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Assessing the impact of telehealth on blood glucose management among patients with diabetes: a systematic review and meta-analysis of randomized controlled trials

Addisu Getie[1*], Baye Tsegaye Amlak[1], Temesgen Ayenew[1] and Mihretie Gedfew[1]

Abstract

Introduction The increasing prevalence of diabetes mellites (DM), especially type 2 diabetes mellitus, presents significant challenges for healthcare systems. Effective blood glucose management is essential for preventing serious complications, and telehealth offers a promising approach to improve patient engagement and adherence. The effectiveness of telehealth on blood glucose management should be investigated. The evaluated metric for diabetes management plans in this study was the change in blood glucose levels, specifically HbA1c, as an indicator of glycemic control. The impact of telehealth interventions on these outcomes was analyzed across various patient groups. This review conducts a comprehensive analysis of the current literature to offer insights that can guide clinical practices and inform policymakers about the advantages of telehealth in managing diabetes.

Methods In this study, several evidence-based databases and relevant clinical trial registries were searched to evaluate the effects of telehealth on blood glucose management among patients with diabetes. The included studies were randomized controlled trials that compared telehealth with traditional in-person management. Microsoft Excel was used to extract and sort the data before it was exported to STATA/MP 17.0 for analysis. A weighted inverse variance random-effects model with a 95% confidence interval was employed to pool the data. Egger's test and Cochrane I^2 statistics were used to assess publication bias and heterogeneity, respectively.

Result This review identified six randomized controlled trials (RCTs) involving a total of 3,995 patients, with 2,022 in the telehealth intervention group and 1,973 in the control group, conducted across the USA, Asia, and Europe. The analysis showed a significant improvement in blood glucose control for patients using telehealth, evidenced by a Standard Mean Difference (SMD) of 0.20 (95% CI: 0.10–0.29; $p < 0.001$), with USA studies reflecting the highest SMD of 0.24 and diabetic veterans showing an even greater SMD of 0.41.

Conclusion and recommendations This study demonstrates that telehealth interventions significantly enhance blood glucose management among patients with diabetes. The findings highlight the need for healthcare systems to prioritize telehealth integration into diabetes management protocols while developing tailored interventions to meet the diverse needs of various patient populations.

*Correspondence:
Addisu Getie
addisu_getie@dmu.edu.et

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Keywords Telehealth, Diabetes mellitus, Blood glucose, HbA1c, Systematic review, Meta-analysis

Introduction

The global rise in diabetes prevalence, particularly type 2 diabetes, presents significant challenges to healthcare systems. According to the International Diabetes Federation, approximately 537 million adults were living with diabetes in 2021, a figure projected to rise to 643 million by 2030 [1]. Effective blood glucose management is crucial in preventing the complications associated with diabetes, which include cardiovascular diseases, kidney failure, and neuropathy [2]. As healthcare systems adapt to meet the demands of this growing population, telehealth has emerged as a promising approach to diabetes management, offering new ways to engage patients and enhance treatment adherence [3].

Telehealth encompasses a variety of technologies that facilitate remote healthcare delivery, including video consultations, mobile health applications, and remote monitoring tools. These technologies can address common barriers faced by patients with diabetes, such as geographical distance, mobility issues, and time constraints [4]. Studies suggest that telehealth interventions can lead to improved self-management, increased patient engagement, and better health outcomes [5]. For instance, a study conducted in 2017 found that telehealth interventions significantly reduced hemoglobin A1c (HbA1c) levels, indicating improved glycemic control among patients with diabetes when compared to standard care [6]. Telemedicine interventions can help patients with diabetes manage their condition and improve HbA1c levels through teleconsultations, remote monitoring, and tailored educational programs. Clinicians can use secure communication channels for timely feedback and personalized care. Adapting telemedicine to local resources, patient needs, and healthcare infrastructure ensures accessibility and effectiveness [7].

Despite the promising results, the efficacy of telehealth interventions remains variable across different populations and settings. While telehealth can be effective, the outcomes are influenced by factors such as patient demographics, the type of telehealth technology employed, and the level of provider support [8]. Additionally, some studies indicate that technology-related barriers, such as lack of access to the internet or digital literacy challenges, may hinder the effectiveness of telehealth in certain demographics [9]. Understanding these dynamics is crucial for optimizing telehealth interventions tailored to diverse patient populations.

This systematic review aims to evaluate the impact of telehealth on blood glucose management specifically within randomized controlled trials (RCTs) involving patients with diabetes. As diabetes prevalence continues to rise, effective management strategies are essential for maintaining optimal glycemic control. Telehealth offers innovative solutions that can help address common barriers faced by patients, such as geographical distance, mobility issues, and time constraints. By synthesizing findings from relevant studies, this review will assess the overall effectiveness of telehealth intervention for glucose monitoring, and remote patient education programs.

Through a comprehensive analysis of the current literature, this review seeks to provide valuable insights that can guide future clinical practices and inform policymakers about the potential benefits of telehealth in diabetes management. Ultimately, this study aims to contribute to the existing body of knowledge and support the development of effective telehealth strategies to improve patient outcomes in diabetes care. Therefore, the main objective of this review was to evaluate the comparative impact of telehealth over traditional in-person management on blood glucose management among patients with diabetes in the world.

Method

Protocol and registration

In this study, we reviewed multiple evidence-based databases such as PubMed, MEDLINE, Embase, CINAHL, grey literature, the Cochrane Library, and Web of Science. We also examined existing systematic reviews and identified relevant ongoing research via clinical trial registries and systematic review databases. Despite this extensive search, there is no discovery of any similar studies currently undergoing publication. However, the study protocol was not registered in the PROSPERO database, and a formal protocol was not created.

