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Telemedicine Intervention for the Management of Type 2 Diabetes Mellitus: A Systematic Review

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ABSTRACT

Introduction: *The global prevalence of Type 2 Diabetes Mellitus (T2DM) is a significant health concern, with projections indicating a continual rise. In Malaysia, T2DM is the predominant form of diabetes, contributing to a substantial burden on public health. Poor glycaemic control and associated complications further accentuate the challenges in managing T2DM. Effective interventions are crucial, and various strategies, including self-management education, peer support, and lifestyle modifications, have shown promise. Telemedicine, defined by the World Health Organization, has emerged as a transformative paradigm in healthcare, particularly in managing chronic conditions like T2DM. This research aims to conduct a comprehensive systematic review to elucidate the effects and utility of telemedicine interventions in T2DM management. The findings have the potential to inform healthcare policies and practices, guiding future research initiatives and innovations in telemedicine and chronic disease management.*

Methodology: *This systematic review complied with the PRISMA guidelines. A comprehensive literature search was performed in PubMed, Scopus, Cochrane Library, Google Scholar, and through the application of the snowball technique. The retrieved articles were screened independently by two authors according to the eligibility criteria at different stages, including title, abstract, and full text. The potential for bias in the studies included was evaluated separately by two authors using the Joanna Briggs Institute critical appraisal tool. The data from all the articles that were included were extracted using a designated template.*

Results: *The comprehensive review of eight studies consistently showed a low risk of bias, reflected in high positive responses to the JBI tool. Both randomized controlled trials (RCTs) and quasi-experimental studies were meticulously evaluated, highlighting the reliability of research designs.*

Conclusion: *The positive findings suggest that telemedicine has the potential to contribute to enhanced glycaemic control, offering valuable insights for integrating these interventions into routine diabetes care.*

Keywords: *Telemedicine, Telemedicine intervention, Systematic review, Type 2 diabetes mellitus, Glycaemic control, Management of diabetes mellitus.*

INTRODUCTION

Based on the provided references, it is evident that type 2 diabetes mellitus (T2DM) is a significant global health concern. The International Diabetes Federation Diabetes Atlas, 9th edition, estimates the global prevalence of diabetes to be 9.3% in 2019, with projections

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indicating an increase to 10.2% by 2030 and 10.9% by 2045 (Saeedi et al., 2019). Furthermore, it is reported that about 1 in 11 adults worldwide have diabetes, with 90% of them having T2DM (Zheng et al., 2018). T2DM is also associated with an increased risk of various types of cancer, making it a critical risk factor for cancer (Joung et al., 2015). In the context of Malaysia, T2DM is the most common form of diabetes, accounting for more than 90% of all cases of adult-onset diabetes (Saddki et al., 2022). The prevalence of T2DM among Malaysian adults has been increasing, reaching 17.5% of the population over a 10-year period (Lee et al., 2019). Additionally, it is reported that the overall prevalence of diabetes mellitus in adults in Malaysia increased in 2019 (Yap et al., 2022). This increase in prevalence has significant implications for public health in Malaysia, as T2DM is among the most common non-communicable diseases in the country (Awang et al., 2022).

The impact of T2DM goes beyond its prevalence, as it is associated with poor glycaemic control among patients. Studies have shown that a significant proportion of T2DM patients do not meet their glycaemic targets, highlighting the challenges in managing the condition effectively (Lee et al., 2019). Furthermore, T2DM is linked to various complications, including hypoglycaemia episodes, osteoporosis, and sleep quality issues, emphasizing the multifaceted nature of its impact on patients' health (Aftina et al., 2021). These findings underscore the escalating burden of T2DM globally. Effective interventions are imperative to address the rising prevalence of T2DM. Studies have shown that diabetes self-management education, peer support (Febriani, 2021), and educational intervention programs (Rusdiana et al., 2020) have the potential to improve glycaemic control and self-efficacy in patients with T2DM. Moreover, lifestyle interventions and adjustments, including dietary modifications, have been demonstrated to play a significant role in preventing the onset of T2DM (Elahi et al., 2018).

