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Global prevalence and determinants associated with the acceptance of monkeypox vaccination

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Abstract

Assessing the acceptance of the monkeypox vaccine is crucial for the success of vaccination programs, yet the prevalence reports remain inconclusive. The aim of this study was to determine the global prevalence of monkeypox vaccine acceptance and identify its associated factors. A meta-analysis was conducted with a comprehensive search strategy on the following databases, including Scopus, Embase, and PubMed, for articles published up to April 5, 2024. This study utilizes a single-arm meta-analysis to calculate the pooled prevalence of monkeypox vaccine acceptance. A *Z*-test was employed to identify factors associated with the vaccine acceptance. Our study analyzed 51 articles encompassing 98,746 participants, revealing an overall monkeypox vaccine acceptance rate of 65%. Notably, the highest acceptance rates were observed among men who have sex with men (MSMs), while healthcare workers (HCWs) showed the lowest acceptance rates. Additionally, our findings indicated an increased acceptance in individuals with educational attainment beyond a bachelor's degree, a history of COVID-19 and influenza vaccination, homosexual orientation, and HIV-positive status. Conversely, lower acceptance risk was associated with those with educational attainment below a bachelor's degree, heterosexual orientation, and bisexual orientation. In conclusion, our current study has determined the rate of monkeypox vaccine acceptance and identified its associated factors. These findings offer valuable insights as the foundation for targeted policies to manage and increase acceptance rates.

Keywords: Monkeypox, vaccine, acceptance, predictors, prevalence

Introduction

Monkeypox vaccination has become a global priority since the potential monkeypox outbreak that was reported in 2022 [1]. Efforts have primarily focused on ensuring the safety and efficacy of available monkeypox vaccines, such as JYNNEOS®, ACAM2000, and the modified smallpox vaccine, as well as increasing vaccination coverage among high-risk populations [2]. Implementing vaccination programs is crucial for effectively managing and preventing monkeypox infections. This urgency is evidenced by the successful control of infections such as

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polio, measles, mumps, and rubella through vaccination initiatives. Additionally, vaccination programs have been shown to improve global health outcomes and economic conditions [3,4]. However, the potential ineffectiveness of any vaccination initiatives needs to be evaluated. A study highlighted obstacles to successful vaccination programs, including rejection, high distribution cost, limited availability of healthcare services, and impractical scheduling for immunization appointments [5]. Among these factors, vaccine rejection is deemed one of the most significant [6]. Individuals who refuse vaccination often spread misinformation and potentially influencing others to do the same. Therefore, assessing vaccine acceptance is crucial for the successful delivery of vaccination programs worldwide [7].

Evaluating vaccine acceptance is important, particularly for novel vaccines or potential vaccine options [6,7]. This occurrence has been reported in instances of Ebola [8], malaria [9], and dengue [10]. Factors influencing vaccine acceptance are multifaceted, including insufficient knowledge about disease prevention and socioeconomic circumstances [11]. This situation poses a challenge for achieving comprehensive vaccine uptake. Furthermore, the governments, which function as the ultimate regulatory bodies of countries, appear to lack specialized interventions to proactively address vaccine acceptance in immunization initiatives. Notably, interim advice regarding vaccination against monkeypox emphasizes primary recommendations such as surveillance, contact tracing, information campaigns, robust pharmacovigilance, and exposure assessment [12]. However, there is a lack of information on how to assess monkeypox vaccination acceptance. The acceptance rate is crucial to evaluate, given that regardless of how well-designed a vaccination program may be, its effectiveness hinges on population acceptance of the vaccine. Several studies have attempted to assess the acceptance level of the monkeypox vaccine. Nevertheless, the findings have been inconclusive, demonstrating variability in acceptance rates [13-16]. Moreover, no study has assessed the cumulative factors contributing to monkeypox vaccine acceptance. Therefore, the aim of this meta-analysis was to estimate the global prevalence and potential influencing factors of monkeypox vaccination acceptance. The findings of this study could serve as a reference for formulating regulations regarding monkeypox vaccination.

Methods

Study design

Between March and April 2024, a comprehensive meta-analysis on monkeypox vaccine acceptance was conducted, including articles from Scopus, Embase, and PubMed. Relevant data were extracted from each article to determine a cumulative effect estimate employing a meticulous approach. Adherence to the guidelines outlined in the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist ensured rigor and consistency in the protocol [17]. The PRISMA checklist for this study is available in **Supplementary Table 1**. The study was registered with the International Prospective Register of Systematic Reviews (PROSPERO) database under the identification number CRD42024534065.

Eligibility criteria

Before the study inclusion in our analysis, potential articles underwent assessment for eligibility criteria. Inclusion criteria comprised epidemiological studies focusing on the prevalence and associated factors related to monkeypox vaccine acceptance with complete data for calculating cumulative prevalence and effect estimates. Meanwhile, exclusion criteria are the irrelevant articles based on their title and abstract, duplications, or those falling into categories such as reviews, commentaries, or editorials. Additionally, articles were excluded if they exhibited poor quality, as determined by the assessment conducted using the Newcastle-Ottawa Scale (NOS).

Quality assessment

The assessment of article quality in this study employed the NOS method. This assessment evaluates three aspects: sample selection, comparability, and results. Scores on the NOS assessment range from 0 to 9 points, where scores of 1–3 indicate poor-quality articles, 4–6 indicate articles of moderate quality, and 7–9 indicate articles of high quality [18]. The assessment process was conducted by three different authors (OR, LNH, and KC), and in cases of divergent assessments, discussions with a senior author (JKF) were held to reach a consensus. The outcomes of the NOS assessment in this study are presented in **Supplementary Table 2**.

