in the studies among the general population (Figure 7b), no publication bias (Z = -0.87, P = 0.54) was found in the studies among healthcare workers (Figure 7c).

3.3. COVID-19 vaccine acceptance rate

The pooled COVID-19 vaccine acceptance rate worldwide was 62.79% (95% CI: 58.98–66.60) and it was estimated from 78 included studies [1, 9, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104] among the general population and health care workers/health professionals with a combined sample size of 1,581,562 (Figure 2). The pooled acceptance rate for the COVID-19 vaccine acceptance among the general population all over the world was estimated at 63.97% (95% CI: 59.73–68.21) with a sample size of 1,559,708 whereas the pooled acceptance rate among healthcare workers with a sample size of 21,854 was found to be 57.59% (95% CI: 49.41–66.48) (Figure 3).

3.4. Acceptance rate of COVID-19 vaccines during the pre- and post-vaccine approval periods

The overall vaccine acceptance rate among the general population and healthcare workers was estimated at 64.81% (95% CI: 60.13–69.48) in the pre-time of COVID-19 vaccine approval (Figure 4). During the post time of COVID-19 vaccine approval, the pooled vaccine acceptance rate among the general population and healthcare workers was found 56.59% (95% CI: 49,96–63.94) (Figure 4). During the pre-time of COVID-19 vaccine approval, the vaccine acceptance rate among the general population was 66.29% (95% CI: 61.24–71.35) while during the post-time of COVID-19 vaccine approval among them it was 56.69% (95% CI: 48.68–64.71) (Figures 8 and 9). Among healthcare workers, the acceptance rate was 58.25% (95% CI: 46.52–69.97) during pre-time of vaccine approval while during post-time of vaccine approval it was 57.83% (95% CI:42.20–73.47) (Figures 8 and 9).

3.5. Regional disparities

We inspected the prevalence of COVID-19 vaccine acceptance in different territories of the world. These regions were defined following

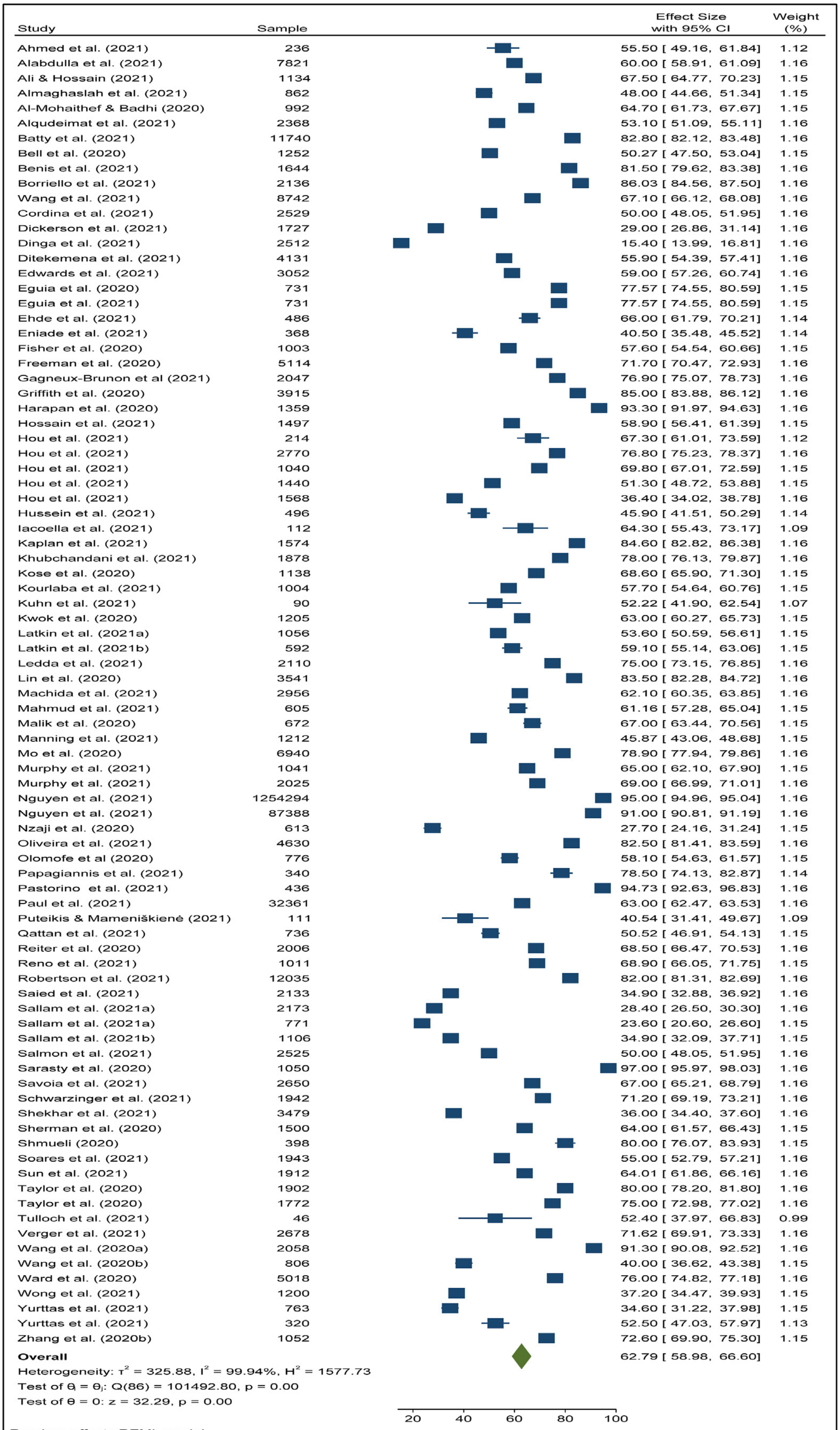

Figure 2. Overall COVID-19 vaccine acceptance rate.

