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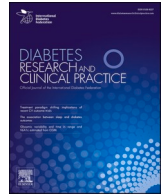
Global acceptance of COVID-19 vaccine among persons with diabetes: A systematic review and meta-analysis

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ABSTRACT

Aim: This review aimed to estimate the level of acceptance of COVID-19 vaccine among persons with diabetes.
Methods: A systematic search was conducted on PubMed, MEDLINE, Embase, and CINAHL to identify relevant studies for this review. A random-effects meta-analysis was performed to generate an overall estimate of vaccine acceptance. The I^2 statistic was used to quantify the degree of variation across studies, and subgroup analysis was conducted to identify the sources of heterogeneity. The review was conducted in line with the Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA).
Results: This review included 18 studies involving 11,292 diabetes patients. The pooled prevalence of COVID-19 vaccine acceptance among persons with diabetes was 76.1 (95% CI: 66.7%–83.5%). The pooled prevalence across the continent ranged from 68.9% (95% CI: 47.8%–84.3%) in Asia to 82.1% (95% CI: 80.2%–83.8%) in Europe. Barriers to vaccine acceptance included misinformation, lack of information, mistrust, health concerns, and external influences.
Conclusion: The barriers to vaccine acceptance identified in this review, could inform the formulation of health policies and public health interventions that are specifically tailored to address the needs of persons with diabetes.

1. Introduction

The COVID-19 pandemic has had a devastating global impact and has led to unprecedented disruptions to healthcare systems, economies, and daily life. COVID-19 is said to have no boundaries and thus affects all individuals irrespective of their composition. However, the clinical spectrum of the disease disproportionately impacts persons with chronic disease, including diabetes [1]. Diabetes has been identified as a significant risk factor for contracting COVID-19 and is associated with higher rates of hospitalization in intensive care units [2,3]. Additionally, individuals with diabetes are nearly two times more likely to experience COVID-19-related mortality compared to those without the condition [3].

The COVID-19 pandemic has prompted a robust response from the healthcare community, including the development and deployment of vaccines. These vaccines have demonstrated the potential to effectively curb the transmission of the virus and mitigate its severe consequences [4]. However, the success of vaccination efforts is contingent upon the willingness and preparedness of the population to accept and receive vaccines [5]. This is particularly crucial for vulnerable populations, such as persons with diabetes. Nonetheless, there have been reports of vaccine hesitancy among some diabetes patients [6,7], despite their prioritization in early vaccine distribution programs [8]. This is partly driven by the belief that COVID-19 is not dangerous to diabetes patients' health and that vaccination does not reduce the risk of infection [9]. Furthermore, safety and efficacy concerns associated with COVID-19 vaccines have been identified as critical predictors of vaccine acceptance [10].

Vaccine hesitancy is a complex issue that impedes efforts against vaccine-preventable diseases [11]. Considering the serious ramifications of COVID-19 on diabetes patients, vaccination is an essential aspect of diabetes management and a vital approach for mitigating the impact of the pandemic on this patient population. This underscores the importance of investigating the rate of vaccine acceptance among persons with diabetes. However, to date, there has been a lack of a comprehensive review synthesizing the acceptance of COVID-19 vaccines among individuals with diabetes. The extent of COVID-19 vaccine acceptance

among diabetes patients remains unclear, as individual studies on this topic have reported varying acceptance rates. Therefore, this review aimed to estimate the level of acceptance of COVID-19 vaccines among persons with diabetes by synthesizing the results of relevant studies across the globe. The barriers to COVID-19 vaccine acceptance were also assessed.

2. Materials and methods

Prior to this study, an extensive search of electronic medical databases was done to explore the available literature and to identify evidence gaps. Subsequently, a protocol for this review was developed and registered on PROSPERO (CRD42022371963). This review adhered to the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines.