Search strategy

The search strategy utilized three databases: PubMed, Embase, and Scopus for articles published up to April 5, 2024. English-written articles were included, and the search keywords comprised variations of "vaccine" OR "vaccination" OR "immunization" AND "monkeypox" OR "MPOX" AND "acceptance" OR "willingness to vaccinate" OR "intention to vaccinate" OR "hesitancy" OR "rejection". These keywords were adapted to the medical subject heading (MeSH). Supplementary articles were sought by reviewing the citation lists of related articles. The article search and screening process was conducted by six independent authors, ensuring comprehensive coverage and thoroughness.

Data extraction

Information retrieval from each article included several key data points: first author's name, year of publication, study location, study design, sample size, mean age, male-to-female ratio, study duration, survey methodology, population source, NOS assessment, the prevalence of monkeypox vaccine acceptance, and factors associated with the vaccine acceptance. The data extraction process was done by four different authors (AR, TDS, DA, and EF) to ensure accuracy and comprehensiveness. In cases of discrepancies or overlapping data, discussions were held with a senior researcher (JKF) to reconcile differences and ensure the integrity of the extracted information.

Covariates

The primary outcome of this study is the prevalence of monkeypox vaccine acceptance, defined as the willingness or intention of individuals to receive a monkeypox vaccine. Data regarding the prevalence of monkeypox vaccine acceptance were presented as numbers and percentages. Furthermore, subgroup analyses were conducted on various demographics, including the general population, medical students, healthcare workers (HCWs), and men who have sex with men (MSMs). These subgroup categories were determined following an exhaustive search for available data. Meanwhile, the predictor covariates encompassed a range of factors, including age, gender, marital status, level of education, occupational status, socioeconomic status, urbanicity, knowledge of monkeypox, sexual orientation, history of chronic disease, HIV positivity, history of sexually transmitted diseases (STDs), history of monkeypox, and history of vaccination, including coronavirus disease of 2019 (COVID-19) vaccination, influenza vaccination, and smallpox vaccination. The selection of predictor covariates was based on the data availability that was determined through a thorough search conducted by four authors (TDS, DA, EF, and DD). Discussions were performed with a senior researcher in discrepancies or overlapping data to ensure consistency and accuracy.

Statistical analysis

In presenting the data, the rate of acceptance of the monkeypox vaccine was depicted as n (%). Egger's test and funnel plot analysis were employed to assess publication bias. A p-value above 0.05 and a symmetrical distribution in the funnel plot indicate the absence of publication bias. In cases where potential publication bias was identified, adjustment was made using the Trim-Fill method [19]. Heterogeneity was evaluated using I-squared and p-heterogeneity statistics. Heterogeneity was considered significant if the I-squared exceeded 50% or the p-heterogeneity was less than 0.10. Random-effects models were utilized for heterogeneous data, while fixed-effects models were applied in the absence of heterogeneity [20]. The cumulative prevalence of monkeypox vaccine acceptance was determined through single-arm meta-analysis with dichotomous data presented as event rates. Mantel–Haenszel tests were conducted for dichotomous variables, and inverse variance methods were used for continuous variables to assess the potential influence of predictor variables on monkeypox vaccine acceptance. A p-value less than 0.05 indicated a significant contribution. Effect estimates for continuous variables were presented as mean±SD, while odds ratios (OR) were used for dichotomous variables, outlined in a forest plot [21]. The analysis was performed using the R package (RStudio version 4.1.1, MA, US).

Results

Article selection

The initial article selection process yielded 284 articles from the Scopus, Embase, and PubMed databases, with an additional 27 articles identified from the citation lists of related articles. In the first exclusion phase, 16 articles were removed as repetitive, while 194 articles were excluded as they were deemed unrelated to the topic. Subsequently, 101 articles underwent full-text evaluation. In the second exclusion phase, 44 review articles and six articles with insufficient information were excluded. Ultimately, the final sample included in the study comprised 51 articles [22-72]. The article selection process in our study is illustrated in **Figure 1**. Baseline characteristics of the articles included in our analysis are presented in **Table 1**.