Telemedicine, as defined by the World Health Organization (WHO), represents a transformative paradigm in healthcare delivery, particularly when distance proves to be a critical factor. The essence of telemedicine lies in the utilization of information and communication technologies to facilitate the exchange of valid information among healthcare professionals (HCPs) for the purpose of diagnosing, treating, and preventing diseases and injuries. Moreover, telemedicine extends its reach to encompass research, evaluation, and the continual education of healthcare providers, all with a collective aim of advancing the health of individuals and communities.

In recent years, the landscape of healthcare has witnessed a burgeoning reliance on telemedicine, a phenomenon significantly shaping the field of diabetology. The imperative to enhance access to healthcare services for individuals grappling with diabetes, coupled with the pursuit of improved clinical outcomes, has propelled the integration of telemedicine into the management of diabetes. As articulated by Dhediya et al., the synergy between patients and healthcare professionals facilitated by electronic communication holds promises in ameliorating the challenges inherent in the management of Type 2 Diabetes Mellitus (Dhediya et al., 2023).

Type 2 diabetes presents an escalating challenge for healthcare systems globally, demanding innovative approaches to ensure optimal patient care and resource efficiency. Acknowledging the increasing prevalence of this long-term condition, there arises an exigency for novel methodologies. Telemedicine, characterized by its utilization of digital technologies to provide healthcare services remotely, emerges as a compelling solution for navigating the

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intricacies associated with Type 2 Diabetes Mellitus. In light of these considerations, this research endeavours to undertake a comprehensive systematic review of existing literature, aiming to elucidate the effects and utility of telemedicine interventions in the management of Type 2 Diabetes Mellitus. Through a meticulous examination of the available body of knowledge, this systematic review aspires to construct an evidence-based narrative, shedding light on how telemedicine interventions contribute to blood sugar control, patient satisfaction, cost-effectiveness, and the overall enhancement of diabetes care quality. The findings of this review hold the potential to influence healthcare policies and clinical practices, thereby fostering further research initiatives and innovative ideas in the realms of telemedicine and chronic disease management.

MATERIAL AND METHODS

Protocol

The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement provides a guideline for reporting systematic reviews and meta-analyses. It aims to ensure transparency, completeness, and accuracy in reporting the rationale, conduct, and findings of systematic reviews. The PRISMA statement consists of a 27-item checklist, an expanded checklist detailing reporting recommendations for each item, the PRISMA abstract checklist, and revised flow diagrams for original and updated reviews (Page et al., 2021). Therefore, for conducting a systematic review, it is essential to adhere to the PRISMA guidelines to ensure the comprehensive and transparent reporting of the review process and findings. Adhering to these guidelines enhances the quality and reliability of systematic reviews, thereby contributing to evidence-based practice and decision-making in healthcare and other fields.

Eligibility Criteria

This systematic review examined the telemedicine studies with T2DM management and the effect of practicing it on their blood glucose level. To be eligible for inclusion criteria in this review, those involved were required to be between 18 and 70 years old and diagnosed with type 2 diabetes mellitus (T2DM). The majority of guidelines adhere to the conventional diagnostic criteria put forth by the International Diabetes Federation (IDF) and the World Health Organization (WHO). Presently, the World Health Organization (WHO) and the International Diabetes Federation (IDF) advocate for the utilization of a 75-gram oral glucose tolerance test (OGTT) that includes the assessment of both fasting and two-hour plasma glucose levels in order to identify impaired glucose tolerance (IGT) and impaired fasting glucose (IFG). Nevertheless, there is a growing body of evidence supporting the utilization of the one-hour 75-gram oral glucose tolerance test (OGTT), which has the potential to be a more effective method for detecting intermediate hyperglycaemia. In the case of type 2 diabetes, if symptoms such as polyuria, polydipsia and unexplained weight loss are present, the diagnosis can be determined by a random venous plasma glucose concentration of 11.1 mmol/l or higher. In the absence of symptoms, the diagnosis can be made based on a fasting plasma glucose concentration of 7.0 mmol/l or higher (whole blood $\geq$ 6.1 mmol/l or HbA1c $\geq$ 6.5%). When abnormal values are found in individuals without symptoms, it is advised to conduct repeat testing, preferably using the same test, as soon as possible on a different day to verify the diagnosis (Magliano et al., 2021). The study design was not restricted solely to randomized controlled trials (RCTs), but also encompassed other study designs such as quasi-experimental studies, which were included in the review. Only studies published in English and conducted between 2013 and 2023 were considered for data extraction. This review

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specifically excluded studies that involved participants diagnosed with type 1 diabetes mellitus (T1DM) and gestational diabetes mellitus (GDM). Additional criteria for exclusion encompass studies involving animals or non-human subjects, as well as study protocols and review articles.