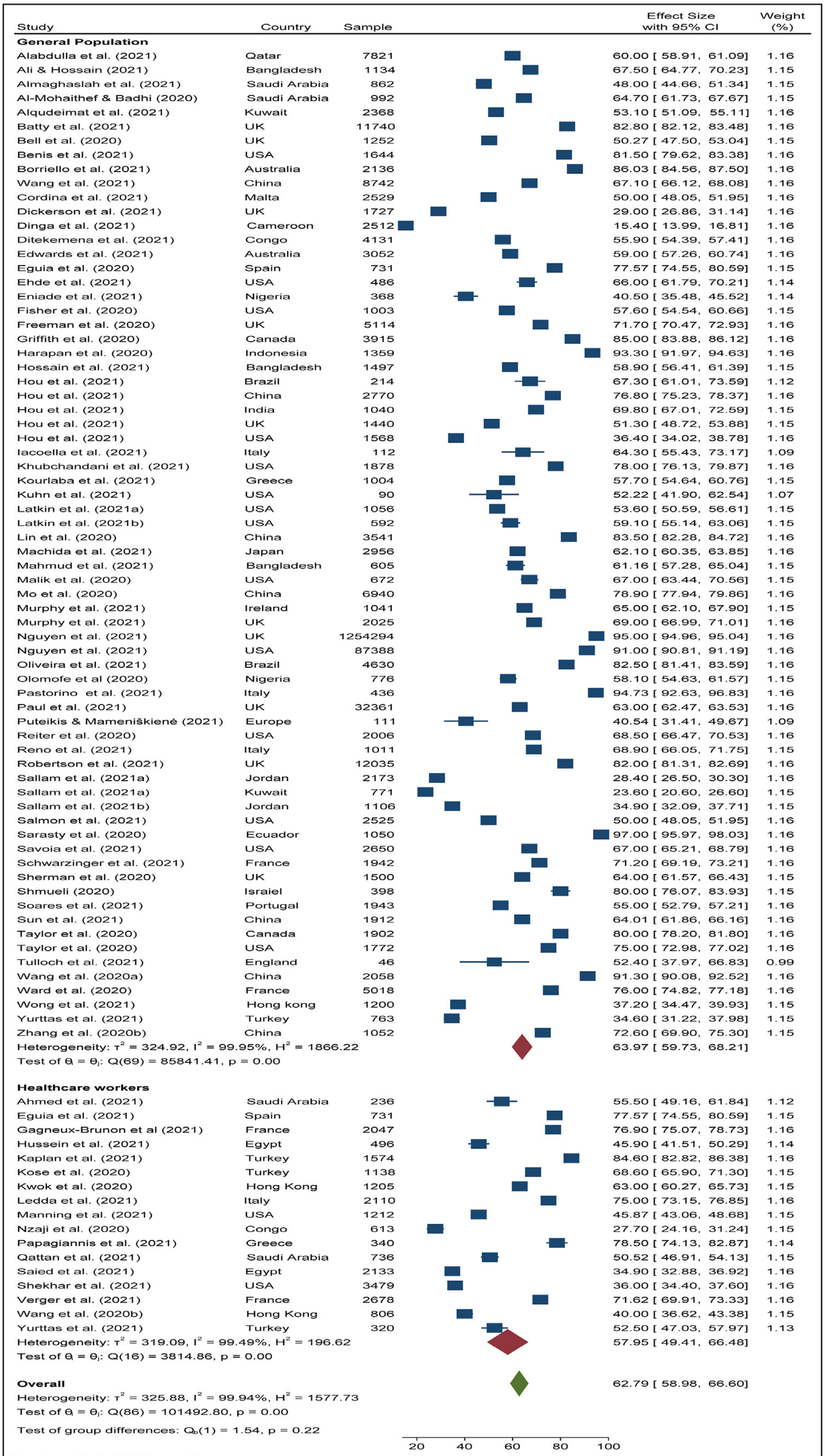

Figure 3. Pooled acceptance rate of COVID-19 vaccine among general population and healthcare workers.

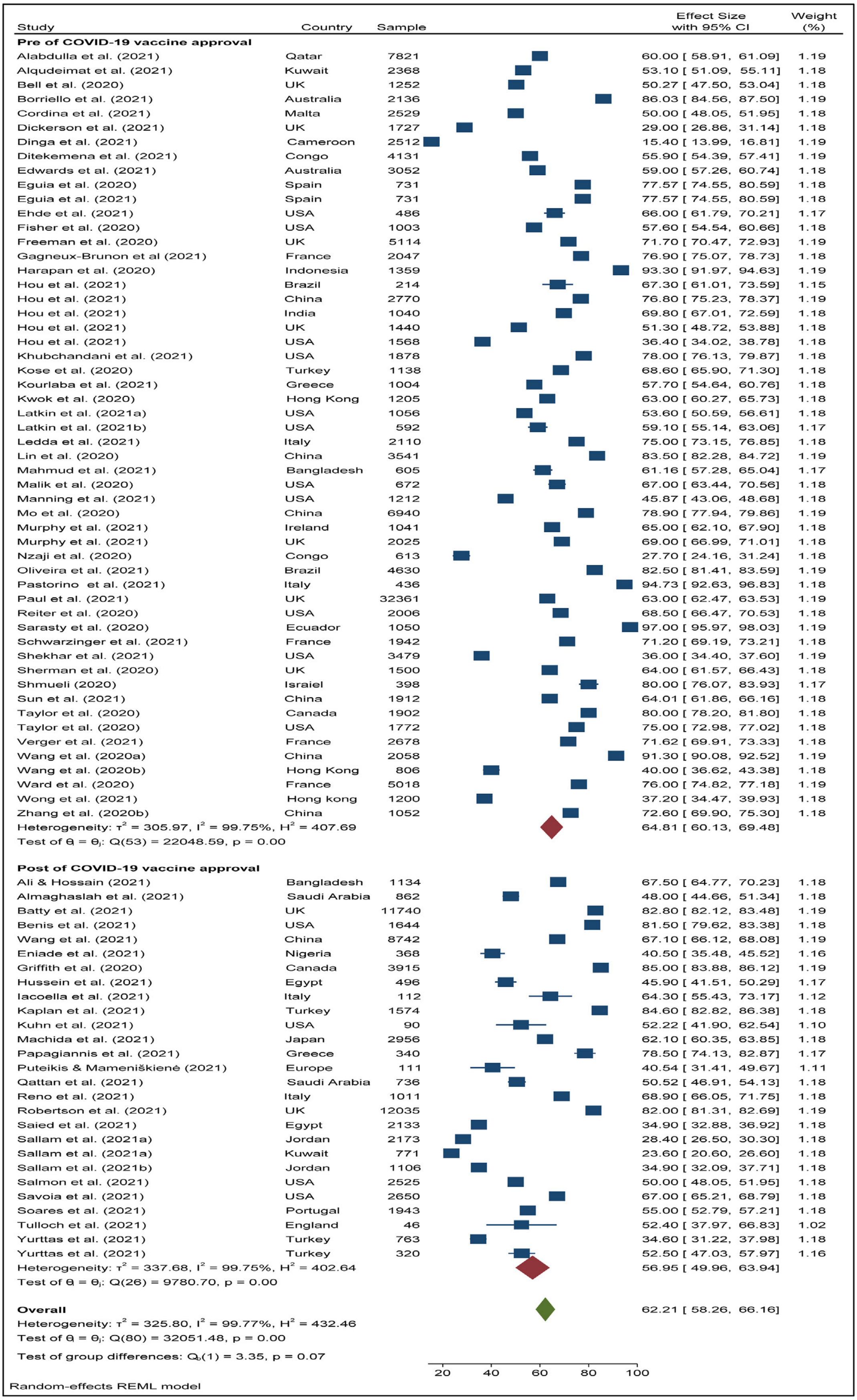

Figure 4. The pooled acceptance rate of COVID-19 vaccine in pre- and post-time of COVID-19 vaccine approval.