2.1. Inclusion and exclusion criteria

The present study adopted the CoCoPop framework (condition, context, and population) to establish the inclusion criteria. This framework was used given its wide recognition in systematic review assessing prevalence or incidence data [12,13]. As such, the inclusion criteria were comprised of primary studies that quantitatively assessed COVID-19 vaccine acceptance (willingness or hesitancy) among persons with diabetes. No restrictions were placed on the study context, provided that the research was conducted in a real-world setting. In addition, only peer-reviewed articles published in the English language were considered for inclusion.

Priority was given to studies that focused primarily on diabetes patients. However, studies conducted on the general population were included if the COVID-19 vaccine acceptance rate was extractable for diabetes patients who were part of the study. On the other hand, review articles, preprints, case reports, conference abstracts, posters, and letters to the editor were excluded. In cases where duplicate studies were identified, wherein a single study was reported in multiple publications, only one study was selected based on its relevance to the outcome of interest and its high methodological quality.

2.2. Outcome definition

The principal outcome of interest of this study was vaccine acceptance among persons with diabetes, operationalized as the proportion of participants who indicated their willingness to receive the COVID-19 vaccine or were not hesitant to take the vaccine. As a secondary objective, barriers to vaccine acceptance were defined as reasons for diabetes patients' unwillingness or hesitancy to receive the COVID-19 vaccine.

2.3. Search strategy

A comprehensive systematic search was conducted on November 20, 2022 to identify relevant literature pertaining to the topic of interest. The search was executed on four major electronic databases: PubMed, MEDLINE, Embase, and Cumulative Index to Nursing and Allied Health Literature (CINAHL). To ensure exhaustiveness, the search was supplemented with additional searches on specialized databases dedicated to COVID-19 research, such as LitCovid and the World Health Organization's COVID-19 research database. A manual examination of reference lists from eligible articles was also conducted to ensure the inclusion of all relevant studies.

The search was updated on February 01, 2023 to include recently indexed studies, with the aim of ensuring the comprehensiveness of the results. The initial search was limited to articles published between the years 2020 and 2022 to reflect the most recent and up-to-date information.

The search strategy was informed by the population and outcome of interest and was developed based on a combination of key terms

including "COVID-19 vaccine," "hesitancy or uptake," and "diabetes." Boolean combinations (AND, OR, NOT) of these terms, along with database-specific index terms, were utilized to optimize the search results. The full details of the search strategy are presented in the **Supplementary file**.

2.4. Screening and study selection

Duplicates from retrieved articles were removed using EndNote 20. The remaining articles were then uploaded to Rayyan [14] for title and abstract screening based on the predefined eligibility criteria. The full text of selected studies was retrieved and assessed to ascertain if they met the requirements for inclusion in this review.

2.5. Data extraction

A standardized data extraction form in Excel format was designed to retrieve important information from the included studies. The extracted data included: first author's name, year of publication, country, study design, type of diabetes, and data on the COVID-19 vaccination acceptance. Both reviewers independently extracted the data.

2.6. Quality assessment

This review comprised of studies that provided data on the prevalence or proportion of COVID-19 vaccine uptake or hesitancy among diabetes patients. Hence, the Joanna Briggs Institute (JBI) critical appraisal checklist for studies reporting prevalence data was used to assess the methodological quality of the included studies [15]. The appraisal tool addresses 9 critical questions and has response options such as "Yes", "No", "Unclear" and "Not applicable". In the absence of a defined cut-off point for the quality score of studies, we denote studies with 50% or more "Yes" across the quality assessment parameters as low risk. A comprehensive description of the quality assessment tool is presented in the **Supplementary file**.