Search strategy

In this systematic review and meta-analysis, we employed a thorough search strategy to identify relevant RCTs evaluating the effects of telehealth on blood glucose management in patients with diabetes. Our search encompassed multiple databases, including PubMed, MEDLINE, Embase, CINAHL, grey literature, the Cochrane Library, and Web of Science. We utilized a combination of keywords and MeSH terms related to telehealth, in-person management, traditional management, diabetes mellitus, and RCTs, such as "impact," "effect," "telecare,"

"telemedicine," "telehealth," "diabetes mellitus," "blood glucose," "HbA1c," "determinants," and "factors." Boolean operators (AND, OR) were used to combine search terms. Additionally, we hand-searched the references of selected articles to identify further relevant studies. Duplicates were removed, and the selection process followed PRISMA guidelines [10] (Table S1).

Screening and eligibility criteria

In this systematic review and meta-analysis, we focused on RCTs that compared the effects of telehealth with traditional in-person management on blood glucose control among patients with diabetes worldwide. All retrieved articles were imported into EndNote reference software version 8 (Thomson Reuters, Stamford, CT, USA) for organization, data cleaning, and duplicate removal. Three authors (AG, BTA, and TA) independently screened and assessed the relevance of each study based on titles and abstracts, applying predefined inclusion criteria. These criteria required studies to compare specific treatments, be either experimental or observational in design, address a significant research question, focus on a defined population, clearly identify participant types, examine the phenomenon of interest, provide contextual or setting details, and report outcomes. After thoroughly reviewing the full texts of the selected studies, all authors (AG, MB, MG, BT, and AW) evaluated each article's eligibility. Any discrepancies were resolved through discussion among the authors. We included RCTs involving patients with diabetes of any type and those that provided quantitative data using standardized, validated assessment tools. Both published and unpublished articles found in university repositories were considered, irrespective of geographical location and publication date. Randomized controlled trials conducted and published in the English language until October 10, 2024, were included. The search date was ranged from October 15–25, 2024. However, non-randomized studies, including observational studies, case reports, conference proceedings, and review articles were excluded from the review. Additionally, RCTs that were not available in full-text format were excluded.

Outcome measurement of the study

The outcome measurement for this study was primarily concentrated on quantifying changes in blood glucose levels, which are critical for evaluating diabetes management. This was assessed using key metrics, HbA1c, which provides an average of blood glucose levels over the preceding two to three months and offers a reliable indicator of long-term glucose control. A reduction in HbA1c levels would signify improved glycemic control, which is essential for minimizing the risk of diabetes-related complications. By focusing on this metric, the study aims to establish a clear connection between telehealth interventions and their impact on blood glucose regulation among patients with diabetes, ultimately contributing to a better understanding of how telehealth can be leveraged to enhance diabetes care.

Data extraction and quality assessment

A standardized form in Microsoft Excel was used to extract data, including authors' names, publication year, study setting, patient characteristics, follow-up duration, sample sizes for both intervention and control groups, and the mean and standard deviation of blood glucose levels for each group. The Cochrane Risk of Bias Tool was employed to assess the methodological quality of the included trials, focusing on aspects like randomization, blinding, and completeness of outcome data. Based on these evaluations, studies were classified as having a high, moderate, or low risk of bias [11]. The quality of the included randomized controlled trials (RCTs) was assessed using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist, which evaluated key study design elements such as randomization, allocation concealment, blinding, and follow-up completeness [12]. To minimize bias, data extraction, and quality assessments were carried out independently by two reviewers, with any disagreements resolved through consensus or consultation with the other authors.

Data synthesis and analysis

The standard mean difference was used to assess the impact of telehealth over traditional in-person management on blood glucose monitoring among patients with diabetes. The data was pooled through a weighted inverse variance random-effects model at a 95% confidence interval [13]. Data extraction and cleaning were performed using Microsoft Excel, and the cleaned data were then exported to STATA version 11.0 (Stata Corporation, College Station, Texas) for further analysis [14]. To evaluate the heterogeneity among the studies, a Cochrane Q test and calculated the I2 statistic along with its associated p-value were employed. Additionally, to explore the sources of heterogeneity among the studies, three analytical approaches: subgroup analysis, sensitivity analysis, and meta-regression were employed. Furthermore, the absence/presence of publication bias was assessed using Egger's test and funnel plots [15]. Finally, a statistical test with a P-value of less than 0.05 was considered statistically significant.

Result

Screening of eligible studies using PRISMA flow chart

As indicated in the PRISMA flow chart, the process of screening eligible studies for this systematic review and

meta-analysis is clearly illustrated. A total of 865 articles were identified through a comprehensive search of electronic databases and other sources. After conducting a thorough assessment that included the removal of duplicates and the screening of abstracts and titles, along with evaluating the availability of full text and applying other eligibility criteria, 859 articles were excluded from consideration. Ultimately, six RCTs that met the inclusion criteria were selected for inclusion in the review (Fig. 1).

Study characteristics

A total of six RCTs were identified that met the inclusion criteria, involving a total of 3,995 patients (2,022 in the intervention group and 1,973 in the control group). These studies were conducted internationally, encompassing three research from the USA [16–18], two in Asia [19, 20], and one in Europe [21]. The trials included in this review reflect a diverse range of patient populations and healthcare settings, with data collected up until October 2024. The patient populations included in this review encompassed a variety of groups, including older adults, ethnically diverse individuals, medically underserved patients, diabetic veterans receiving outpatient care, type 2 DM patients, patients with type 2 DM during the COVID-19 pandemic, and individuals with gestational diabetes. The follow-up periods for these studies varied significantly, spanning from three months to five years, while sample sizes ranged from 106 to 1,665 participants. Importantly, all studies included in this review were designed as RCTs (Table 1).