Search Strategy

A systematic search was conducted across four databases, namely SCOPUS, Cochrane Library, PubMed, and Google Scholar, to identify relevant studies or articles. The search strategy involved utilizing both domain and sub-domain terms, which were combined using Boolean operators "OR" and "AND". Keywords within the same domain were linked using the Boolean operator "OR" while the operator "AND" was used to connect keywords between different domains.

In addition, the snowball technique, a method for identifying articles through the reference lists of retrieved articles from databases, was employed to broaden the number of articles available for selection. The outcomes of the search approach were subsequently incorporated, stored, and organized in Mendeley, encompassing the elimination of any duplicate entries. Microsoft Excel was utilized to facilitate and record the process of study selection and data extraction. The keywords and its synonyms are summarized in Table 1.

Table 1: The keywords used in search of articles from databases.

Domain	Subdomain
Type 2 diabetes mellitus	“Diabetes mellitus type 2” OR “Type 2 diabetes mellitus” OR “T2DM” OR “Hyperglycaemia” OR “Glucose intolerance” OR “High blood sugar” OR “Insulin resistance”
Telemedicine	“Telemedicine” OR “Telemedicine intervention” OR “Telehealth” OR “Tele pharmacy”
Management of T2DM	“Management of T2DM” OR “Control of T2DM” OR “HbA1C control”

Study Selection

Two authors independently reviewed the studies based on specified criteria for acceptance during the stages of title, abstract, and full-text study selection. All the authors involved in the screening process had full access to all the details of the studies and were not kept in ignorance about any information. Two independent authors conducted a separate evaluation of study titles and abstracts until they reached a point of agreement. The two authors engaged in a discussion to address any disagreements. If they were unable to reach an agreement, the discrepancies were then brought to the attention of the third author. In this process, the criteria were refined as needed. Studies that met the specified criteria were obtained for a comprehensive evaluation of the complete text.

The full-text screening process involved independent double screening by the two authors. This study only included full-text records that were selected for inclusion by both authors. If the authors failed to reach an agreement, the disagreements were then discussed with the third author. When necessary, the third authors were contacted to obtain additional information or clarification to determine if the study met the eligibility criteria. The main rationale for the exclusion of articles was thoroughly documented at every stage of the study selection process. The study selection was performed utilizing Microsoft Excel. A definitive

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compilation of articles was compiled and saved in Mendeley and Microsoft Excel for the purpose of extracting data.

Data Collection and Extraction

The author evaluated the studies that fulfilled the criteria and extracted the relevant data. The extracted data included information such as authors, publication year, study region, study design, total number of participants enrolled, study intervention, intervention duration, and the primary and secondary outcome findings or results.

The data from each research study were entered into a table in Microsoft Excel to simplify the analysis of the included studies. The numerical data were extracted and displayed as the mean ± standard deviation, or mean (SEM), accompanied by p-values. Statistical significance was established when the $P<0.05$.

Risk of Bias in Individual Studies

Two authors independently evaluated the risk of bias for all the studies included by assessing their methodological quality using the critical appraisal checklists from the Joanna Briggs Institute (JBI) (Barker et al., 2023). A score of '1' was assigned if the studies met the specified criteria of the checklist, and '0' if they did not. Subsequently, the cumulative score was computed and subsequently transformed into a percentage.

Research findings with a percentage below 50% were categorized as having a significant risk of bias. Findings with a percentage between 50% and 69% were considered to have a moderate risk of bias, while those with a percentage of 70% or higher were classified as having a high risk of bias (Franco et al., 2020). Any conflicts will be resolved through dialogue between the two authors and subsequently with the third author if consensus is not reached between the two authors. The risk of bias for each type of included studies was subsequently represented as traffic-light plots using the Risk-of-bias VISualization (robvis) tool (McGuinness & Higgins, 2021).