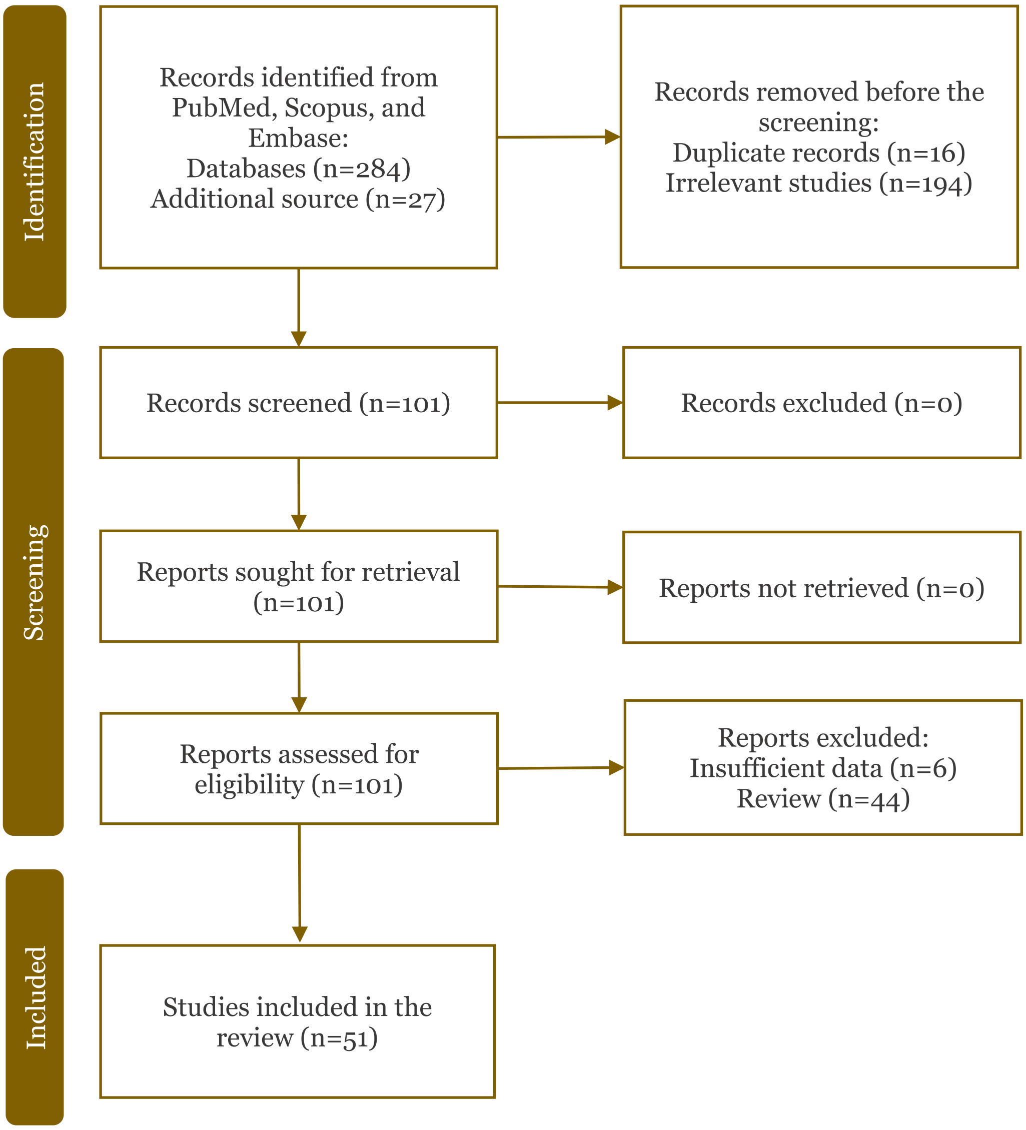

Figure 1. A flowchart of article selection.

Table 1. Baseline characteristics of included studies

Author	Region	Sample size	Age (mean±SD or range)	Gender (male/female) %	Study period	Survey type	Population	NOS
Abd-Elhafeez *et al.* 2023 [22]	Mixed	11919	21.7±2.2	45.6/54.4	NA	Online	MS	6
Ahmed *et al.* (a) 2023 [23]	Iraq	510	18–57	54.3/45.7	Jul 22	NA	GP	7
Ahmed *et al.* (b) 2023 [24]	Iraq	637	21–51	49.9/50.1	Nov 22-Jan 23	Online	HCW	7
Alarif *et al.* 2023 [25]	Saudi Arabia	743	25–56	49.1/50.9	Sep-Nov 22	Online	HCW	7
Andersen *et al.* 2024 [26]	US	373	43–62	73.9/24.2	Aug 22-Jan 23	Online	GP	6
Araoz-Salinas *et al.* 2023 [27]	Peru	373	31.0±9.0	85.0/6.2	Nov 22-Jan 23	Online and Offline	MSM	7
Bates *et al.* 2022 [28]	US	182	26–75	57.4/35.0	Sep 22	Online	HCW	6
Caycho-Rodríguez *et al.* 2023 [29]	Peru	472	28.1±9.7	39.4/60.6	Dec 22	Online	GP	6
Chen *et al.* 2023 [30]	China	154	22.0±12.0	96.1/3.9	Aug 22	Online	GP	6
Crosato *et al.* 2024 [31]	Italy	144	30–60	96.5/2.8	Aug-Oct 22	Offline	GP	7
Curtis *et al.* 2023 [32]	US	317	29.9±4.8	81.3/14.7	Dec-21	Offline	GP	6
Dong *et al.* 2023 [33]	China	512	30.0±26.4	50.7/49.3	Sept-Oct 22	Online	GP	7
Dukers-Muijrers *et al.* 2023 [34]	Netherland	1856	42.0±31.0	NA	Jul-22	Online	MSM	6
Filardo *et al.* 2023 [35]	US	273	35–57	27.0/71.0	Oct-Nov 22	Offline	GP	7
Fu *et al.* 2023 [36]	China	577	32.0±28.0	NA	Aug-Sept 22	Online	MSM	7
Ghazy *et al.* 2023 [37]	Egypt	605	30.0±6.8	60.8/39.2	Nov-Dec 22	Online	GP	7
Harapan *et al.* (a) 2020 [38]	Indonesia	407	NA	31.4/68.6	Jul 19	Online	HCW	7
Harapan *et al.* (b) 2020 [39]	Indonesia	407	NA	31.4/68.6	Jul 19	Online	HCW	7
Hong *et al.* 2023 [40]	China	1032	27.9±7.9	NA	Aug-Sept 22	Online	MSM	7
Huang *et al.* 2024 [41]	China	1093	18–25	NA	Sept-Nov 22	Online	MSM	7
Islam *et al.* 2023 [42]	Lebanon	260	24.4±8.4	24.1/75.9	Sep 22	Online	GP	7
Jamaleddine *et al.* 2023 [43]	Lebanon	493	36–54	NA	Jul-Aug 22	Online	GP	7
Jongen *et al.* 2024 [44]	Netherland	492	18–68	NA	Jun-Aug 22	Online	MSM	7
Karapinar *et al.* 2023 [45]	Turkey	707	22.5±3.5	45.7/54.3	Oct 22	Online	MSM	7
Kumar *et al.* 2022 [46]	Malaysia	946	NA	32.8/67.2	Jul-Aug 22	Online	MS	7
Lin *et al.* 2022 [47]	Malaysia	229	18–40	29.7/70.3	Jun-Sept 2022	Online	MS	7
Lounis *et al.* 2023 [48]	Algeria	111	20–30	14.3/85.7	Dec 22	Online	HCW	7
Lounis *et al.* 2024 [49]	Algeria	196	24.6±2.9	NA	Sep 22	Online	MS	7
Luo *et al.* 2024 [50]	China	2493	NA	50.3/49.7	Jan 23	Online	MSM	6
Mahameed *et al.* 2023 [51]	Jordan	485	18–66	NA	Jul 22	Online	GP	7
Paparini *et al.* 2023 [52]	Sweden	1932	30–47	NA	Jul-Aug 22	Online	MSM	7
Peptan *et al.* 2022 [53]	Czech Republic	1376	46.1±12.0	9.7/88.9	Sep 22	Online	GP	6
Ren *et al.* 2023 [54]	Czech Republic	2293	NA	5.6/94.4	Oct 22	Online	HCW	6
Reyes-Urueña *et al.* 2022 [55]	Sweden	32902	42.9±10.0	35.0/65.0	May 22	Online	MSM	6
Riad *et al.* 2022 [56]	Czech Republic	341	18–59	41.3/58.7	Aug-Sept 22	Online	HCW	7
Riad *et al.* 2023 [57]	Czech Republic	144	26–38	65.3/34.7	Aug 22	Online	HCW	6
Riccò *et al.* 2022 [58]	Italy	163	37.0±7.0	34.5/40.4	Jul-Aug 22	Online	HCW	7
Sahin *et al.* 2022 [59]	Turkey	283	NA	42.0/58.0	May-Jun 22	Online	HCW	7
Salim *et al.* 2022 [60]	Indonesia	75	36.0±14.0	NA	Jul 22	Online	MS	6
Scarinci *et al.* 2023 [61]	Italy	204	NA	28.6/71.4	Apr-Aug 22	Online	HCW	7
Temsah *et al.* 2022 [62]	Saudi Arabia	1546	18–49	NA	Aug 22	Offline	GP	6