Telehealth interventions and standard-of-care interventions

Telehealth interventions in diabetes management typically include remote consultations via video calls, phone calls, or secure messaging, enabling patients to receive healthcare support without needing to visit a clinic. These interventions may also incorporate remote monitoring of vital signs, such as blood glucose levels, using devices that transmit data to healthcare providers for ongoing assessment and adjustments. In addition, personalized educational programs may be delivered through digital platforms to help patients manage their

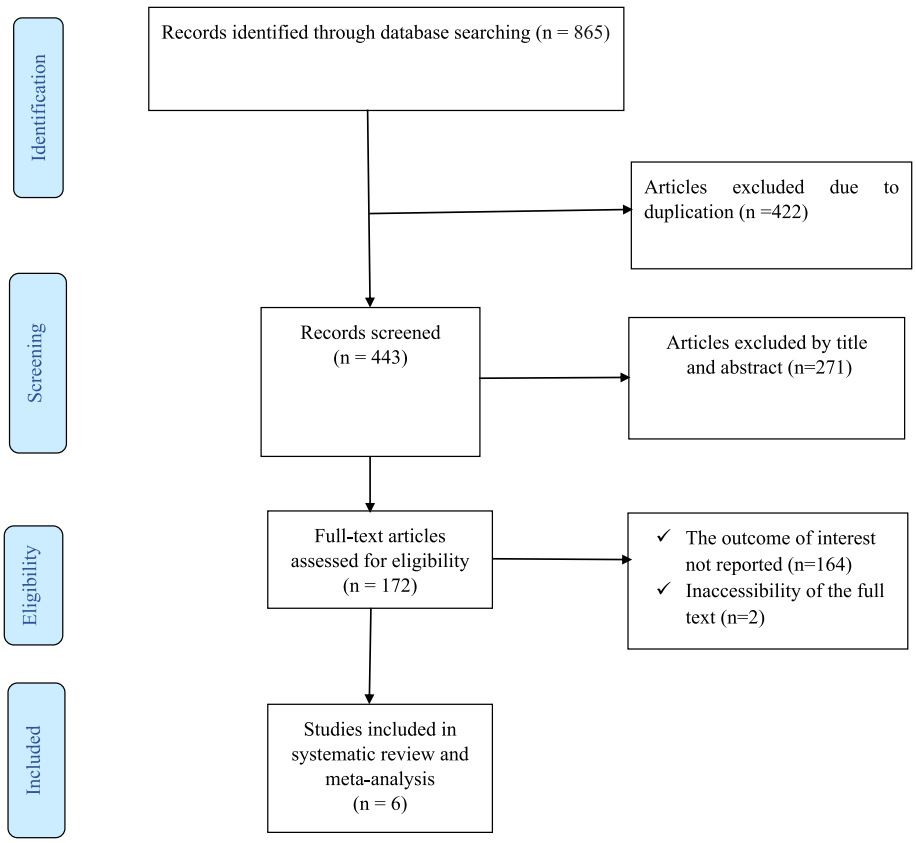

Fig. 1 The PRISMA flow diagram of identification and selection of RCTs done on the impact of telehealth on blood glucose management among patients with diabetes in the world

Table 1 Study characteristics on RCTs done to evaluate the impact of telehealth on blood glucose management among patients with diabetes in the world

Author & publication year	Setting	Patient category	Follow-up period	Sample size IG	Sample size CG	Mean change IG	Mean change CG	SD IG	SD CG
Shea et al., 2006 [16]	USA	Older, Ethnically Diverse, Medically Underserved Patients	One year	844	821	0.38	0.25	0.61	0.49
Shea et al., 2009 [17]	USA	Older, Ethnically Diverse, Medically Underserved Patients	Five years	844	821	0.34	0.07	0.57	0.26
Cook et al., 2012 [18]	USA	DIABETIC VETERAN OUTPATIENTS	Two years	57	58	0.66	0.25	0.80	0.49
AlMutairi et al., 2021 [19]	Asia	Type 2 diabetes mellitus during the COVID-19 pandemic	Three months	100	100	1.82	1.54	1.33	1.22
Munda et al., 2023 [21]	Europe	Gestational diabetes	One year	54	52	0.3	0.22	0.54	0.46
Molavynejad et al., 2022 [20]	Asia	Type 2 diabetes mellitus	Three months	123	121	0.91	0.84	0.94	0.90

CG Control Group, *IG* Intervention Group, *SD* Standard Deviation

condition. In contrast, standard-of-care interventions typically involve in-person visits to healthcare facilities, where patients receive face-to-face consultations, blood glucose monitoring, and personalized treatment plans. Standard care may also include periodic follow-ups, lifestyle recommendations, and medication adjustments based on in-person assessments.

Meta-analysis

Impact of telehealth on blood glucose management

This study examined the effects of telehealth on blood glucose management among patients with diabetes worldwide, comparing those who received telehealth interventions to those who underwent traditional in-person management. The findings revealed a notable improvement in blood glucose control among patients utilizing telehealth, as indicated by a Standard Mean Difference of (SMD = 0.20; 95% CI: 0.10–0.29; $p < 0.001$). This finding highlights a statistically significant advantage of telehealth over in-person management (Fig. 2).

Heterogeneity and investigation of the source of heterogeneity

In this review, a moderate level of heterogeneity among the included studies was observed, with an I^2 value of 74.96%. To identify the sources of this heterogeneity, three analytical approaches, including subgroup analysis, meta-regression, and sensitivity analysis were conducted. The moderators chosen for subgroup analysis and meta-regression included the continent where each study was conducted and patient characteristics such as diabetes type, age, and other relevant factors used for patient categorization.