2.7. Statistical analysis

The meta-analysis was performed based on a random-effects model. This model was used given the considerable variability across the included studies. Furthermore, we computed the pooled prevalence of COVID-19 vaccine acceptance using a generalized linear mixed model with the logit transformation, as recommended by Warton and Hui [16]. The 95% confidence interval (CI) for the proportion was calculated using the Clopper-Pearson interval and results from the analysis presented in forest plots. We quantified the proportion of variability due to heterogeneity across studies using the I^2 statistic, with values of 25%, 50%, and 75% indicating low, moderate, and high levels of heterogeneity, respectively [17]. Subgroup analysis was done for gender, continent, data collection method, sample size, and diabetes participants as the primary focus of the study. The presence of publication bias was evaluated using funnel plots and was statistically explored using the test proposed by Peters et al [18]. The meta-package in R statistical software was used for the statistical analysis.

3. Results

3.1. Search results

Our systematic search yielded a total of 2499 studies, which comprised of 2464 records from four databases (PubMed, MEDLINE, Embase, and CINAHL) and 35 records from others sources. After duplicate records were removed and 2351 articles had been screened for their titles and abstracts, the full text of 62 articles were assessed. Finally, 18 articles met our inclusion criteria for this study. A summary of the steps involved in the screening process and reasons for exclusion

of articles after full-text review are provided in Fig. 1.

3.2. Characteristics of included studies

All included studies consisted of cross-sectional designs. However, 1 study used a mixed-method approach to evaluate the responses of the participants [19]. Majority of the studies were published in 2022 (n = 12). The study involved 11,292 diabetes participants, the majority of which were females (54.1%) as per studies that reported both gender proportions. Apart from Osuagwu et al's study which recruited participants from multiple countries in Sub-Saharan Africa, all the remaining studies involved a single country. Grouped under the continent of study, Asia dominated with 8 studies [6,9,20 –25], followed by North America (n = 5) [26 –30], Europe (n = 2) [7,31], Africa (n = 2) [19,32], and Australia (n = 1) [33]. A summary of the characteristics of the included studies is provided in Table 1.

3.3. Quality of included studies

The quality assessment of the included studies identified that all studies had a score of 50% and above with a mean score of 67.3%. The authors (EE and SA) involved in the quality assessment of the included studies agreed on almost 85% of the scores awarded. Disagreements were discussed and consensus was attained. Results of the quality assessment are presented in Table 1.

3.4. Meta-analysis of COVID-19 vaccine acceptance

The proportion of persons with diabetes who accepted the COVID-19 vaccine ranged from 36.2% [6] to 94.0% [25]. The meta-analysis showed that the pooled prevalence of COVID-19 vaccine acceptance was 76.1% (95% CI: 66.7 – 83.5). There was a significantly high heterogeneity among the studies (I^2 = 99%, p < 0.01) as shown in Fig. 2.