Author	Region	Sample size	Age (mean±SD or range)	Gender (male/female) %	Study period	Survey type	Population	NOS
Torres *et al*. 2023 [63]	Brazil	6236	NA	NA	Jul 22	Online	MSM	6
Tran *et al*. 2023 [64]	Vietnam	842	18–50	37.4/62.2	Aug-Sept 22	Online	GP	7
Turpin *et al*. 2023 [65]	US	24	18–55	48.0/51.0	Jul 22	Online	MSM	6
Wang *et al*. 2022 [66]	Netherland	394	16–26	44.0/43.8	Aug-Sept 23	Online	MSM	7
Wang *et al*. 2023 [67]	China	2135	18–36	NA	Jul-Aug 23	Online	GP	7
Winters *et al*. 2022 [68]	US	856	25–40	NA	Jul 22	Online	GP	6
Yang *et al*. 2024 [69]	China	7311	18–59	NA	Jul 22	Online	MS	6
Zheng *et al*. 2022 [70]	China	3340	NA	NA	May-Aug 22	Online	MSM	7
Zheng *et al*. 2023 [71]	China	7196	NA	NA	Jul 22	Online	MSM	6
Zucman *et al*. 2022 [72]	France	155	34.3±8.2	NA	Aug-Sept 22	Online	MSM	7

GP: general population; HCW: healthcare worker; MS: medical students; MSM: men who have sex with men; NA: not available; NOS: Newcastle–Ottawa scale; SD: standard deviation

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The rate of acceptance for the monkeypox vaccine

In our study, 65% of participants showed a willingness to accept monkeypox vaccination (event rate=0.65; 95%CI: 0.59, 0.71; p<0.0001; p-Egger: 0.0581; p-Heterogeneity<0.0001) (**Figure 2**). Subgroup analysis results based on demographic populations were as follows: in the general population, the prevalence of monkeypox vaccination acceptance was 56% (event rate=0.56; 95%CI: 0.49, 0.63; p=0.0890; p-Egger= 0.8556; p-Heterogeneity<0.0001) (**Figure 3A**). Among medical students, the prevalence of monkeypox vaccination acceptance was 64% (event rate=0.64; 95%CI: 0.46, 0.78; p=0.1360; p-Egger=0.9291; p-Heterogeneity<0.0001) (**Figure 3B**). Within the HCW population, the prevalence of monkeypox vaccination acceptance was 52% (event rate=0.52; 95%CI: 0.36, 0.68; p=0.7890; p-Egger=0.4068; p-Heterogeneity<0.0001) (**Figure 3C**). Among MSMs, the prevalence of monkeypox vaccination acceptance was notably high at 82% (event rate=0.82; 95%CI: 0.76, 0.86; p<0.0001; p-Egger=0.9294; p-Heterogeneity<0.0001) (**Figure 3D**).