Subgroup analysis

According to the results of the subgroup analysis, studies conducted in the USA demonstrated the highest Standardized Mean Difference (SMD = 0.24; 95% CI: 0.10–0.38; $p < 0.001$) compared to studies from Asia and Europe (Fig. 3). Additionally, research done on diabetic veteran outpatient patients showed a greater standard mean difference of (SMD = 0.41; 95% CI: 0.17–0.65; $p < 0.001$) relative to other group of patients with diabetes (Fig. 4).

Meta-regression

The results from the meta-regression analysis revealed that the moderators, specifically the continent and patient category, did not significantly contribute to the observed heterogeneity among the studies. With *P*-values of 0.577 for the continent and 0.968 for the patient category, these findings suggest that variations in outcomes were not strongly influenced by the geographical location of the studies or the specific characteristics of the patient groups analyzed (Table 2).

Sensitivity analysis

The sensitivity analysis, which utilized a one-point leave-out approach, showed that none of the studies significantly affected the overall results, as all remained within

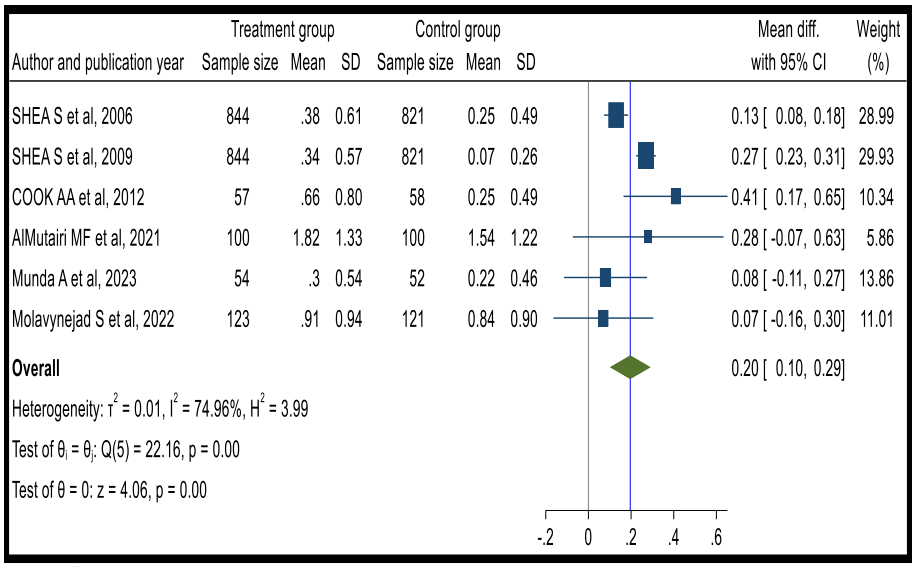

Fig. 2 Forest plot using a random-effects model illustrating the effects of telehealth on blood glucose management among patients with diabetes in the world

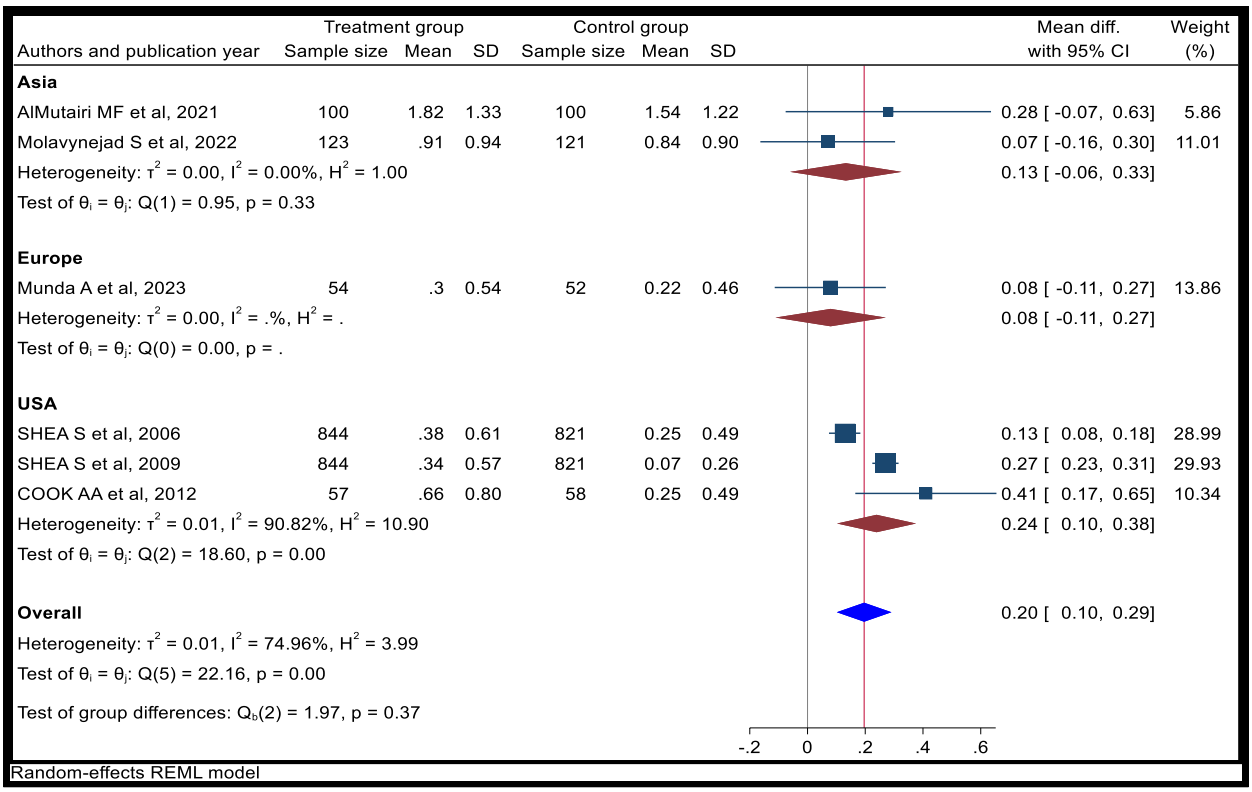

Fig. 3 Forest plot employing a random-effects model displays subgroup analysis by continent, illustrating the impact of telehealth on blood glucose management among patients with diabetes worldwide