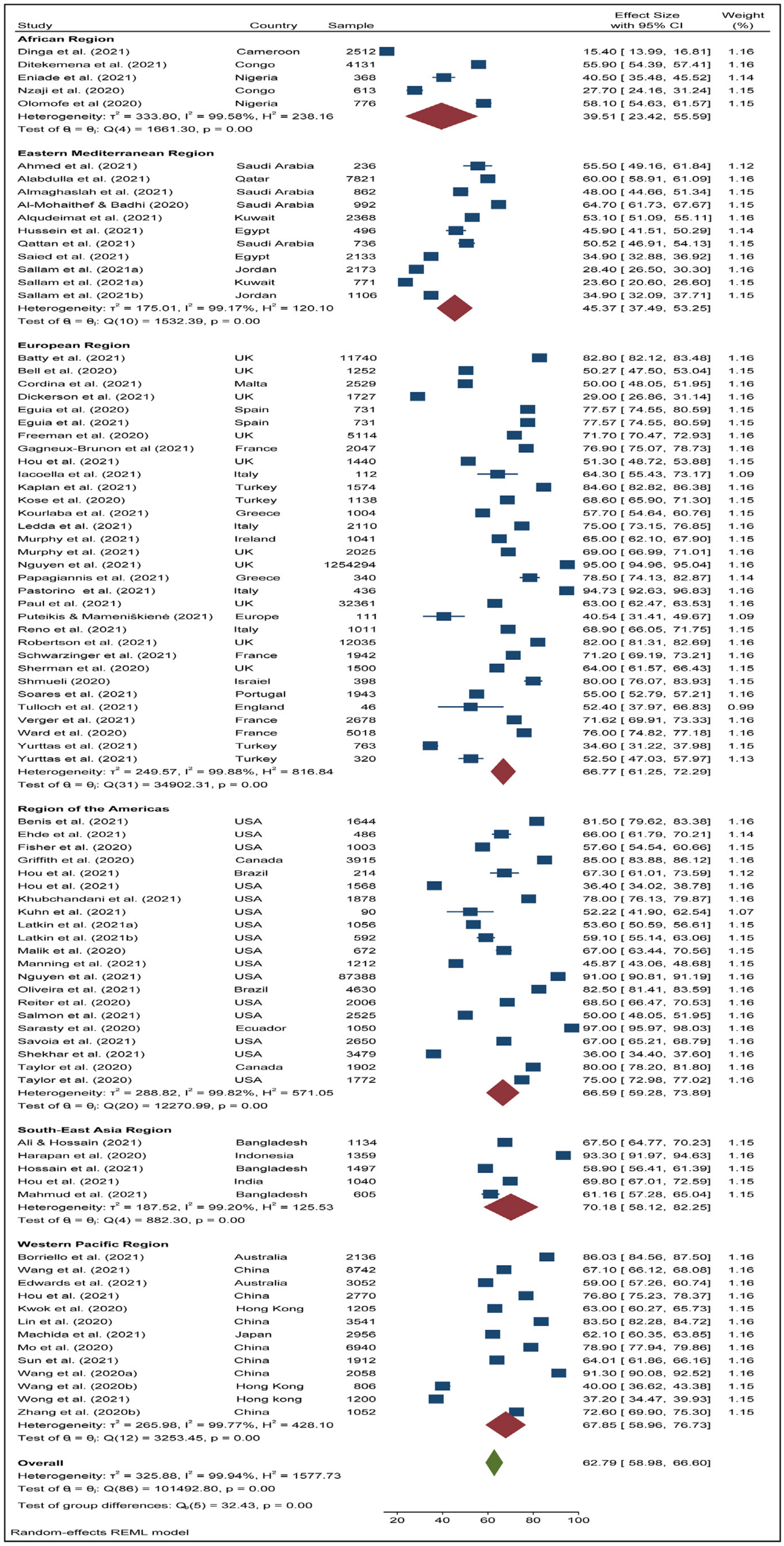

Figure 5. The pooled acceptance rate of COVID-19 vaccine across different territory of the world.

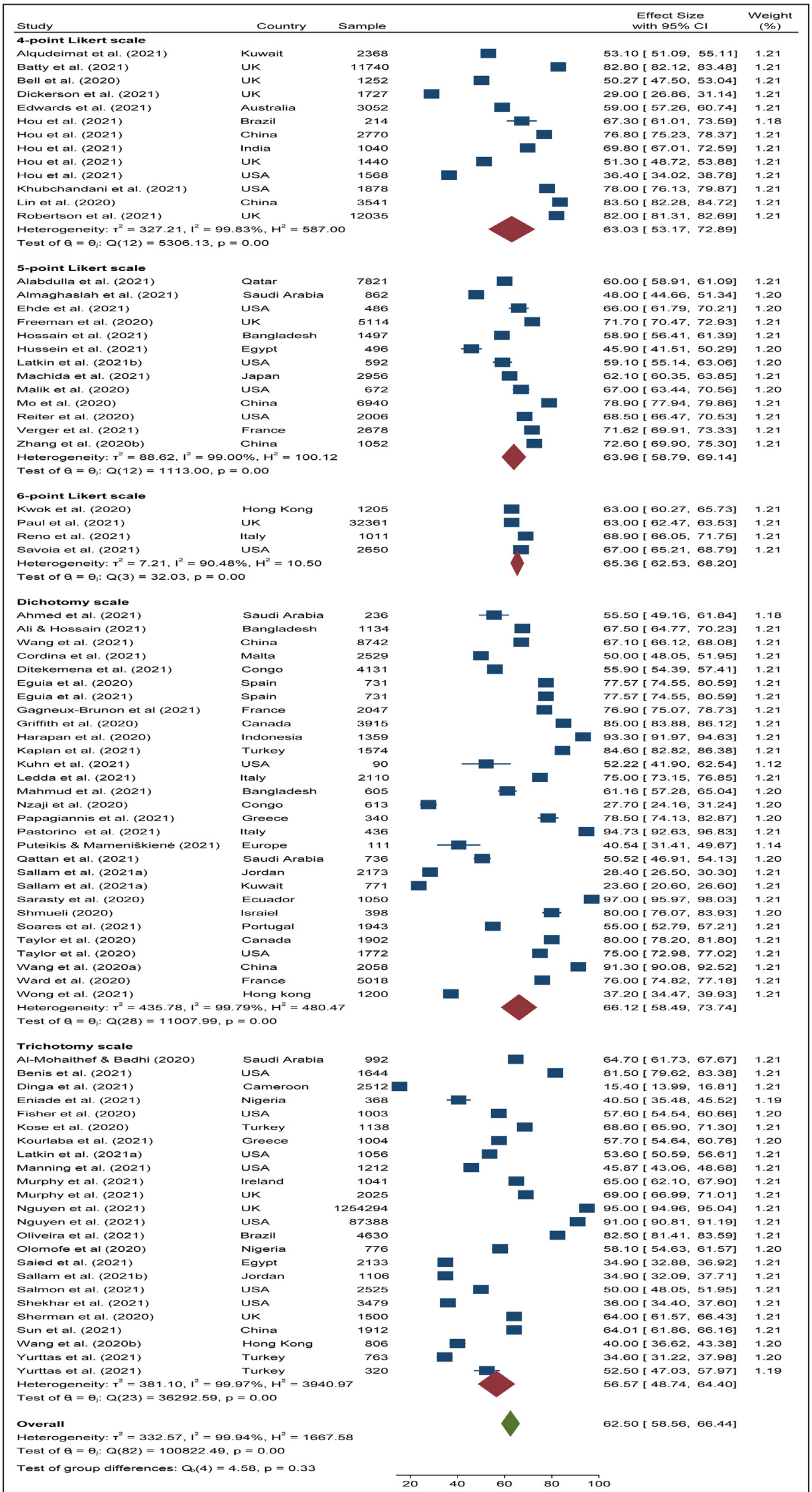

Figure 6. The pooled acceptance rate of COVID-19 vaccine across different estimation methods.