Results from the subgroup analysis are presented in Table 2. Subgroup analysis per continent of the study revealed regional variability in vaccine acceptance, with the highest acceptance reported in Europe
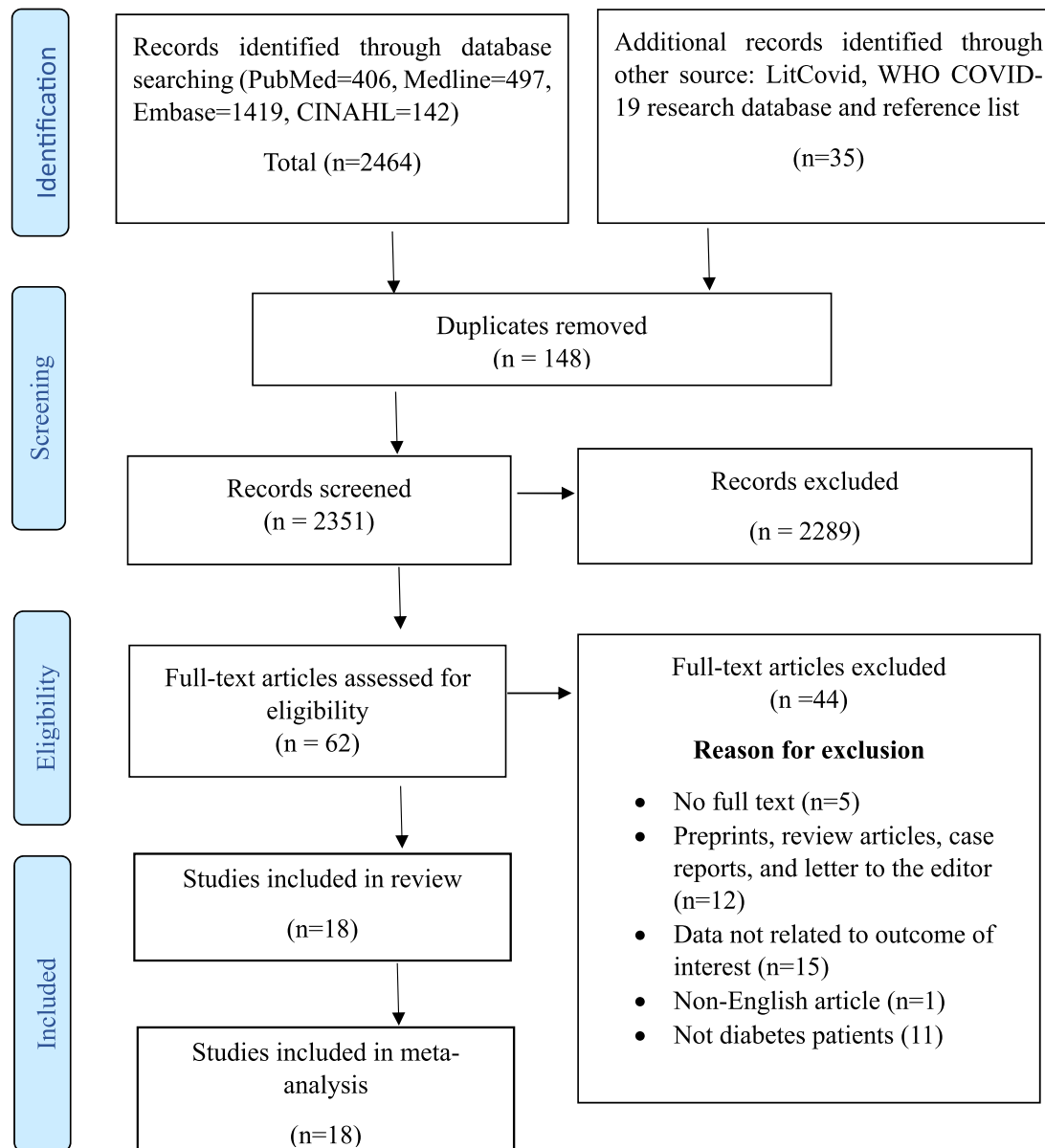

Fig. 1. PRISMA flow chart summarizing the article selection process.

Table 1
Characteristics of the included studies.

First author (Year)	Country	Type of diabetes	Study Design	Diabetes sample	Female proportion	Vaccine acceptance	Quality assessment score	Quality of study
Wang (2022)	China	Both	CS	483	47.8	210	7	High
Lu (2022)	China	T2DM	CS	170	51.8	131	5	High
Tsai (2022)	USA	T2DM	CS	1400	NR	1134	5	High
Day (2022)	Australia	NI	CS	842	44.9	742	7	High
Osuagwu (2022)	SSA	NI	MM	73	34.2	48	5	High
Asadi-Pooya (2022)	Iran	NI	CS	127	NR	108	5	High
Kolobov (2022)	Israel	Both	CS	308	61.2	127	5	High
Mesele (2022)	Ethiopia	Both	CS	386	30.6	319	7	High
Velario (2022)	Canada	NI	CS	193	NR	114	7	High
Kanyangarara (2022)	USA	NI	CS	1210	NR	1135	5	High
Syed (2021)	Malaysia	NI	CS	97	NR	73	8	High
Czeisler (2021)	USA	NI	CS	760	59.1	597	5	High
Guaraldi (2021)	Italy	T2DM	CS	1176	73.1	967	5	High
Aldossari (2021)	Saudi Arabia	Both	CS	709	59.5	257	7	High
Scoccimarro (2021)	Italy	Both	CS	502	60.2	410	5	High
Waite (2021)	Canada	NI	CS	744	NR	589	6	High
Abedin (2021)	Bangladesh	NI	CS	488	NR	331	7	High
Okobo (2021)	Japan	NI	CS	1628	NR	1531	8	High