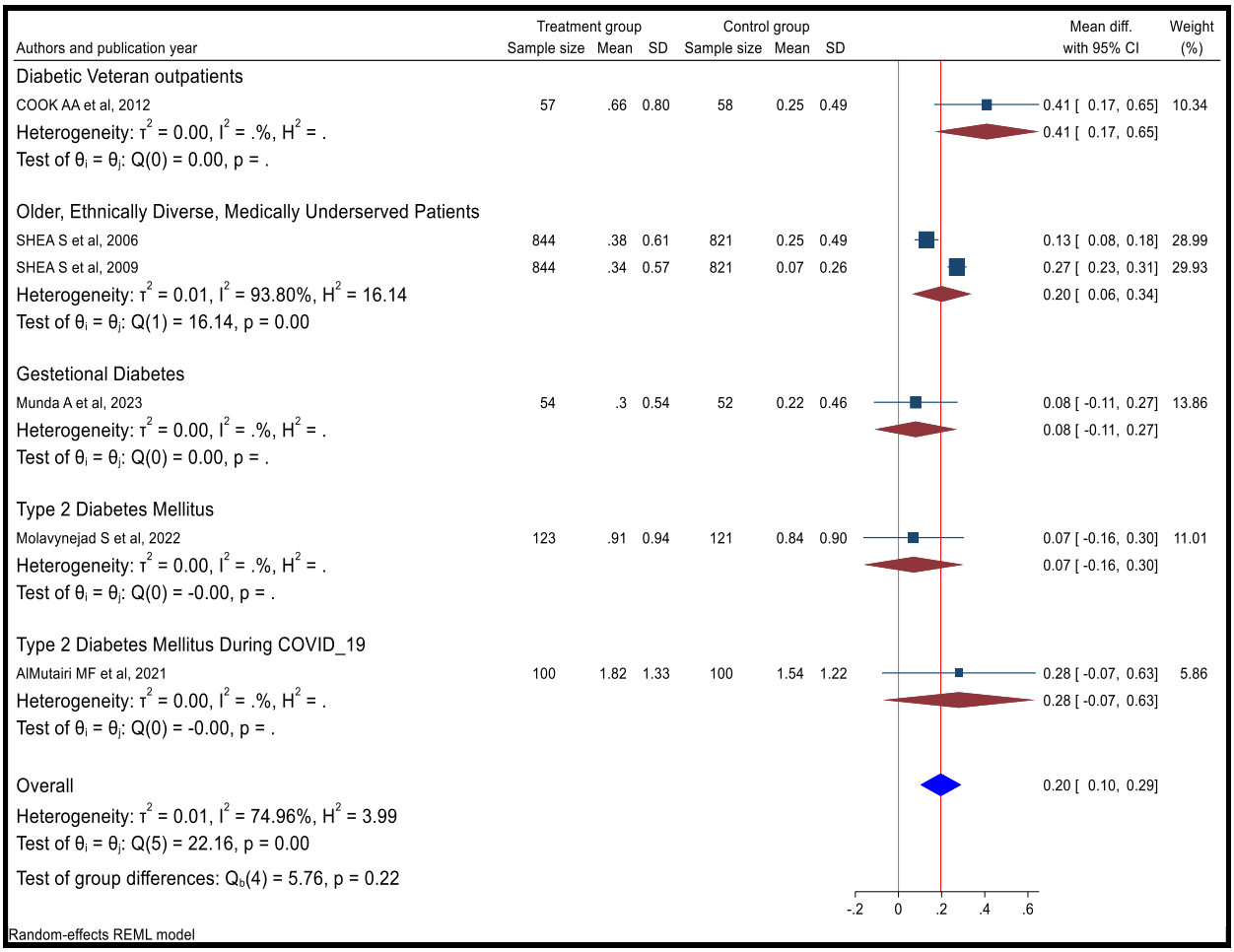

Fig. 4 Forest plot employing a random-effects model displays subgroup analysis by patient category, illustrating the impact of telehealth on blood glucose management among patients with diabetes worldwide

Table 2 Meta-regression analysis results illustrating the effects of telehealth on blood glucose management among patients with diabetes in the world

Moderators	Coefficient	Standard error	Z	*P*>/Z/	95% CI
Continent	-0.77	0.14	-0.56	0.577	-0.35,0.19
Patient category	-0.003	0.07	-0.04	0.968	-0.14,0.13
-cons	0.32	0.13	2.50	0.013	0.068,0.568

Patient category (older, ethnically diverse, medically underserved patients, diabetic veteran outpatients, type 2 DM, type 2 DM during the COVID-19 pandemic, and gestational diabetes)

the confidence interval of 0.10 to 0.29. This finding indicates that the overall conclusions of the analysis are stable and reliable, meaning that the presence or absence of any single study does not have an outsized impact on the findings (Fig. 5).

Publication bias

The funnel plot illustrated a symmetrical distribution of the studies included in the analysis, suggesting that there is no significant publication bias present. This conclusion is supported by Egger's test, which returned a non-significant *p*-value of 0.8455, indicating that there is little to no evidence of bias influencing the overall results (Fig. 6). Furthermore, the trim and fill analysis verified the absence of publication bias, as the mean difference between the observed studies and the studies adjusted for potential missing data remained similar.