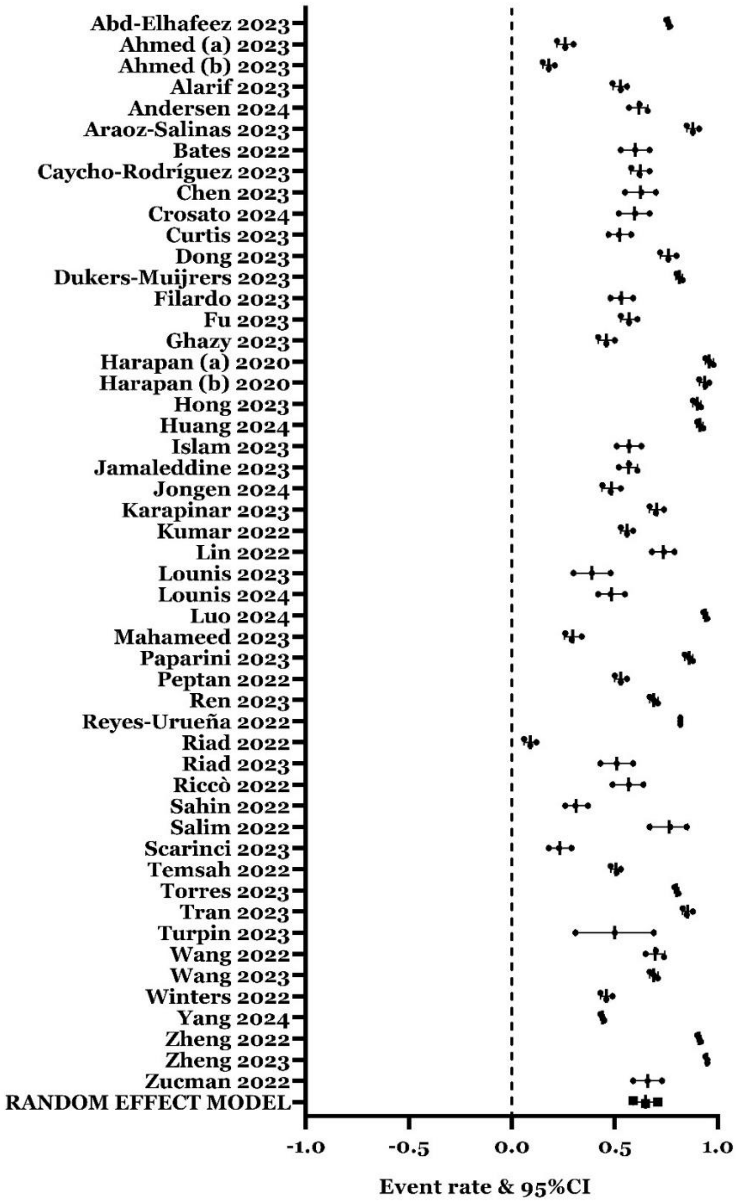

Figure 2. The prevalence of monkeypox vaccination acceptance in all populations (event rate: 0.65; 95%CI: 0.59–0.71; p<0.0001; p-Egger=0.0581; p-Heterogeneity<0.0001).

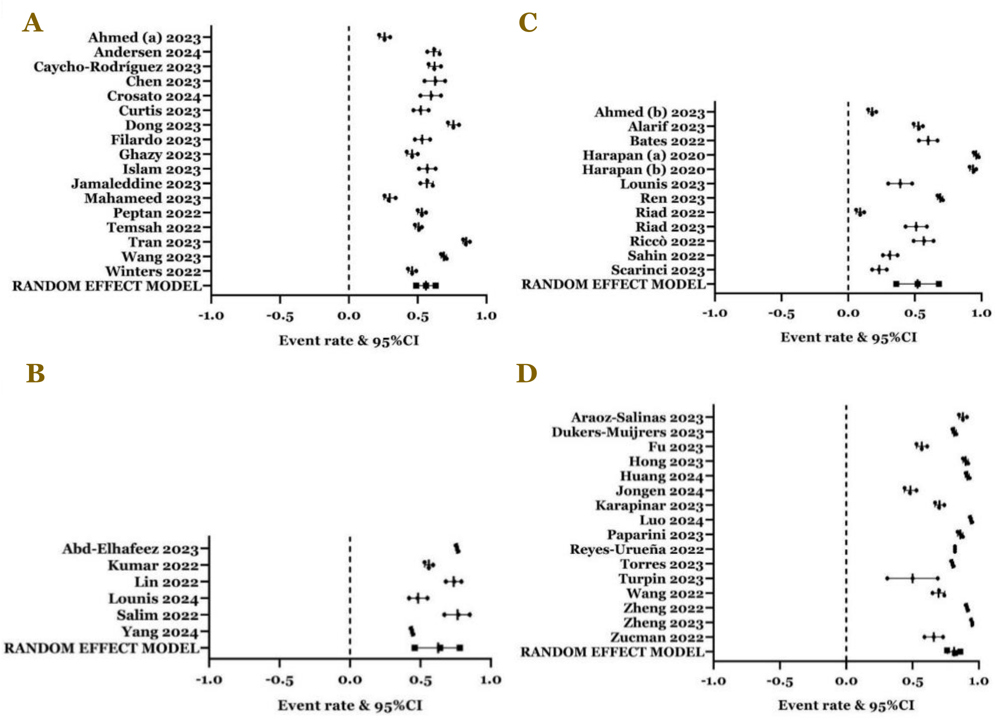

Figure 3. The prevalence of monkeypox vaccination acceptance in (A) general population (event rate: 0.56; 95%CI: 0.49, 0.63; p=0.0890; p-Egger: 0.8556; p-Heterogeneity<0.0001); (B) medical students (event rate: 0.64; 95%CI: 0.46, 0.78; p=0.1360; p-Egger=0.9291; p-Heterogeneity<0.0001); (C) healthcare workers (event rate: 0.52; 95%CI: 0.36, 0.68; p=0.7890; p-Egger=0.4068; p-Heterogeneity<0.0001); and (D) men who have sex with men (event rate: 0.82; 95%CI: 0.76, 0.86; p<0.0001; p-Egger=0.9294; p-Heterogeneity<0.0001).