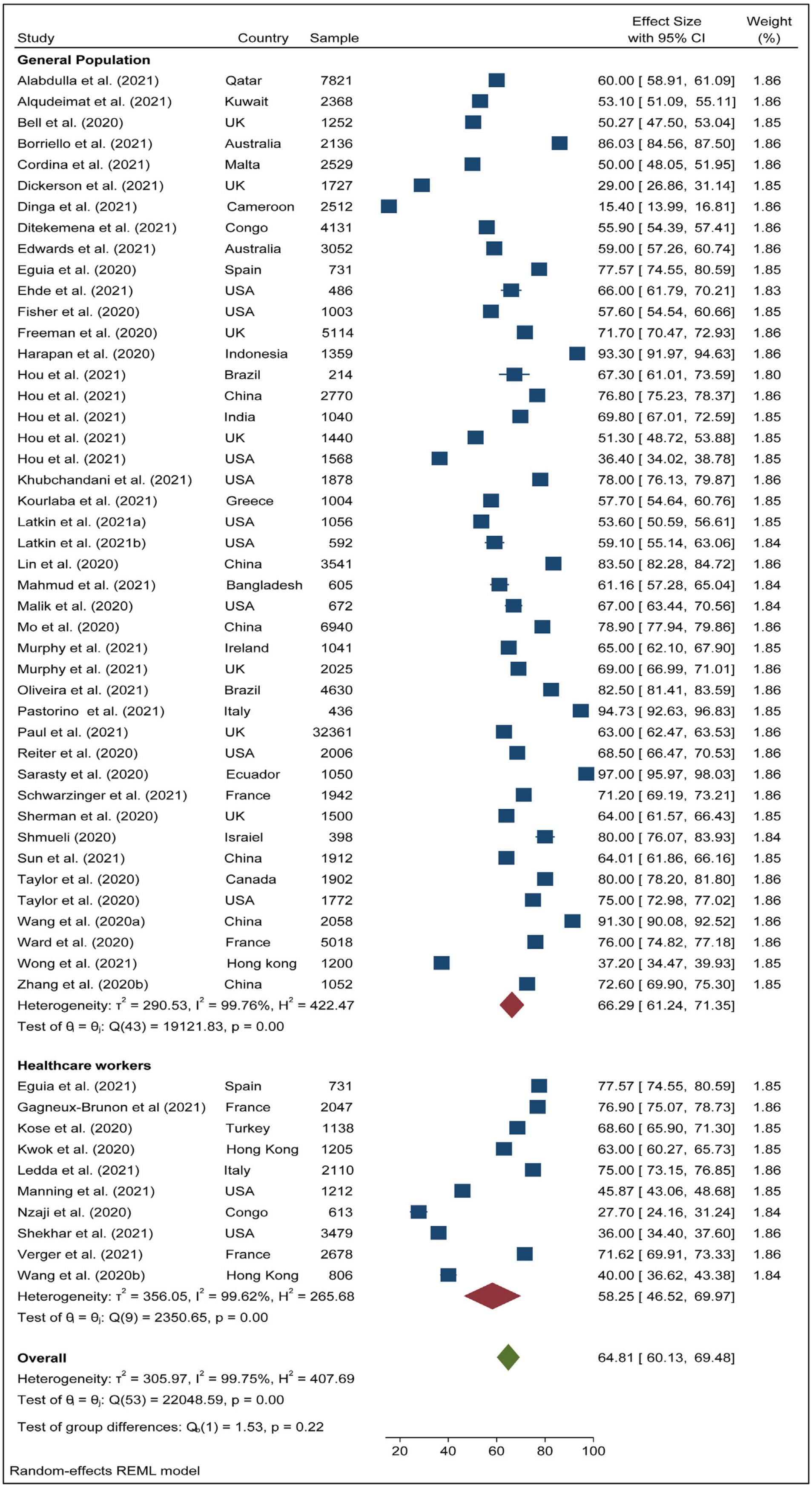

Figure 7. Pre COVID-19 vaccine approval acceptance rate among general population and healthcare workers.

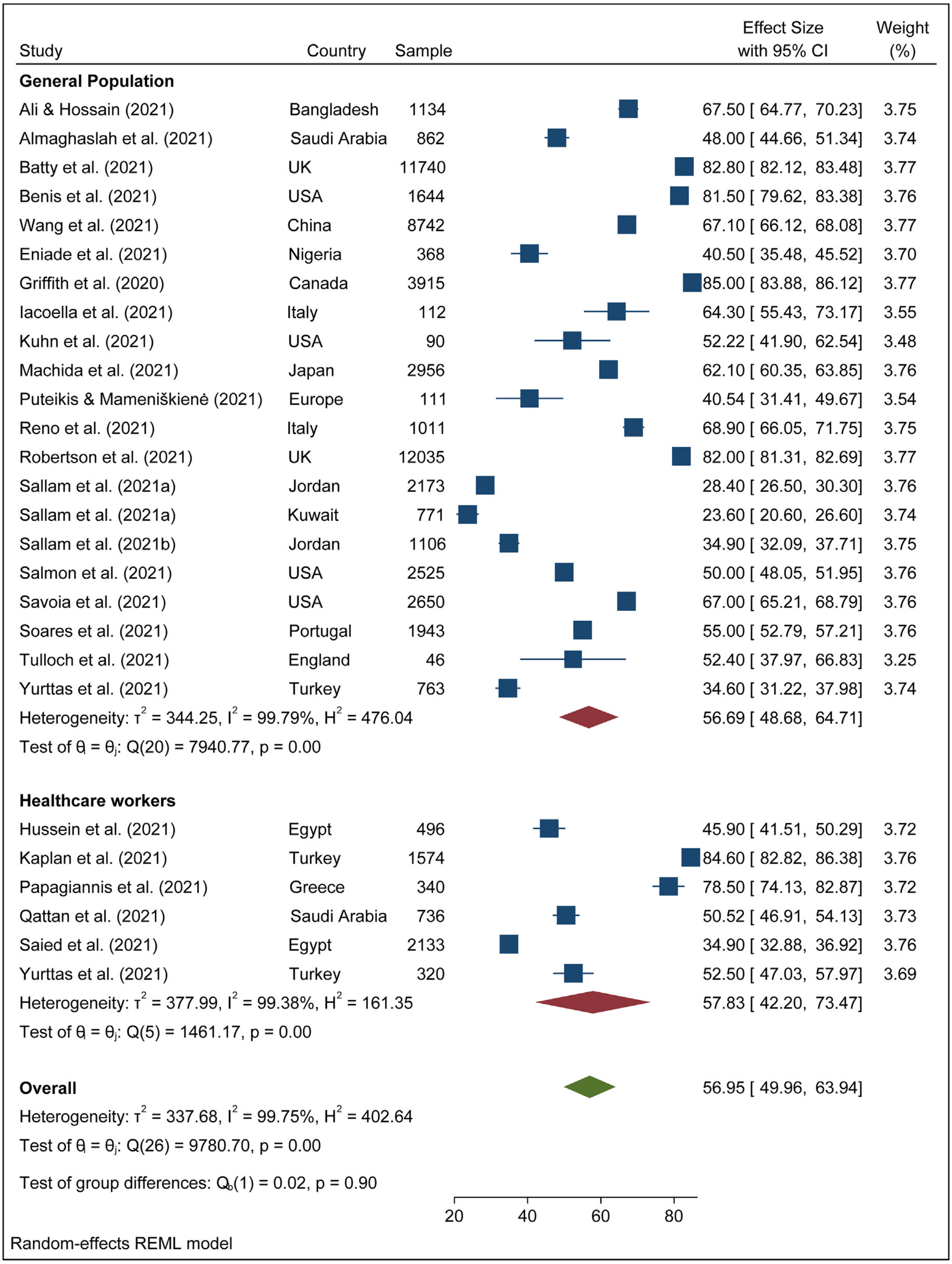

Figure 8. Post COVID-19 vaccine approval acceptance rate among general population and healthcare workers.

the WHO's division of its member countries by region. The region-wise COVID-19 vaccine acceptance rate is presented in Figure 5 and described in detail below.

3.5.1. African Region

In total, we included 5 studies from this region with a sample size of 8,400 and estimated the acceptance rate of COVID-19 vaccines as 39.51% (95% CI: 23.42–55.59) (Figure 5). In this territory, the highest acceptance rate was 58.10% (95% CI: 54.63–61.57) in Nigeria [82] and the lowest acceptance rate was found at 15.40% (95% CI: 13.99–16.81) in Cameroon [9]. The overall COVID-19 vaccine acceptance rate among the general population and healthcare workers in this territory respectively was 42.46% (95% CI: 23.10–61.82) and 27.70% (95% CI: 24.16–31.24) (Table 2).

Table 1. Summary characteristics of the selected Studies.