Discussion

This result underscores a statistically significant benefit of telehealth compared to in-person management. It demonstrates a marked improvement in blood glucose control among patients using telehealth, with a Standard Mean Difference of 0.20 (95% CI: 0.10–0.29; $p < 0.001$). This finding aligns with recent literature that emphasizes

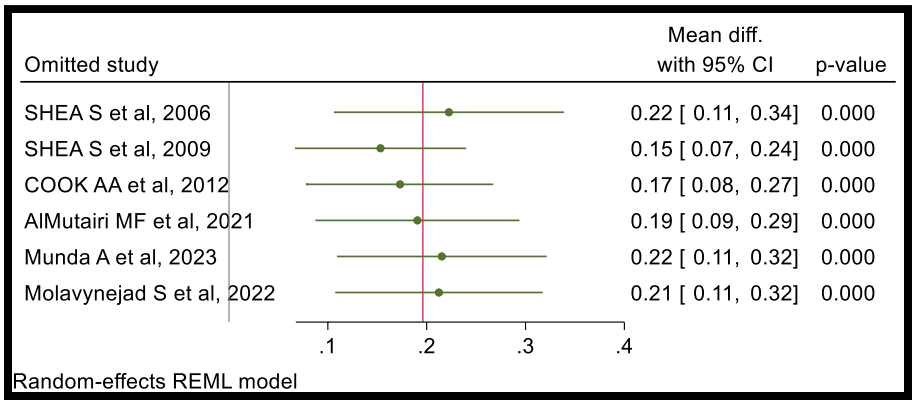

Fig. 5 Sensitivity analysis utilizing a random-effects model to demonstrate the impact of a leave-one-out estimate on the study illustrating the impact of telehealth on blood glucose management among patients with diabetes worldwide

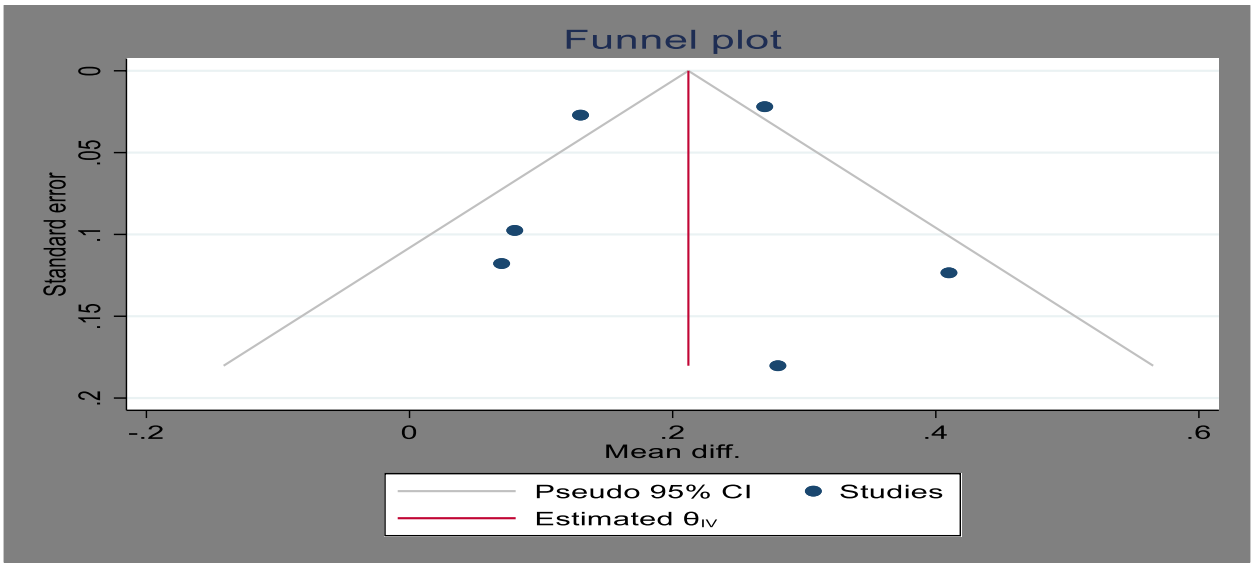

Fig. 6 Funnel plot with 95% confidence limits illustrating the distribution of the included studies examining the impact of telehealth on blood glucose management among patients with diabetes worldwide

the benefits of telehealth interventions and is consistent with prior research demonstrating its effectiveness in monitoring and consultation to enhance patient outcomes in blood glucose management [22]. Likewise, a 2021 study revealed that patients utilizing telehealth demonstrated higher adherence to diabetes management plans, reinforcing the idea that telehealth is a valuable addition to blood glucose management. This indicates that telehealth not only enhances clinical outcomes but also promotes greater patient engagement and adherence [23]. On the other hand, some studies have reported mixed findings regarding the effectiveness of telehealth compared to in-person management. For instance, a 2023 study found that while telehealth offered significant benefits, its effectiveness differed based on demographic factors like age and socioeconomic status [24]. This contrast underscores the importance of considering individual patient characteristics when evaluating the impact of telehealth interventions. Furthermore, it emphasizes the need for tailored approaches to diabetes management, as the effectiveness of telehealth may not be uniform across all patient populations.

The results from the subgroup analysis indicated that studies conducted in the USA exhibited the highest Standardized Mean Difference compared to studies from Asia and Europe. This aligns with another study conducted in 2020, which also highlighted the effectiveness of telehealth in the American context, potentially due to

greater technological integration in healthcare settings [25]. Furthermore, research conducted on diabetic veteran outpatient patients yielded a higher SMD, indicating that this specific population may experience particularly beneficial outcomes from telehealth interventions [26]. These results underscore the variability in telehealth effectiveness across different populations and regions, emphasizing the necessity for tailored approaches in diabetes management.