CS: Cross-sectional, MM: Mixed method, NI: Not indicated, NR: Not reported, T2DM: Type 2 diabetes mellitus.
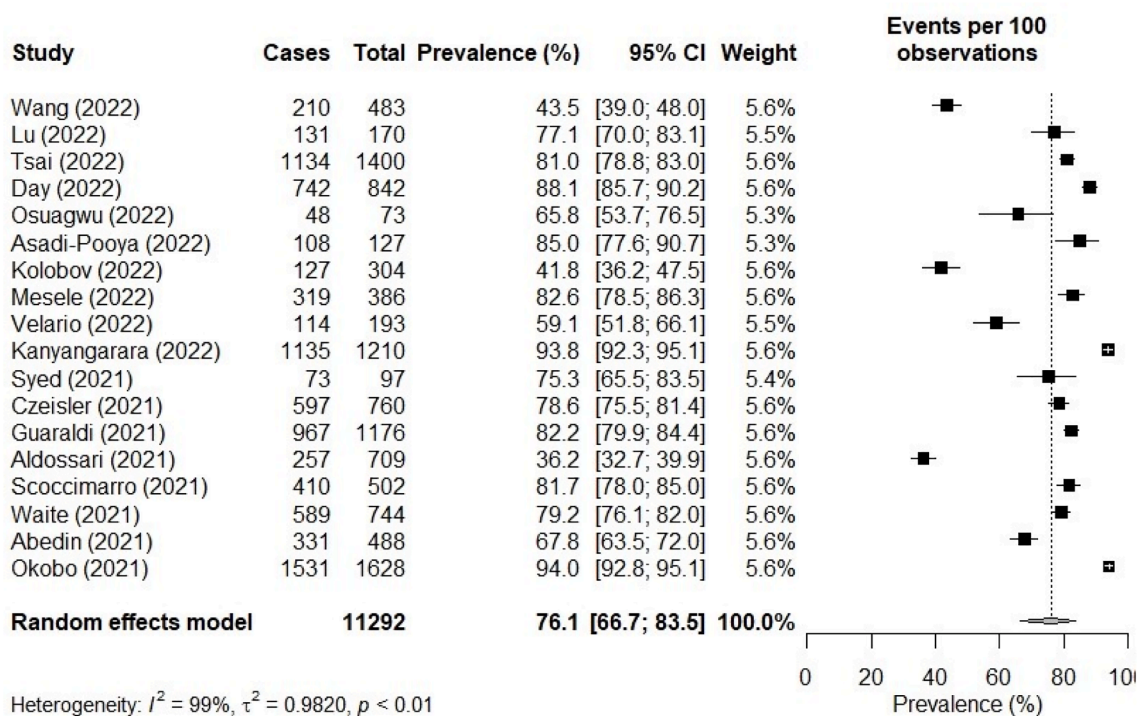
Fig. 2. COVID-19 vaccine acceptance among persons with diabetes.

82.1% (95% CI: 80.2 – 83.8) and the lowest in Asia 68.9% (95% CI: 47.8 – 84.3). In terms of gender-based comparisons, the acceptance of COVID-19 vaccine was higher in male diabetes patients 73.2% (95% CI: 54.3 – 86.3) compared to their female counterparts 59.1% (95% CI: 40.2 – 75.8). Moreover, studies with a sample size > 500, conducted online and primarily focused on non-diabetes participants, had a high proportion of COVID-19 vaccine acceptance. No heterogeneity was identified in studies from Europe. However, the result was insignificant ($I^2 = 0$, p = 0.79).