Author name	Study Type	Sampling method	Country	Study duration	Response rate %	Male %	Measurement	Sample	Target population	Study quality	Acceptance rate % (95% CI)
Ahmed et al. (2021)	Cross-sectional	N. A.	Saudi Arabia	N. A	37	29.4	Dichotomy scale	236	Healthcare workers	17	55.5 (49.16–61.84)
Alabdulla et al. (2021)	Cross-sectional	N. A.	Qatar	October 15 - November 15, 2020	N. A.	59.43	5-point Likert scale	7821	General Population	19	60 (58.91–61.09)
Ali & Hossain (2021)	Cross-sectional	N. A.	Bangladesh	January 18 - January 31, 2021	100	59.2	Dichotomy scale	1134	General Population	23	67.5 (64.77–70.23)
Almaghaslah et al. (2021)	Cross-sectional	N. A.	Saudi Arabia	January 15 - February 07, 2021	N. A.	45.5	5-point Likert scale	862	General Population	20	48 (44.66–51.34)
Al-Mohaithef & Badhi (2020)	Cross-sectional	Snowball sampling	Saudi Arabia	N. A.	N. A.	34.17	Trichotomy scale	992	General Population	19	64.7 (61.73–67.67)
Alqudeimat et al. (2021)	Cross-sectional	Snowball sampling	Kuwait	26-Aug-20	N. A.	31.8	4-point Likert scale	2368	General Population	27	53.1 (51.09–55.11)
Batty et al. (2021)	Cohort Study	N. A.	UK	November–December, 2020	62	43	4-point Likert scale	11740	General Population	21	82.8 (82.12–83.48)
Bell et al. (2020)	Cross-sectional	N. A.	UK	April 19 - May 11, 2020	N. A.	5	4-point Likert scale	1252	General Population	15	50.27 (47.5–53.04)
Benis et al. (2021)	Cross-sectional	N. A.	USA	December 10 - December 24, 2020	N. A.	53.9	Trichotomy scale	1644	General Population	25	81.5 (79.62–83.38)
Borriello et al. (2021)	Cross-sectional	N. A.	Australia	March 27 - March 31, 2020	99.3	49.3	N. A.	2136	General Population	16	86.03 (84.56–87.5)
Cordina et al. (2021)	Cross-sectional	N. A.	Malta	Octoer 26 - November 26, 2020	N. A.	26.4	Dichotomy scale	2529	General Population	16	50 (48.05–51.95)
Dickerson et al. (2021)	Cohort study	N. A.	UK	October 29 - December 9, 2020	31	6.5	4-point Likert scale	1727	General Population	21	29 (26.86–31.14)
Dinga et al. (2021)	Cross-sectional	N. A.	Cameroon	May–August, 2020	N. A.	45.1	Trichotomy scale	2512	General Population	20	15.4 (13.99–16.81)
Ditekemena et al. (2021)	Cross-sectional	N. A.	Congo	August 24 - September 8, 2020	99.3	31.6	Dichotomy scale	4131	General Population	21	55.9 (54.39–57.41)
Edwards et al. (2021)	Longitudinal	N. A.	Australia	Apr-20	7.8	N. A.	4-point Likert scale	3052	General Population	22	59 (57.26–60.74)
Eguia et al. (2020)	Cross-sectional	N. A.	Spain	September 10 - November 23, 2020	72.95	44.04	Dichotomy scale	731	General Population	21	77.57 (74.55–80.59)
Eguia et al. (2021)	Cross-sectional	N. A.	Spain	September 10 - November 23, 2020	N. A.	45.05	Dichotomy scale	731	Healthcare workers	22	77.57 (74.55–80.59)
Ehde et al. (2021)	Cross-sectional	N. A.	USA	April 10 - May 6, 2020	93.1	17.3	5-point Likert scale	486	General Population	23	66 (61.79–70.21)
Eniade et al. (2021)	Cross-sectional	N. A.	Nigeria	December, 2020	N. A.	41.1	Trichotomy scale	368	General Population	20	40.5 (35.48–45.52)
Fisher et al. (2020)	Cross-sectional	N. A.	USA	April 16 - April 20, 2020	N. A.	64	Trichotomy scale	1003	General Population	24	57.6 (54.54–60.66)
Freeman et al. (2020)	Cross-sectional	Quota sampling	UK	September 24 - October 17, 2020	N. A.	50	5-point Likert scale	5114	General Population	25	71.7 (70.47–72.93)
Gagneux-Brunon et al (2021)	Cross-sectional	N. A.	France	March 26 - July 2, 2020	74	26	Dichotomy scale	2047	Healthcare workers	28	76.9 (75.07–78.73)
Griffith et al. (2020)	Cross-sectional	N. A.	Canada	December 10 - December 23, 2020	N. A.	N. A.	Dichotomy scale	3915	General Population	19	85 (83.88–86.12)
Harapan et al. (2020)	Cross-sectional	Snowball sampling	Indonesia	March 25 - April 6, 2020	N. A.	34.3	Dichotomy scale	1359	General Population	25	93.3 (91.97–94.63)

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Table 1 (*continued*)

Author name	Study Type	Sampling method	Country	Study duration	Response rate %	Male %	Measurement	Sample	Target population	Study quality	Acceptance rate % (95% CI)
Hossain et al. (2021)	Cross-sectional	PPS sampling	Bangladesh	N. A.	100	53	5-point Likert scale	1497	General Population	15	58.9 (56.41–61.39)
Hou et al. (2021)	Cross-sectional	N. A.	Brazil	June 13 - July 31, 2020	54.6	N.A.	4-point Likert scale	214	General Population	16	67.3 (61.01–73.59)
Hou et al. (2021)	Cross-sectional	N. A.	China	June 13 - July 31, 2020	54.6	N.A.	4-point Likert scale	2770	General Population	16	76.8 (75.23–78.37)
Hou et al. (2021)	Cross-sectional	N. A.	India	June 13 - July 31, 2020	54.6	N.A.	4-point Likert scale	1040	General Population	16	69.8 (67.01–72.59)
Hou et al. (2021)	Cross-sectional	N. A.	UK	June 13 - July 31, 2020	54.6	N.A.	4-point Likert scale	1440	General Population	16	51.3 (48.72–53.88)
Hou et al. (2021)	Cross-sectional	N. A.	USA	June 13 - July 31, 2020	54.6	N.A.	4-point Likert scale	1568	General Population	16	36.4 (34.02–38.78)
Hussein et al. (2021)	Cross-sectional	N. A.	Egypt	December 1 - January 1, 2021	99.2	34.9	5-point Likert scale	496	Healthcare workers	25	45.9 (41.51–50.29)
Iacoella et al. (2021)	Cross-sectional	N. A.	Italy	February 1 - February 15, 2021	100	75.9	N. A.	112	General Population	16	64.3 (55.43–73.17)
Kaplan et al. (2021)	Cross-sectional	N. A.	Turkey	December, 2020	N. A.	41.2	Dichotomy scale	1574	Healthcare workers	28	84.6 (82.82–86.38)
Khubchandani et al. (2021)	Cross-sectional	N. A.	USA	June, 2020	N. A.	48	4-point Likert scale	1878	General Population	23	78 (76.13–79.87)
Kose et al. (2020)	Cross-sectional	N. A.	Turkey	September 17- September 20, 2020	N. A.	27.5	Trichotomy scale	1138	Healthcare workers	24	68.6 (65.9–71.3)
Kourlaba et al. (2021)	Cross-sectional	N. A.	Greece	April 28- May 3, 2020	38.66	49	Trichotomy scale	1004	General Population	20	57.7 (54.64–60.76)
Kuhn et al. (2021)	Cross-sectional	N. A.	USA	December 2020–January 2021	65.8	41	Dichotomy scale	90	General Population	19	52.22 (41.9–62.54)
Kwok et al. (2020)	Cross-sectional	N. A.	Hong Kong	March 16 - April 29, 2020	N. A.	N. A.	6-point Likert scale	1205	Healthcare workers	23	63 (60.27–65.73)
Latkin et al. (2021a)	Cross-sectional	N. A.	USA	May 14 - May 18, 2020	24.1	29.9	Trichotomy scale	1056	General Population	22	53.6 (50.59–56.61)
Latkin et al. (2021b)	Cross-sectional	N. A.	USA	July, 2020	N.A.	43.9	5-point Likert scale	592	General Population	19	59.1 (55.14–63.06)
Ledda et al. (2021)	Cross-sectional	N. A.	Italy	January–December, 2020	99	48	Dichotomy scale	2110	Healthcare workers	20	75 (73.15–76.85)
Lin et al. (2020)	Cross-sectional	N. A.	China	May 1 - May 9, 2020	N. A.	48.1	4-point Likert scale	3541	General Population	26	83.5 (82.28–84.72)
Machida et al. (2021)	Cross-sectional	N. A.	Japan	January 14 - January 18, 2021	98.5	49.32	5-point Likert scale	2956	General Population	20	62.1 (60.35–63.85)
Mahmud et al. (2021)	Cross-sectional	N. A.	Bangladesh	January 30 - February 06, 2020	N. A.	62.15	Dichotomy scale	605	General Population	30	61.16 (57.28–65.04)
Malik et al. (2020)	Cross-sectional	Bootstrap resampling	USA	May, 2020	N. A.	43	5-point Likert scale	672	General Population	19	67 (63.44–70.56)
Manning et al. (2021)	Cross-sectional	N. A.	USA	August 10 - September 14, 2020	84.9	10.89	Trichotomy scale	1212	Healthcare workers	17	45.87 (43.06–48.68)
Mo et al. (2020)	Cross-sectional	N. A.	China	November 1 - November 28, 2020	72.3	36.4	5-point Likert scale	6940	General Population	23	78.9 (77.94–79.86)
Murphy et al. (2021)	Cross-sectional	N. A.	Ireland	March 31 - April 05, 2020	N. A.	48.2	Trichotomy scale	1041	General Population	27	65 (62.1–67.9)