The meta-regression analysis revealed that the selected moderators, namely continent and patient category, did not significantly explain the heterogeneity observed among the studies. This suggests that other factors may be contributing to the differences identified across the research, highlighting the complex nature of telehealth interventions. For example, disparities in healthcare systems, technological accessibility, and socioeconomic conditions may significantly impact outcomes. Additionally, variations in study design, such as the duration of interventions, the types of telehealth services provided, the technologies utilized, and the frequency of follow-ups—could further account for the inconsistencies in results [27]. Furthermore, patient-specific factors like comorbidities, health literacy, and cultural attitudes toward telehealth could significantly impact the effectiveness of these interventions. For example, patients with multiple health issues may require more comprehensive care that telehealth alone might not adequately provide [28].

The sensitivity analysis employed a one-point leave-out approach, demonstrating that no individual study significantly impacted the overall results. This finding strengthens confidence in the robustness and reliability of the conclusions drawn from the meta-analysis, indicating that the effects observed are consistent and not disproportionately influenced by any single study [29]. The funnel plot illustrated a symmetrical distribution of the studies, indicating the absence of significant publication bias. This conclusion is supported by Egger's test, which yielded a non-significant *p*-value, suggesting that there is no evidence of bias affecting the overall results [30]. The trim and fill analysis further confirmed this absence of bias, with similar mean differences between observed and adjusted studies, reinforcing the reliability of our findings and affirming their robustness against potential publication bias.

The study uses meta-regression and subgroup analysis to address heterogeneity, which may stem from differences in patient demographics and healthcare system structures. Factors such as age, gender, socioeconomic status, education, and cultural background influence patient engagement with telehealth, with older adults and lower-income populations often facing barriers like limited technological access [31, 32]. Variations in telehealth infrastructure, electronic health record integration, provider training, and follow-up protocols also impact outcomes [33, 34]. Additionally, regional disparities in policies, funding, and healthcare delivery models, such as urban–rural divides and fee-for-service systems, contribute to inconsistencies in effectiveness [35]. Overall, these complexities suggest a need for deeper exploration into additional moderators that could elucidate the sources of heterogeneity, helping to tailor telehealth approaches to diverse populations more effectively.

Strengths and limitations of the study

The main strength of this study lies in its comprehensive methodology, which includes subgroup analysis, meta-regression, and sensitivity analysis to investigate sources of heterogeneity. The reliability of the findings is further reinforced by sensitivity analysis and the absence of significant publication bias. However, there are notable limitations. High heterogeneity among the studies complicates the interpretation of the overall effect size. Additionally, the lack of registration in PROSPERO raises concerns about transparency and the potential for bias. Furthermore, the limited number of included trials may result in less reliable conclusions, underscoring the need for future research with larger sample sizes to validate these findings.

Conclusion and recommendations

This study provides convincing evidence that telehealth interventions significantly improve blood glucose management among patients with diabetes compared to traditional in-person care. The effectiveness of telehealth varies across different populations, with diabetic veterans and studies conducted in the USA showing particularly pronounced improvements. Despite the findings from this review supporting the efficacy of telehealth, it is crucial to acknowledge the variability in patient responses and the necessity for ongoing research to optimize these interventions. Therefore, healthcare systems should prioritize the integration of telehealth solutions into diabetes management protocols. Given the variability in the effectiveness of telehealth, it is important to develop tailored interventions that address the specific needs and characteristics of diverse patient populations. Additionally, future research should investigate other factors that could influence the effectiveness of telehealth, including socioeconomic status, technological literacy, and patient engagement, as understanding these elements will improve the design and implementation of telehealth interventions.

Abbreviations

CI	Confidence Interval
COVI-19	Corona Virus Disease-19
HbA1c	Hemoglobin A1c
PRISMA	Preferred Reporting Items for Systematic Review and Meta-analysis
RCTs	Randomized Control Trials
SMD	Standardized Mean Difference

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s12913-025-12401-9.

Supplementary Material 1: Table S1. Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA-S) guideline for reporting the findings.

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Authors' contributions
AG designed the study, designed, and ran the literature search. All authors (AG, BTA, TA, and MG) acquired data, screened records, extracted data, and assessed the risk of bias. AG performed statistical analyses and wrote the report. All authors provided critical conceptual input, analyzed and interpreted the data, and critically revised the report. All authors read and approved the final manuscript.

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Data availability
All related data have been presented within the manuscript. The dataset supporting the conclusions of this article is available from the authors on request.

Declarations

Ethics approval and consent to participate
Not applicable.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

Author details
[1]Department of Nursing, College of Medicine and Health Sciences, Debre Markos University, Debre Markos, Ethiopia.