Determinants related to the acceptance of monkeypox vaccination

Among all the covariates analyzed, the result indicated that only educational attainment (**Figure 4A**), history of vaccination (**Figure 4B** and **4C**), HIV positivity, and sexual orientation, including bisexual (**Figure 5A**), heterosexual (**Figure 5B**), and homosexual orientation (**Figure 5C**) contributed to the acceptance of monkeypox vaccination. Regarding educational attainment, individuals with a Bachelor of Science (BSc) degree or higher had a 1.36 times higher risk of accepting the monkeypox vaccine compared to those with educational attainment below BSc level (OR=1.36; 95%CI: 1.11, 1.66; p=0.0030; p-Egger=0.0687; p-Heterogeneity<0.0001). Furthermore, concerning the history of vaccination, our findings suggested that individuals with a history of COVID-19 (OR=2.48; 95%CI: 1.50, 4.07; p<0.0001; p-Egger=0.4259; p-Heterogeneity=0.0010) and influenza vaccination (OR=1.46; 95%CI: 1.09, 1.95; p=0.0120; p-Egger=0.2308; p-Heterogeneity=0.2660) had an elevated risk of accepting monkeypox vaccination. In terms of sexual orientation, homosexual individuals exhibited a higher likelihood of accepting monkeypox vaccination (OR=1.27; 95%CI: 1.10, 1.47; p=0.0010; p-Egger=0.6958; p-Heterogeneity=0.5670) than heterosexual group, while individuals identifying as bisexual (OR=0.84; 95%CI: 0.72, 0.99; p=0.0350; p-Egger=0.0110; p-Heterogeneity=0.5000) and heterosexual (OR=0.76; 95%CI: 0.59, 0.97; p=0.0260; p-Egger=0.7406; p-Heterogeneity=0.6830) exhibited the opposite effect compared to homosexuals. Additionally, this study indicated that individuals living with HIV had an increased risk of accepting monkeypox vaccination (OR=1.43; 95%CI: 1.16, 1.77; p=0.0010; p-Egger=0.3304; p-Heterogeneity=0.0750). The outcomes of the analysis concerning factors linked to the acceptance of monkeypox vaccination are depicted in **Table 2**.

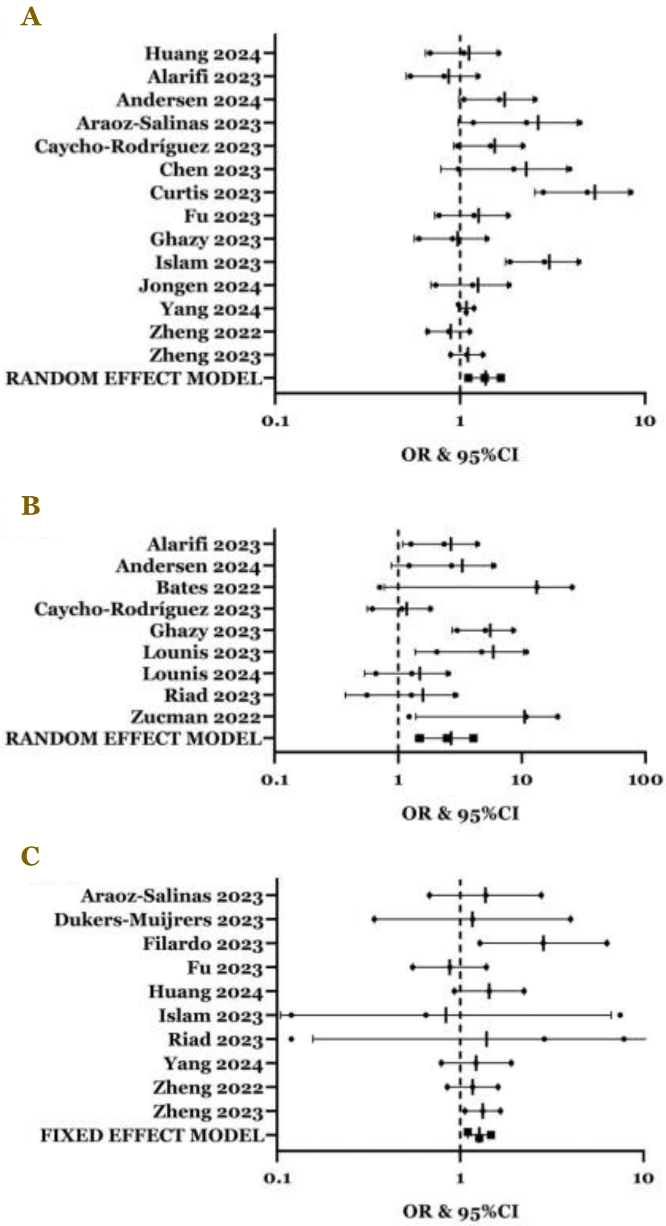

Figure 4. Individuals with (A) education levels of BSc or higher (OR=1.36; 95%CI: 1.11, 1.66; p=0.0030; p-Egger=0.0687; p-Heterogeneity<0.0001); (B) had a history of COVID-19 vaccination (OR=2.48; 95%CI: 1.50, 4.07; p<0.0001; p-Egger=0.4259; p-Heterogeneity=0.0010); and (C) had a history of influenza vaccination had a higher acceptance rate of monkeypox vaccination (OR=1.39; 95%CI: 1.10, 1.76; p=0.0060; p-Egger=0.2308; p-Heterogeneity=0.2660).

Heterogeneity and potential publication bias

The results of the *Q*-test indicated the heterogeneity in the overall monkeypox vaccine acceptance prevalence and its subgroup analysis. The heterogeneity data were presented using a random effect model. In this study, the heterogeneity was negligible in the middle-income variable, sexual orientation, and influenza vaccination, with the data presented in a fixed effect model. Furthermore, Egger's test and funnel plot analyses (see **Underlying data**) revealed potential publication bias in the age and bisexual orientation variables. Consequently, data interpretation was adjusted using the trim-fill method.