3.5. Publication bias

The results of the funnel plot analysis, presented in Fig. 3, revealed an asymmetrical distribution of the studies, suggesting the potential presence of publication bias. In contrast, the results from the statistical tests for publication bias, as assessed through Peters' test, indicated no evidence of publication bias (p-value = 0.3406). The divergent results between the funnel plot analysis and the statistical test may be a consequence of the high heterogeneity of the studies included in the analysis, rather than publication bias, as noted by Sterne et al [34].

Table 2
Subgroups analysis of COVID-19 vaccine acceptance.

Variables		No. of studies	Proportion (95% CI)	I^2	p-value
Sample size	<500	9	67.7	97%	P < 0.01
	>500	9	(55.9–77.7)	99%	
			82.6		P < 0.01
			(71.3–90.0)		
Gender	Male	6	73.2	96%	P < 0.01
	Female	6	(54.3–86.3)	96%	
			59.1		P < 0.01
			(40.2–75.8)		
Continent	Asia	8	68.9	99%	P < 0.01
	North America	5	(47.8–84.3)	98%	
	Europe	2	80.8	0%	P < 0.01
	Africa	2	(70.8–88.0)	90%	
			82.1		P = 0.79
			(80.2–83.8)		
			75.6		P < 0.01
			(56.0–88.3)		
Data collection method	In person	6	71.7	98%	P < 0.01
	Online	12	(56.8–83.0)	99%	
			78.0		P < 0.01
			(66.2–86.6)		
Diabetes as primary focus	Yes	9	67.5	99%	P < 0.01
	No	9	(51.9–80.0)	98%	
			83.0		P < 0.01
			(74.5–89.0)		

3.6. Barriers to vaccine acceptance

Reasons behind diabetes patients' unwillingness to accept COVID-19 vaccine were extracted from 5 studies. In all, nineteen reasons were cited by diabetes patients as barriers for their unwillingness to accept the COVID-19 vaccine. These reasons emerged under 5 themes as summarized in Table 3. Reasons for vaccine unwillingness stemmed predominately from health or safety concerns in relation to COVID-19 vaccination [6,9,19,20,22]. These concerns were centered on the perceived negative experience with the vaccine, such as side effects from

the vaccine, adverse reactions, allergic reactions, glucose variation, and the possibility of vaccines leading to other diseases.

4. Discussion

4.1. Summary of the results

The aim of this study was to determine the acceptance rate of the COVID-19 vaccine among individuals with diabetes. To achieve this objective, a comprehensive literature search was conducted to identify relevant studies, and a meta-analysis was performed to synthesize the prevalence data. The findings of our meta-analysis revealed that

Table 3
Barriers to COVID-19 vaccine acceptance.