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References

1. International Diabetes Federation. IDF Diabetes Atlas. 10th ed. Brussels, Belgium: International Diabetes Federation; 2021.
2. Zheng Y, Ley SH, Hu FB. Global epidemiology of type 2 diabetes and its cardiovascular implications. Nat Rev Cardiol. 2018;15(2):85–98.
3. Bachmann J, Jansen L. Telehealth in diabetes management: a systematic review. Diabetes Technol Ther. 2020;22(5):338–51.
4. Ferguson TJ, Leung D. Telehealth in diabetes care: a systematic review of the literature. J Diabetes Sci Technol. 2020;14(4):700–8.
5. Hamine S, Gerth A, Waisman J, Boulanger A. A systematic review of telemonitoring for diabetes management: benefits and challenges. J Telemed Telecare. 2015;21(3):117–27.
6. Kitsiou S, Paré G, Jaana M, Cohen A. Effectiveness of telehealth interventions on diabetes management: a systematic review and meta-analysis. J Diabetes Sci Technol. 2017;11(2):318–32.
7. Liu F, Li J, Li X, Yang Z, Wang W, Zhao L, et al. Efficacy of telemedicine intervention in the self-management of patients with type 2 diabetes: a systematic review and meta-analysis. Front Public Health. 2024;12:1405770.
8. Wang J, Zhao H. Telehealth interventions for diabetes management: a systematic review and meta-analysis. Diabetes Technol Ther. 2020;22(9):703–13.
9. Baker SJ, Morris RJ. Digital health equity: addressing the challenges of telehealth for marginalized populations. Health Aff. 2021;40(4):604–12.
10. Rethlefsen ML, Kirtley S, Waffenschmidt S, Ayala AP, Moher D, Page MJ, et al. PRISMA-S: an extension to the PRISMA statement for reporting literature searches in systematic reviews. Syst Rev. 2021;10:1–19.
11. Minozzi S, Cinquini M, Gianola S, Gonzalez-Lorenzo M, Banzi R. The revised Cochrane risk of bias tool for randomized trials (RoB 2) showed low interrater reliability and challenges in its application. J Clin Epidemiol. 2020;126:37–44.
12. Barker TH, Stone JC, Sears K, Klugar M, Tufanaru C, Leonardi-Bee J, et al. The revised JBI critical appraisal tool for the assessment of risk of bias for randomized controlled trials. JBI Evid Synth. 2023;21(3):494–506.
13. Borenstein M, Hedges LV, Higgins JP, Rothstein HR. A basic introduction to fixed-effect and random-effects models for meta-analysis. Res Synth Methods. 2010;1(2):97–111.
14. Rücker G, Schwarzer G, Carpenter JR, Schumacher M. Undue reliance on I 2 in assessing heterogeneity may mislead. BMC Med Res Methodol. 2008;8:1–9.
15. Egger M, Smith GD, Schneider M, Minder C. Bias in meta-analysis detected by a simple, graphical test. BMJ. 1997;315(7109):629–34.
16. Shea S, Weinstock RS, Starren J, Teresi J, Palmas W, Field L, et al. A randomized trial comparing telemedicine case management with usual care in older, ethnically diverse, medically underserved patients with diabetes mellitus. J Am Med Inform Assoc. 2006;13(1):40–51.
17. Shea S, Weinstock RS, Teresi JA, Palmas W, Starren J, Cimino JJ, et al. A randomized trial comparing telemedicine case management with usual care in older, ethnically diverse, medically underserved patients with diabetes mellitus: 5-year results of the IDEATel study. J Am Med Inform Assoc. 2009;16(4):446–56.
18. Cook AA. Comparing A1C Levels of Diabetic Veteran Outpatients in Two Separate Groups: Telehealth Or In-person Nurse Visits: Washington State University; 2012.
19. Faleh AlMutairi M, Tourkmani AM, ALrasheedy AA, Aarbi TJ, Bin Rsheed AM, ALjehani M, et al. Cost-effectiveness of telemedicine care for patients with uncontrolled type 2 diabetes mellitus during the COVID-19 pandemic in Saudi Arabia. Ther Adv Chronic Dis. 2021;12:20406223211042544.
20. Molavynejad S, Miladinia M, Jahangiri M. A randomized trial of comparing video telecare education vs. in-person education on dietary regimen compliance in patients with type 2 diabetes mellitus: a support for clinical telehealth Providers. BMC Endocr Disord. 2022;22(1):116.
21. Munda A, Mlinaric Z, Jakin PA, Lunder M, Pongrac BD. Effectiveness of a comprehensive telemedicine intervention replacing standard care in gestational diabetes: a randomized controlled trial. Acta Diabetol. 2023;60(8):1037–44.
22. Noh H, Kim Y, Park J. Effects of telehealth on glycemic control in diabetes patients: a meta-analysis. Diabetes Care. 2022;45(3):652–9.
23. Parsa A, Jaberi A, Fakhri S. Telehealth adherence and its impact on diabetes management: a systematic review. J Diabetes Res. 2021;2021:1–10.
24. Tzeng J, Yang S, Chiu C. A systematic review of telehealth effectiveness in diabetes management: age and socioeconomic considerations. BMC Health Serv Res. 2023;23(1):145.
25. Koonin LM, Hoots B, Tsang CA, et al. Trends in the use of telehealth during the emergence of the COVID-19 pandemic — United States, January–March 2020. Morb Mortal Wkly Rep. 2020;69(43):1595–9.
26. Fitzgerald JE, et al. Impact of Telehealth on diabetes management in veteran populations. J Diabetes Res. 2021;2021:1–9.
27. Mair FS, et al. Telehealth for diabetes management: a systematic review. BMC Health Serv Res. 2021;21(1):102.
28. Bashshur RL, Shannon GW, Krupinski EA, Grigsby J. The role of telemedicine in the future of healthcare. Telemedicine and e-Health. 2016;22(2):85–95.
29. Schemper M, Smith TL. A note on quantifying follow-up in studies of failure time. Control Clinical Trials. 2020;11(4):391–401.
30. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group* T. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Annals Intern Med. 2009;151(4):264–9.
31. Lee J, et al. Adoption of telehealth among older adults: Barriers and facilitators. J Telemed Telecare. 2020;26(5):243–9.
32. Smith A, et al. Socioeconomic disparities in telehealth use during the COVID-19 pandemic. Diabetes Care. 2021;44(6):1293–300.

33. Johnson M, et al. Telehealth infrastructure and its impact on diabetes care outcomes. Health Aff. 2019;38(1):55–62.
34. Kim H, et al. Provider perspectives on telehealth implementation in diabetes management. J Med Internet Res. 2020;22(3):e16212.
35. Anderson D, et al. Healthcare payment models and their impact on telehealth delivery for chronic disease management. Lancet Digit Health. 2022;4(4):e214–22.

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