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Table 1 (*continued*)

Author name	Study Type	Sampling method	Country	Study duration	Response rate %	Male %	Measurement	Sample	Target population	Study quality	Acceptance rate % (95% CI)
Murphy et al. (2021)	Cross-sectional	N. A.	UK	March 23 - March 28, 2020	N. A.	48.3	Trichotomy scale	2025	General Population	27	69 (66.99–71.01)
Nguyen et al. (2021)	Cohort study	N. A.	UK	March 24, 2020–February 16, 2021	28.33	46.34	Trichotomy scale	1254294	General Population	28	95 (94.96–95.04)
Nguyen et al. (2021)	Cohort study	N. A.	USA	March 24, 2020–February 16, 2021	23.6	45.35	Trichotomy scale	87388	General Population	28	91 (90.81–91.19)
Nzaji et al. (2020)	Cross-sectional	N. A.	Congo	March–April 30, 2020	N. A.	50.9	Dichotomy scale	613	Healthcare workers	22	27.7 (24.16–31.24)
Oliveira et al. (2021)	Cross-sectional	Multistage stratified sampling	Brazil	October 19 - October 30, 2020	90.78	80.2	Trichotomy scale	4630	General Population	21	82.5 (81.41–83.59)
Olomofe et al (2020)	Cross-sectional	N. A.	Nigeria	N. A	N. A.	58.1	Trichotomy scale	776	General Population	25	58.1 (54.63–61.57)
Papagiannis et al. (2021)	Cross-sectional	N. A.	Greece	December 15 - December 22, 2020	N. A.	50	Dichotomy scale	340	Healthcare workers	20	78.5 (74.13–82.87)
Pastorino et al. (2021)	Cross-sectional	N. A.	Italy	June 8 - July 12, 2020	78	29.59	Dichotomy scale	436	General Population	22	94.73 (92.63–96.83)
Paul et al. (2021)	Cross-sectional	N. A.	UK	September 7 - October 5, 2020	71.57	49.4	6-point Likert scale	32361	General Population	18	63 (62.47–63.53)
Puteikis & Mameniškienė (2021)	Cross-sectional	N. A.	Europe	December 7 - December 31, 2020	100	39.6	Dichotomy scale	111	General Population	23	40.54 (31.41–49.67)
Qattan et al. (2021)	Cross-sectional	N. A.	Saudi Arabia	December 8 - December 14, 2020	91.44	60.18	Dichotomy scale	736	Healthcare workers	20	50.52 (46.91–54.13)
Reiter et al. (2020)	Cross-sectional	N. A.	USA	May, 2020	N. A.	43	5-point Likert scale	2006	General Population	20	68.5 (66.47–70.53)
Reno et al. (2021)	Cross-sectional	N. A.	Italy	January 19 - January 26, 2021	100	44.8	6-point Likert scale	1011	General Population	25	68.9 (66.05–71.75)
Robertson et al. (2021)	Cross-sectional	N. A.	UK	November 24 - December 1, 2020	62	46.8	4-point Likert scale	12035	General Population	28	82 (81.31–82.69)
Saied et al. (2021)	Cross-sectional	N. A.	Egypt	January, 2021	N. A.	34.8	Trichotomy scale	2133	Healthcare workers	24	34.9 (32.88–36.92)
Sallam et al. (2021a)	Cross-sectional	N. A.	Jordan	December 14 - December 18, 2020	N. A.	30.6	Dichotomy scale	2173	General Population	26	28.4 (26.5–30.3)
Sallam et al. (2021a)	Cross-sectional	N. A.	Kuwait	December 14 - December 18, 2020	N. A.	30.6	Dichotomy scale	771	General Population	23	23.6 (20.6–26.6)
Sallam et al. (2021b)	Cross-sectional	N. A.	Jordan	January 19 - January 23, 2021	96.2	27.5	Trichotomy scale	1106	General Population	22	34.9 (32.09–37.71)
Salmon et al. (2021)	Panel survey	N. A.	USA	November 25 - December 07, 2020	N. A.	48.2	Trichotomy scale	2525	General Population	20	50 (48.05–51.95)
Sarasty et al. (2020)	Cross-sectional	N. A.	Ecuador	April 2 - April 7, 2020	N. A.	61	Dichotomy scale	1050	General Population	21	97 (95.97–98.03)
Savoia et al. (2021)	Cross-sectional	N. A.	USA	December 13 - December 23, 2020	84	53.5	6-point Likert scale	2650	General Population	18	67 (65.21–68.79)
Schwarzinger et al. (2021)	Cross-sectional	N. A.	France	June 22 - July 3, 2020	97.1	48.9	N. A.	1942	General Population	20	71.2 (69.19–73.21)
Shekhar et al. (2021)	Cross-sectional	Snowball sampling	USA	October 7 - November 9, 2020	85.26	25	Trichotomy scale	3479	Healthcare workers	19	36 (34.4–37.6)
Sherman et al. (2020)	Cross-sectional	Quota sampling	UK	July 14 - July 17, 2020	98	49	Dichotomy scale	1500	General Population	24	64 (61.57–66.43)

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Table 1 (*continued*)

Author name	Study Type	Sampling method	Country	Study duration	Response rate %	Male %	Measurement	Sample	Target population	Study quality	Acceptance rate % (95% CI)
Shmueli (2020)	cross-sectional	N.A	Israiel	May 24- June 24, 2020	N. A.	40	Dichotomy scale	398	General Population	21	80 (76.07–83.93)
Soares et al. (2021)	Cross-sectional	N. A.	Portugal	September 2020–January 2021	N. A.	28.89	Dichotomy scale	1943	General Population	27	55 (52.79–57.21)
Sun et al. (2021)	Cross-sectional	N. A.	China	March–April, 2020	100	30.23	Trichotomy scale	1912	General Population	21	64.01 (61.86–66.16)
Taylor et al. (2020)	Cross-sectional	Commercial survey sampling	Canada	May, 2020	N. A.	57	Dichotomy scale	1902	General Population	16	80 (78.2–81.8)
Taylor et al. (2020)	Cross-sectional	Commercial survey sampling	USA	May, 2020	N. A.	57	Dichotomy scale	1772	General Population	19	75 (72.98–77.02)
Tulloch et al. (2021)	Cross-sectional	N. A.	England	January 21 - January 29, 2021	53	N. A.	N. A.	46	General Population	20	52.4 (37.97–66.83)
Verger et al. (2021)	Cross-sectional	N. A.	France	October–November, 2020	100	30.75	5-point Likert scale	2678	Healthcare workers	24	71.62 (69.91–73.33)
Wang et al. (2020a)	Cross-sectional	Stratified random sampling	China	March, 2020	N. A.	45.8	Dichotomy scale	2058	General Population	28	91.3 (90.08–92.52)
Wang et al. (2020b)	Cross-sectional	N. A.	Hong Kong	February–March, 2020	5.18	19.3	Trichotomy scale	806	Healthcare workers	15	40 (36.62–43.38)
Wang et al. (2021)	Cross-sectional	N. A.	China	January 10 - January 22, 2021	99.6	33.6	Dichotomy scale	8742	General Population	19	67.1 (66.12–68.08)
Ward et al. (2020)	Cross-sectional	Stratified random sampling	France	April, 2020	N. A.	N. A.	Dichotomy scale	5018	General Population	26	76 (74.82–77.18)
Wong et al. (2021)	Cross-sectional	N. A.	Hong kong	July 27 - August 27, 2020	55	28.7	Dichotomy scale	1200	General Population	20	37.2 (34.47–39.93)
Yurttas et al. (2021)	Cross-sectional	N. A.	Turkey	January 4 - January 13, 2021	100	33.81	Trichotomy scale	763	General Population	26	34.6 (31.22–37.98)
Yurttas et al. (2021)	Cross-sectional	N. A.	Turkey	January 4 - January 13, 2021	22.85	27.5	Trichotomy scale	320	Healthcare workers	26	52.5 (47.03–57.97)
Zhang et al. (2020b)	Cross-sectional	N. A.	China	September 1 - September 7, 2020	77.4	37.5	5-point Likert scale	1052	General Population	22	72.6 (69.9–75.3)

PPS, Probability proportional to size; N.A., Not available; UK, United Kingdom; USA, United States of America.