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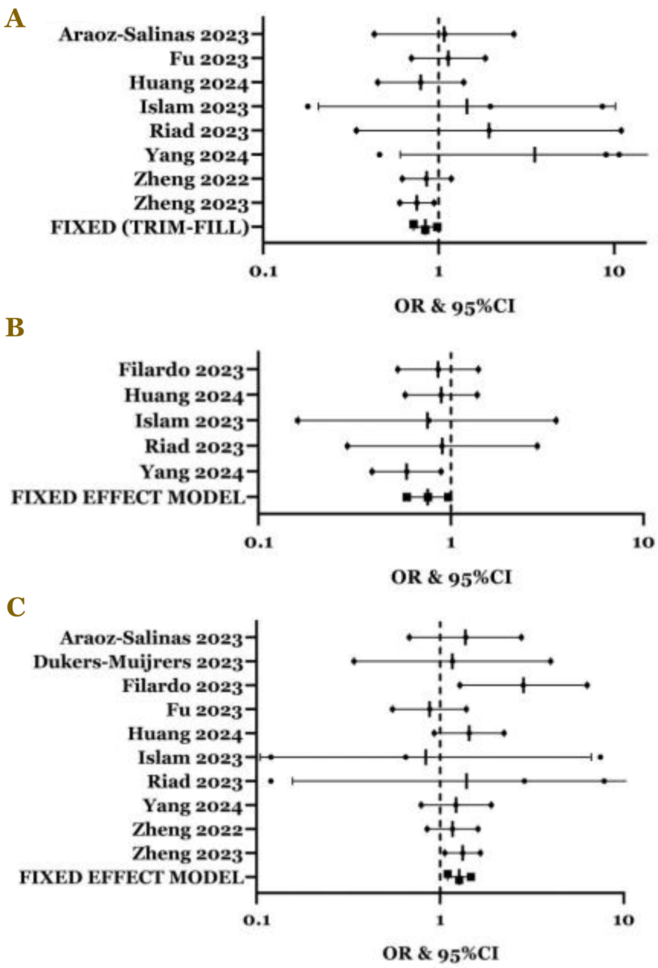

Figure 5. The acceptance of monkeypox vaccination among individuals with (A) bisexual orientation (OR=0.84; 95%CI: 0.72, 0.99; *p*=0.0350; *p*-Egger's=0.0110; *p*-Heterogeneity=0.5000); (B) heterosexual (OR=0.76; 95%CI: 0.59, 0.97; *p*=0.0260; *p*-Egger=0.7406; *p*-Heterogeneity=0.6830), and (C) homosexual (OR=1.27; 95%CI: 1.10, 1.47; *p*=0.0010; *p*-Egger=0.6958; *p*-Heterogeneity=0.5670).

Table 2. The potential factors associated with the acceptance of monkeypox vaccination

Covariates	Acceptance/total (%)	Number of studies	Mean difference*/odds ratio	95% confidence interval	*p*-Egger	*p*-Heterogeneity	*p*-value
Age (years), mean±SD	36.90±9.64	10	0.52*	-1.24–2.28	0.0423	<0.0001	0.5630
Gender							
Male	4198/7991 (52.53)	20	1.20	0.97–1.48	0.3674	<0.0001	0.0910
Female	4208/8175 (51.47)	20	0.84	0.68–1.03	0.3674	<0.0001	0.0910
Marital status							
Married	1366/2057 (66.41)	8	0.82	0.62–1.09	0.6400	0.0010	0.1700
Single	6945/8222 (84.47)	8	1.22	0.92–1.61	0.6400	0.0010	0.1700
Educational attainment							
<BSc	6803/9436 (72.10)	14	0.74	0.60–0.90	0.0687	<0.0001	0.0030
≥BSc	9136/13212 (69.15)	14	1.36	1.11–1.66	0.0687	<0.0001	0.0030
Employment							
Not working	563/932 (60.41)	7	0.84	0.27–2.66	0.1432	<0.0001	0.7690
Working	5010/6450 (77.67)	7	1.19	0.38–3.75	0.1432	<0.0001	0.7690
Socioeconomic status							
Low income	2195/3142 (69.86)	7	1.03	0.72–1.48	0.2537	<0.0001	0.8570
Middle income	1624/2168 (74.91)	7	0.88	0.77–1.01	0.7162	0.1180	0.0740
High income	958/1273 (75.26)	7	1.04	0.62 – 1.74	0.4024	<0.0001	0.8910
Urbanicity							
Urban	6780/11294 (60.03)	10	1.21	0.91–1.61	0.4015	<0.0001	0.1980
Rural	1592/3242 (49.11)	10	0.83	0.62–1.10	0.4015	<0.0001	0.1980
Good knowledge of monkeypox	2081/2859 (72.79)	9	1.23	0.80–1.90	0.6176	<0.0001	0.3410
Sexual orientation							
Bisexual	2285/2508 (91.11)	8	0.84	0.72–0.99	0.0110	0.5000	0.0350
Heterosexual	3913/8314 (47.07)	5	0.76	0.59–0.97	0.7406	0.6830	0.0260
Homosexual	9672/10694 (90.44)	10	1.27	1.10–1.47	0.6958	0.5670	0.0010
History of chronic disease(s)	942/1135 (83.00)	7	1.20	0.84–1.71	0.0973	0.0730	0.3180
HIV positivity	4610/5197 (88.71)	7	1.43	1.16–1.77	0.3304	0.0750	0.0010
History of STDs	7044/8130 (86.64)	8	1.25	0.86–1.80	0.0823	<0.0001	0.2430
History of monkeypox	311/371 (83.83)	4	1.34	0.82–2.20	0.2305	0.0630	0.2430
History of vaccination							
COVID-19 vaccination	1398/2400 (58.25)	9	2.48	1.50–4.07	0.4259	0.0010	<0.0001
Influenza vaccination	722/1272 (56.76)	6	1.39	1.10–1.76	0.2308	0.2660	0.0060
Smallpox vaccination	676/994 (68.01)	6	0.88	0.61–1.27	0.1297	0.0080	0.4990