RESULTS

Study Selection

During the search process, a comprehensive number of studies were identified in four databases, namely PubMed, Scopus, Cochrane Library, and Google Scholar. Three studies were identified using the snowball technique, which involved examining the references in the related articles. PubMed documented a total of 196 studies, while Scopus documented 83 studies. Cochrane documented 7 studies, and Google Scholar documented 8 studies. We excluded 78 studies from the total search results due to duplication in the databases utilized. A total of 216 studies were screened by reviewing the title and abstract. A total of 160 studies were excluded from the analysis due to the following reasons: 14 were review articles, 3 were study protocols, 9 had the wrong study population, and 134 were unrelated to the research topic.

After evaluating the title and abstract, 33 studies remained, and a full-text screening was conducted. During the full-text screening, we excluded 17 studies that were not available in full text and 9 studies that did not include all diabetic patients as participants. We identified a total of 16 studies using the snowball technique. However, we were unable to access the full text of 8 of these studies, resulting in a final count of 8 studies. Subsequently, we eliminated an additional 7 articles due to the presence of duplicate findings as well as incorrect

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intervention. After completing the process of selecting studies, we determined that 8 studies met the criteria to be included in this systematic review.

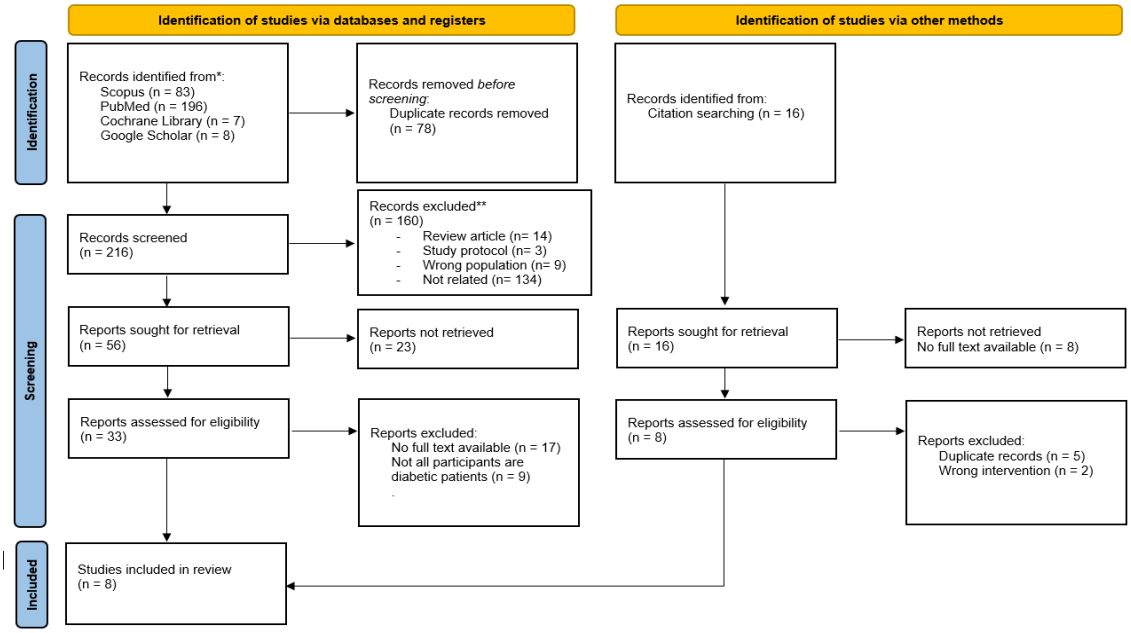

Figure 1: Flowchart of study selection process

Study Characteristics

The studies incorporated in this analysis span a timeframe from 2013 to 2023, reflecting contemporary research on the subject. The comprehensive review encompasses a diverse array of study designs, with seven Randomized Controlled Trials (RCTs) and one quasi-experimental study, ensuring a robust exploration of the topic. Geographically, the studies present a global perspective, with research conducted in China (3 studies), the United States of America (1 study), Canada (1 study), Turkey (1 study), Germany (1 study), and Indonesia (1 study). This breadth of international representation enhances the generalizability and applicability of the findings across various cultural and healthcare contexts.

Various telemedicine modalities were employed across the eight studies, showcasing a diverse range of technological interventions for diabetes management. These included smartphone applications such as "BlueStar," "WeChat," and "Teman Diabetes," each offering distinct features for patient engagement. Additionally, glucometers equipped with data transmission capabilities allowed for seamless integration with mHealth telemedicine systems, enabling real-time monitoring.