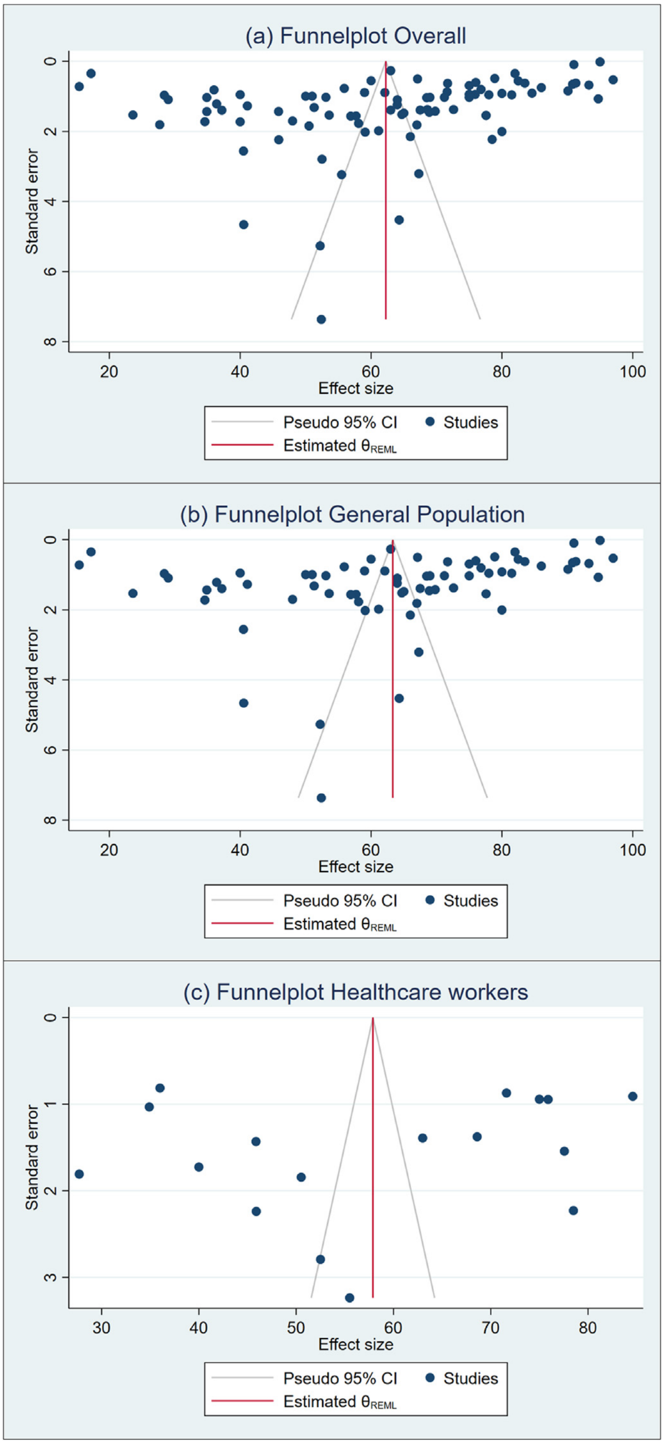

Figure 9. Funnel plot for included studies across different target population.

3.5.2. Eastern Mediterranean Region

A total of 12 studies with a sample size of 19,694 estimated a pooled COVID-19 vaccine acceptance rate of 45.37% (95% CI: 37.49–53.25) in this region (Figure 5). In this territory, the highest acceptance rate was found at 64.70% (95% CI: 61.73–67.67) in Saudi Arabia [48] and the lowest acceptance rate was found at 23.60% (95% CI: 20.60–26.60) in Kuwait [15]. The acceptance rate of COVID-19 vaccines in this region was 46.34% (95% CI: 37.73–55.12) among healthcare workers and 44.64% (95% CI: 32.88–56.48) (Table 2) among the general population (Table 2).

3.5.3. European Region

A large number of studies (32 studies with a sample size of 1,351,511) were found in this territory where the overall COVID-19 vaccine acceptance rate was found to be 66.77% (95% CI: 61.25–72.29) (Figure 5). In this region, the highest acceptance rate was 95.00% (95% CI: 94.96–95.04) in the UK [80] and the lowest acceptance rate was 29.00% (95% CI: 26.86–31.14) also in the UK [12]. Among healthcare workers, the acceptance rate of COVID-19 vaccines was 73.33% (95% CI: 66.90–79.75) in this territory and among the general population, it was 64.58% (95% CI: 57.69–71.46) (Table 2).

3.5.4. Region of the Americas

A total of 21 studies with a sample size of 121,732 were found in this territory. The overall COVID-19 vaccine acceptance rate was found at 66.59% (95% CI: 59.28–73.89) (Figure 5). The highest acceptance rate was observed to be 97.00% (95% CI: 95.97–98.04) in Ecuador [92] and the lowest acceptance rate was 36.00% (95% CI: 34.41–37.59) in the USA [14]. In this territory, 40.86% (95% CI: 31.19–50.54) of the healthcare workers showed a willingness to accept COVID-19 vaccines, and 69.33% (95% CI: 59.88–74.74) of the general population agreed to accept COVID-19 vaccines (Table 2).

3.5.5. South-East Asia Region

The pooled COVID-19 vaccine acceptance rate in this region was estimated as 70.18% (95% CI: 58.12–82.25) (Figure 5) from five studies with a sample size of 5,635. The highest acceptance rate was seen at 93.30% (95% CI: 91.97–94.62) in Indonesia [63] and the lowest acceptance rate was 70.18% (95% CI: 58.12–82.25) in Bangladesh [64]. All the studies we found in this territory by systematic searching were among the general population (Table 2).

3.5.6. Western Pacific Region

The overall COVID-19 vaccine acceptance rate was found as 67.85% (95% CI: 58.96–76.73) (Figure 5) in this territory from 13 studies with a sample size of 38,370. The acceptance rate was highest at 91.30% (95% CI: 90.08–92.52) in China [22] and lowest at 37.20% (95% CI: 34.47–39.93) in Hong Kong [17]. The COVID-19 vaccine acceptance rate among healthcare workers and the general population were estimated respectively at 51.52% (95% CI: 28.98–74.06) and 70.80% (95% CI: 61.81–7979) (Table 2).

4. Discussion

Vaccine hesitancy is a long-standing problem that poses a significant challenge to public health, as evidenced by certain communicable diseases [105] such as Measles, pertussis, and SARS outbreaks. Vaccine acceptance can be a barrier in worldwide attempts to mitigate the detrimental effects of a pandemic on public health and can restrict the power of health systems to control the COVID-19 pandemic. Thus, by accounting for the regional disparities, estimating the COVID-19 vaccine acceptance rate can be effective in designing the action plan to improve vaccine acceptance and battle against the COVID-19 pandemic.

The results of our systematic review and meta-analysis include 1,581,562 respondents. Among them, 1,559,708 were general population and 21,854 were healthcare workers that were pulled from 78 study samples across 32 countries. Results show that the COVID-19 vaccine acceptance rate estimated combinedly among the general population and healthcare workers at post time of vaccine approval (56.59%) was considerably lower than the acceptance rate (64.81%) before the vaccine approval (Figure 4). During the pre-approval time, the general population showed a higher vaccine acceptance rate (66.29%) compared to the post-approval time (56.69%) (Figures 8 and 9). It was inspected in the previous two systematic reviews [37, 106] that in many regions, the COVID-19 vaccine acceptance rates were decreasing over time. This declining trend in the COVID-19 vaccine acceptance rate was also observed among the general population in a longitudinal study in China

Table 2. Regional disparities of acceptance of COVID-19 vaccine among general population and healthcare workers.