BSc: Bachelor of Science; STD: sexually transmitted disease

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Discussion

Our study found that the global prevalence of monkeypox vaccination acceptance was 65%. Subgroup analysis revealed that the highest prevalence of monkeypox vaccination acceptance was among MSMs (82%), followed by medical students (64%), and the general population (56%). Conversely, HCWs exhibited the lowest prevalence of monkeypox vaccine acceptance (52%). Our findings showed a higher rate of monkeypox vaccine acceptance compared to the last meta-analyses, with acceptance rates ranging between 56%–61% [13-16]. Furthermore, our study offers several advantages over the previous meta-analysis. First, our sample size was larger population, including 51 articles with 98,746 participants, compared to the previous study, which encompassed 10–30 articles with 8,045–81,792 participants [13-16]. Second, prior studies lacked adequate statistical testing methods, as they uniformly applied random effect models despite significant heterogeneity ranging from 0% to 80% [15]. The choice between random or fixed effect models should have been aligned with the level of heterogeneity to avoid biases in the results [20]. Third, some references had been omitted in previous studies [13], as a reference, is crucial for ensuring the replicability of meta-analysis procedures. Fourth, previous studies only reported overall prevalence rates [13-16], and this study also identified contributing factors to monkeypox vaccination acceptance.

Our study also revealed that educational attainment of at least a BSc degree, history of COVID-19 vaccination, and influenza vaccination were associated with increased acceptance of the monkeypox vaccine. However, the underlying reasons for our study's findings remain difficult to explain. It should be noted that educational attainment of at least a BSc degree indicated that individuals likely had good knowledge of health behaviors [73]. However, this did not align with our results, as we failed to demonstrate a clear role of knowledge about monkeypox in the monkeypox vaccine acceptance. This complexity is difficult to explain. It is important to understand that knowledge and applying health awareness behaviors do not always align. Having good knowledge of a disease does not necessarily equate to adopting good health behaviors. Good knowledge alone, without awareness behaviors, may not be adequate in triggering acceptance of the monkeypox vaccine [74]. This condition may explain our findings that individuals with a good awareness of disease prevention, such as those who had received influenza and COVID-19 vaccinations, showed increased acceptance of the monkeypox vaccine. This study revealed that although the majority of study participants demonstrated adequate understanding, the vaccine acceptance rate was relatively lower [75]. Another study also emphasized the crucial role of awareness in increasing vaccine acceptance [76]. This explanation may correspond to our findings that individuals with a history of COVID-19 and influenza vaccination and those with the educational attainment of at least a BSc degree showed a favorable response to monkeypox vaccine acceptance.

Furthermore, we found that individuals with homosexual orientation and those who were HIV-positive exhibited higher acceptance of monkeypox vaccination, while individuals identified as heterosexual or bisexual demonstrated lower acceptance. In the case of HIV patients, it is widely acknowledged that a significant portion of them engage in behaviors associated with homosexuality [77]. Hence, this correlation could provide insight into the idea that both HIV-positive status and homosexual behavior played contributory roles in the heightened acceptance of monkeypox vaccination. Several factors explain this increased acceptance within these demographic groups. First, due to their sexual behaviors and close contact with multiple partners, they are deemed a high-risk demographic for monkeypox infection [16]. Second, their heightened awareness of the threat posed by monkeypox and the critical importance of vaccination was evident through their increased concern regarding outbreaks and their expressed intentions to receive the vaccine [78]. Third, within the homosexual community, there is a noticeable sense of solidarity and collective responsibility toward safeguarding both individual health and the broader community from the possible consequences of the illness [55]. This collective mindset likely fostered acceptance and uptake of the monkeypox vaccine among the populations.

This study has several implications. First, it contributed to understanding the prevalence of monkeypox vaccine acceptance across various demographics, enabling the identification of the groups that are more inclined to accept the vaccine and those who require focused education and outreach efforts. These findings are crucial in shaping more effective vaccination campaigns and public health policies, supporting monkeypox vaccination initiatives [79]. Second, our study identified the determinants of vaccine acceptance, including educational level, vaccination history, HIV status, and sexual orientation. This knowledge could guide targeted interventions to strengthen vaccine acceptance within specific populations [80]. Third, by comparing vaccine acceptance rates among diverse groups such as the general population, MSMs, medical students, and HCWs, we could identify disparities in acceptance and tailor public health interventions accordingly. Fourth, understanding the prevalence of vaccine acceptance could help the vaccine distribution strategies and potentially prioritize vaccination for high-risk groups or implement focused outreach to enhance acceptance in specific populations [79]. In summary, our investigation into the global prevalence and associated factors of monkeypox vaccine acceptance is pivotal for guiding public health policies and strategies to mitigate the spread of the disease.

There are some limitations to this study. First, although this meta-analysis serves as a methodological approach to calculate the crude effect of relevant factors and establish evidence, evaluating the impact of potential confounding variables proved challenging. Factors such as government regulations, sources of information on monkeypox vaccination, and environmental influences were not included in this study, necessitating a cautious interpretation of our findings. Second, this study involved a multinational population, where the understanding of disease prevention may have varied among individuals with similar socioeconomic and educational backgrounds in different regions. Third, the proportion of selected articles varied across regions, potentially influencing the final results. Fourth, in determining contributing factors, this study included diverse populations such as HCWs, the general population, medical students, and MSMs, which may have yet to fully represent all groups at risk of monkeypox infection. Fifth, our study lacked longitudinal data on vaccine acceptance, inhibiting our ability to discern changes over time and assess the impact of public health interventions.

Conclusion

This meta-analysis found that the global acceptance rate for monkeypox vaccination was estimated to be 65%. Additionally, our findings revealed that the acceptance of monkeypox vaccine was influenced by several factors, including educational attainment, history of vaccination, HIV status, and sexual orientation.

Ethics approval

Not required.

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Competing interests

All the authors declare that there are no conflicts of interest.

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Underlying data

Supplementary data can be accessed through this link: https://doi.org/10.6084/m9.figshare.25598916.

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