Themes	Reasons for vaccine hesitancy
Misinformation	• Belief that the SARS-CoV-2 vaccine is unsafe • Belief that COVID-19 is not dangerous to diabetes patients' health • Belief that vaccination does not reduce the risk of infection • Different conspiracy theories
Lack of Information	• No current reports of follow-up after vaccination of diabetes patients • Relatively fast production • Not many trials done • Uncertainties about the genetic component
Mistrust	• Not trust pharmaceutical manufacturing companies • Not trust the countries where the vaccines were produced • Not trust the manufacturing process of the vaccine.
Health Concerns	• Fear of side effects from the vaccine • Fear of other adverse reactions after vaccination • Glucose variation • Possibility of leading to other diseases • Afraid of allergic reaction
External Influence	• COVID-19 vaccination was not recommended by their physicians • Families suggested not to receive vaccination • Advice from religious leaders
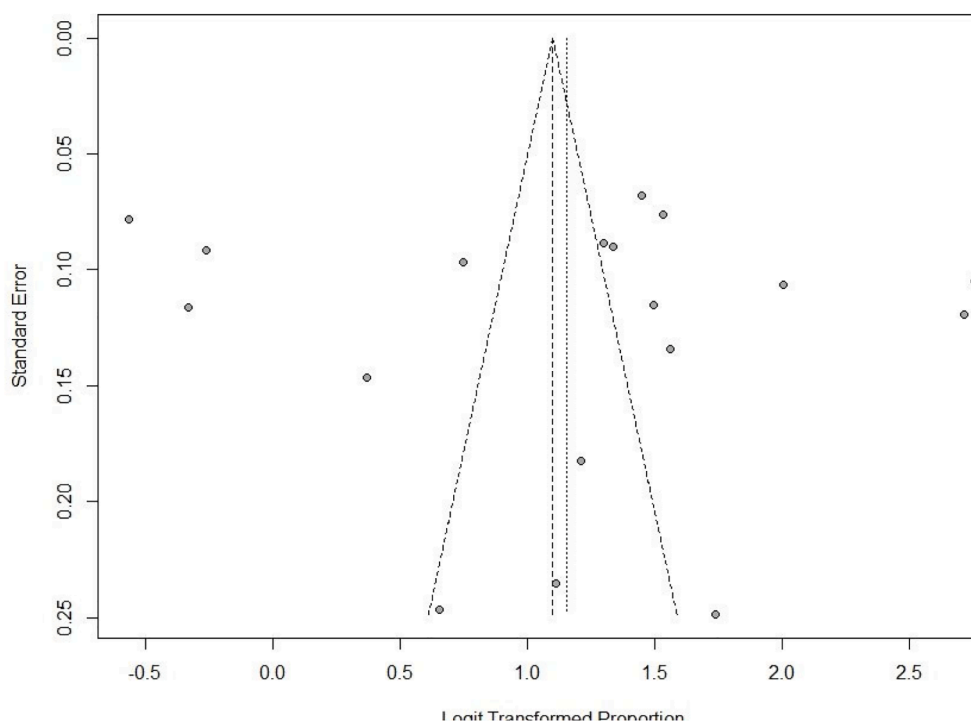
Fig. 3. Funnel plot for COVID-19 vaccine acceptance among persons with diabetes.

individuals with diabetes have a combined COVID-19 vaccine acceptance rate of 76.1% (95% CI: 66.7– 83.5). This high acceptance rate could be attributed to diabetes patients' heightened awareness of their susceptibility to the COVID-19 disease [35] which may have led to a better understanding of the benefits of vaccination in preventing severe illness and hospitalization. Our findings align with empirical studies that demonstrate the conscientiousness of diabetes patients regarding preventive measures against COVID-19, such as proper hand hygiene, wearing of face masks, and maintaining social distancing [36,37]. Moreover, the earlier prioritization of individuals with diabetes in the COVID-19 vaccine rollout [8] may have played a role in increasing awareness and education about the importance of vaccination in this population, which in turn may have boosted their willingness to accept the vaccine. Compared to the findings of meta-analysis of the general population, the acceptance rate of the COVID-19 vaccine among individuals with diabetes is higher, as demonstrated in our results [11,38–40]. It is also worth noting that the results of this study demonstrate a higher acceptance rate of COVID-19 vaccine among individuals with diabetes as compared to other high-risk populations, such as cancer patients (59%) [41] and patients with chronic disease in general (65%) [42].