Territory	Healthcare worker		General population	
	Acceptance rate % (95% CI)	(I^2, Q (df.)) P-value	Acceptance rate % (95% CI)	(I^2, Q (df.)) P-value
African Region	27.70 (24.16–31.24)*		42.46 (23.10–61.82)	($I^2 = 99.68$, Q (3) = 1640.68) P-value < 0.001
Eastern Mediterranean Region	46.43 (37.73–55.12)	($I^2 = 95.51$, Q (3) = 86.30) P-value < 0.001	44.68 (32.88–56.48)	($I^2 = 99.81$, Q (7) = 7241.10) P-value < 0.001
European Region	73.33 (66.90–79.75)	($I^2 = 98.34$, Q (7) = 216.91) P-value < 0.001	64.58 (57.69–71.46)	($I^2 = 99.91$, Q (23) = 32.539.23) P-value < 0.001
Region of the Americas	40.86 (31.19–50.54)	($I^2 = 97.22$, Q (1) = 35.93) P-value < 0.001	69.33 (59.88–74.74)	($I^2 = 99.79$, Q (18) = 7210.29) P-value < 0.001
South-East Asia Region	-	-	70.18 (58.12–82.25)	($I^2 = 99.20$, Q (4) = 882.30) P-value < 0.001
Western Pacific Region	51.52 (28.98–74.06)	($I^2 = 99.07$, Q (1) = 107.69) P-value < 0.001	70.80 (61.81–79.79)	($I^2 = 99.76$, Q (10) = 2773.69) P-value < 0.001

* refers that only one study was included in this subgroup; - refers that no study was considered in this subgroup; CI, Confidence Interval

[107]. These are mixed findings because there is also evidence that the acceptance rate is increasing [21]. Researchers [27, 37, 106, 107] agreed that the misinformation about COVID-19, uncertainty about the vaccine efficacy and safety, inconvenience of vaccination, and faster development of COVID-19 vaccines might lead to a decline in vaccine acceptance rate. It is also evident that after vaccine approval, a large group of people is not willing to take the COVID-19 vaccines due to vaccine side effects which created widespread concern [108, 109, 110].

Considerable geographical disparities in vaccine acceptance were found in this study. A comparatively higher acceptance rate was found in the South-East Asia Region (70.18%%), followed by the Western Pacific Region (67.85%), the European Region (66.77%), the Region of the Americas (66.59%), Eastern Mediterranean Region (45.37%), and African Region (39.51%). In a previous study, a very high COVID-19 vaccine acceptance rate was found in the South-East Asia region (90%) by considering only 3 studies in this region [37].

In the African region, the prevalence of vaccine acceptance among the general population was estimated at 42.46% and among healthcare workers was observed at 27.70% (Table 2). An early awareness, perceptions, and practices survey study on COVID-19 in North-Central Nigeria recorded an acceptance rate of only 29%, highlighting the need for further research to accurately depict COVID-19 vaccine hesitancy in Africa [111]. A study found that a lack of desire to receive the vaccine in Cameroon is concerning and several measures need to implement to reduce the COVID-19 vaccine hesitancy to gain herd immunity among both general populations and healthcare workers [9, 112]. However, we found a lack of studies on vaccine acceptance in this region (only five). To generalize the result to the entire region, further studies are required.

In the Eastern Mediterranean Region, 46.43% of the healthcare workers and 44.68% of the general population showed a willingness to accept COVID-19 vaccines (Table 2). A cross-sectional study in 10 Countries in Eastern Mediterranean Region showed a 58% of vaccine acceptance rate among healthcare workers [113]. In this region, the highest acceptance rate was found in Saudi Arabia [48] and the lowest acceptance rate was found in Kuwait [15]. Low vaccination rates in Kuwait may be attributed to the region's prevalent acceptance of conspiratorial ideas, which has resulted in a pessimistic mindset against vaccination [114].

In Europe, both the highest and lowest acceptance rates were found in the UK [12, 80]. Such COVID-19 vaccine hesitancy trends matched those seen in a previous study, which found comparatively higher rates of vaccine hesitancy in the UK [50, 90]. Furthermore, many studies found disparities in the vaccine acceptance rate among adults, healthcare workers, students, etc. in Europe which is also partly investigated in our studies [115, 116, 117].

In American Regions, the COVID-19 vaccine acceptance rate was 69.33% among the general population and 40.86% among healthcare workers (Table 2). Ecuador [92] reported the highest acceptance rate and the lowest acceptance rate was found in the USA [14] in this territory. Ecuador and Brazil reported more than 70% of vaccine acceptance rates observed in some previous studies which are consistent with our studies as Ecuador reported the highest rate [118]. The refusal of a safe, reliable, and widely available COVID-19 vaccine has been a major issue since the beginning in the USA which might be the reason for the lowest acceptance rate in the USA, but the scenario has changed recently [119]. The lower COVID-19 vaccine acceptance rate (33.5%) among healthcare workers in American regions was found in previous studies [120] which is also consistent with our studies.

In South-East Asia Region, no studies were found among healthcare workers. All the studies showed an acceptance rate of 70.18% among the general population (Table 2). The highest acceptance rate was found in Indonesia [63] and the lowest acceptance rate was found in Bangladesh [64]. The lack of confidence in vaccine safety and efficacy, the healthcare system, and management in Bangladesh might be the reasons for the lower vaccine acceptance rate [27].

In the Western Pacific region, around 71% of the general population and 51.52% of healthcare workers intended to accept COVID-19 vaccines (Table 2). China [22] reported the highest acceptance rate, whereas, the lowest acceptance rate was found in Hong Kong [17]. A study found that almost 90% of respondents in China showed a willingness to take vaccines [118] which is consistent with our research.

4.1. Strengths

To our knowledge, this is the first comprehensive study that covered all the territories of the world to investigate COVID-19 vaccine acceptance and found a large number of studies through systematic search. In this study, we estimated the vaccine acceptance rates for several possible subgroups. We also inspected the COVID-19 vaccine approval effect on the vaccine acceptance rate worldwide among healthcare workers and general populations.

4.2. Limitations

The study has a few limitations. First, it's important to keep in mind that many of the experiments used in this study asked people if they planned to have the vaccine before it was available. Second, diverse approaches to expressing willingness to consider COVID-19 vaccines in multiple trials posed a significant constraint. Third, in the African and South-East Asian regions, we found only five studies each. It is unwise to generalize the findings to an entire region based on only five studies' data. Fourth, since some studies were done within the same country, some of the included studies might consider the same population. Fifth, since some of the documents were not written in English, we may have overlooked them in the final report. Last but not least, the studies did not consider any heterogeneous effect (such as age variation, sex variation, and so on) on the vaccine acceptance rate.

5. Conclusions

This systematic review and meta-analysis come up with a timely and comprehensive synthesis of the existing literature highlighting the low COVID-19 vaccine acceptance rate among both general people and healthcare workers. The study also detects regional disparities in COVID-19 vaccine acceptance rates. African region and Eastern Mediterranean region showed substantially low acceptance rates. However, very few relevant studies were found in the African and South-East Asian regions making it difficult to generalize the results to the entire regions. A lesser acceptance rate was observed among healthcare workers compared to general people and the vaccine acceptance rate considerably reduced among the general population after vaccine approval (11 December 2020). Such studies will help to implement intervention programs to reduce vaccination hesitancy and increase uptake among the vulnerable group or in regions with a low acceptance rate. The authors of this study highly recommend that more research be undertaken across all regions of the world to determine the factors that might cause COVID-19 vaccination aversion.

Declarations

Author contribution statement

Sultan Mahmud; Md Mohsin: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Sorif Hossain: Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Md Mynul Islam; Abdul Muyeed: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

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Data availability statement

Data included in article/supplementary material/referenced in article.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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