Our subgroup analysis, stratified according to continent, has revealed notable variations in the acceptance rates of COVID-19 vaccines. Specifically, we observed the highest acceptance rates in Europe, followed by America, Africa, and the lowest in Asia. This finding is consistent with previous meta-analyses that examined vaccine acceptance rates among individuals with chronic diseases, which similarly reported higher acceptance rates in Europe and America compared to Asia [42]. The high vaccine acceptance rate in Europe and America is attributed to the implementation of policies such as the early prioritization of persons with chronic disease which is likely to have increased awareness about the importance of vaccination [42]. It is worth nothing that other factors may also account for the variation of the vaccine willingness across continents. Additionally, our analysis of gender differences in vaccine acceptance rates revealed that male diabetes patients had a higher acceptance rate compared to their female counterparts. This finding aligns with the outcomes of previous meta-analyses conducted on the general population, which indicated that males are more inclined to accept COVID-19 vaccines [11,38,40]. Research has shown that males are more susceptible to contracting COVID-19, more prone to experiencing severe symptoms, and have a poorer prognosis [43,44]. This heightened risk may serve as a motivating factor for males to actively seek vaccination. Moreover, it has been observed that males possess a greater level of confidence in the safety of the COVID-19 vaccine [22], which could also contribute to the observed higher acceptance rates. It is important to acknowledge that, apart from gender, other sociodemographic factors may also influence COVID-19 vaccine acceptance rates. However, due to limited information on these variables from the included studies, their analysis was not conducted. Future research should therefore explore the influence of these sociodemographic factors on COVID-19 vaccine acceptance rates to gain a more thorough understanding of the subject matter.

Barriers associated with COVID-19 vaccine acceptance emerged under 5 themes, namely, misinformation, lack of information, mistrust, health concerns, and external influences. Several studies on vaccine hesitancy have consistently identified these themes [45,46]. The dissemination of false information via digital media platforms presents a major challenge, particularly in the realm of misinformation. Addressing this barrier requires a robust fact-checking and counter-messaging strategy to provide accurate information to the public [47]. It is also crucial for the scientific and healthcare communities to work in unison to dispel myths and provide reliable information, thereby building trust and encouraging vaccine uptake, particularly among high-risk populations such as individuals with diabetes. Addressing health-related concerns about COVID-19 vaccines is of utmost importance and requires healthcare providers to furnish credible and evidence-based information on vaccine safety and efficacy, in addition to closely monitoring and reporting any adverse events. Given that adverse events associated with COVID-19 vaccines are mostly mild and resolvable [48], healthcare providers must help patients to understand this concept and stay informed.

4.2. Strengths and limitations

This review provides a comprehensive analysis of the acceptance of COVID-19 vaccination among individuals diagnosed with diabetes, offering valuable insights into the current status of vaccine uptake within this population. The primary strength of this review lies in its novelty, as it establishes a benchmark for future investigations in this field. Additionally, the literature search employed specialized databases dedicated to COVID-19 research, ensuring the inclusion of all relevant studies on this topic. Despite these strengths, the review does have some limitations that must be acknowledged. Firstly, the studies included in the analysis exhibit a significant level of heterogeneity, which may challenge the validity of definitive conclusions regarding vaccine acceptance among individuals with diabetes. Another limitation lies in the fact that we did not assess the impact of different vaccine types on acceptance rates among diabetes patients, which could have influenced the outcomes. Furthermore, the exclusion of non-English language articles may introduce a potential bias by omitting perspectives from diverse cultural and linguistic groups, thereby limiting the generalizability of the findings. In light of these limitations, it is crucial to interpret the results of this review with caution.

5. Conclusion

In conclusion, the results of this study suggest that a majority of diabetes patients have accepted the COVID-19 vaccine. However, given the higher risk of severe COVID-19 among individuals with diabetes, it is important for healthcare providers to continue promoting the benefits of vaccination and addressing any concerns to increase vaccine uptake. The barriers that have been identified can be leveraged to formulate health policies and public health interventions that are specifically tailored to address the needs of persons with diabetes.

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Authors' Contributions

The study was a collaborative effort between both authors. E.E conceptualized the study and designed the methods. Both authors (S.A and E.E) performed the study selection, data extraction, quality assessment, analysis, and wrote the manuscript. Both authors also critically reviewed the manuscript. The authors read and approved the final manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.diabres.2023.110731.

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