The utilization of text messages (SMS) and regular phone calls served as effective communication channels to provide ongoing support and guidance. Some interventions incorporated connected Blood Glucose Meters (BGM), ensuring continuous data submission and personalized tele-coaching based on individual needs. Furthermore, innovative approaches like the Multimodal Telemedical Lifestyle Intervention Program (TeLIPro) demonstrated a holistic strategy for diabetes care, incorporating videoconferencing via internet-enabled tablets and 3-way calling, enhancing accessibility and engagement in remote healthcare delivery.

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Table 2: Summary of the Main Characteristics of the included Studies

Author (Year)	Study Design	Country	Total Participants	Type of Telemedicine/ Intervention used	Study Duration
(Agarwal et al., 2019)	Multicenter Pragmatic Randomized Controlled Trial	Canada	223 T2DM patients	Smartphone application "BlueStar"	6 months
(Sun et al., 2019)	Randomized Controlled Trial	China	91 T2DM patients	Glucometers capable of data transmission and received advice pertaining to medication, diet, and exercise via the mHealth telemedicine system.	7 months
(Sayin Kasar et al., 2022)	Randomized Controlled Trial	Turkey	80 T2DM patients	A text message (SMS) was sent to each patient once a week, and a phone call was made every two weeks.	9 months
(Han et al., 2023)	Randomized Controlled Trial	China	418 T2DM patients	A connected (Blood Glucose Meter) BGM with real-time data submission as well as individual needs-based tele-coaching	6 months
(Kempf et al., 2023)	Randomized Controlled Trial	Germany	1163 T2DM patients	Multimodal Telemedical Lifestyle Intervention Program (TeLIPro)	3 years
(Gerber et al., 2023)	Randomized Controlled Trial	USA	221 T2DM patients	Videoconference via an internet-enabled computer tablet and 3-way calling (audio or video)	2 years
(Feng et al., 2023)	Randomized Controlled Trial	China	228 T2DM patients	Smartphone application "WeChat"	1 year
(Hasanah et al., 2021)	Quasi-experimental	Indonesia	92 T2DM patients	Smartphone application "Teman Diabetes"	5 months

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Risk of Bias Within Study

In the comprehensive review of the eight included studies, a consistent and favourable pattern emerged, indicating a low risk of bias across all investigations. This was reflected in the high percentage of positive responses to the questions posed by the Joanna Briggs Institute (JBI) tool, affirming the robust methodological quality of the studies. The meticulous evaluation using the JBI tool, encompassing randomized controlled trials (RCTs) and quasi-experimental studies, showcased the reliability and rigor of the research designs employed. The uniform demonstration of low bias risk underscores the credibility and internal validity of the findings, reinforcing the overall strength of the evidence synthesized in this review.

In the realm of randomized controlled trials (RCTs) included in this review, a consistent trend emerged, revealing a high risk of bias specifically in domains four, five, and six of the assessment tools. This indicates that participants, those administering treatment, and outcome assessors were not blinded to the treatment assignments. Domain four, pertaining to the blinding of participants, exhibited a high risk of bias across all RCTs, suggesting a lack of concealment of treatment information from those directly involved in the trials. Similarly, domain five, focusing on the blinding of treatment providers, indicated a prevalent high risk of bias as the individuals delivering the interventions were not kept unaware of the assigned treatments. Moreover, domain six, addressing the blinding of outcome assessors, displayed a consistent high risk of bias, implying that those evaluating the study outcomes were not blinded to the treatment allocations. Additionally, in one specific RCT study by Agarwal et al. (2019), domain three, which assesses the similarity of treatment groups at baseline, revealed a high risk of bias, indicating dissimilarities in the baseline characteristics of the treatment groups. These findings collectively suggest potential limitations in the blinding procedures and baseline comparability across the reviewed RCTs.

In contrast to the randomized controlled trials (RCTs) where specific biases were identified, the quasi-experimental study included in this review demonstrated an overall low risk of bias. This suggests that the design and implementation of the quasi-experimental study were methodologically robust and that potential sources of bias were effectively mitigated. The low risk of bias indicates that the study successfully addressed key methodological considerations, such as participant selection, confounding variables, and data collection procedures. The assessment of bias within studies is presented in Figure 2a and Figure 2b.

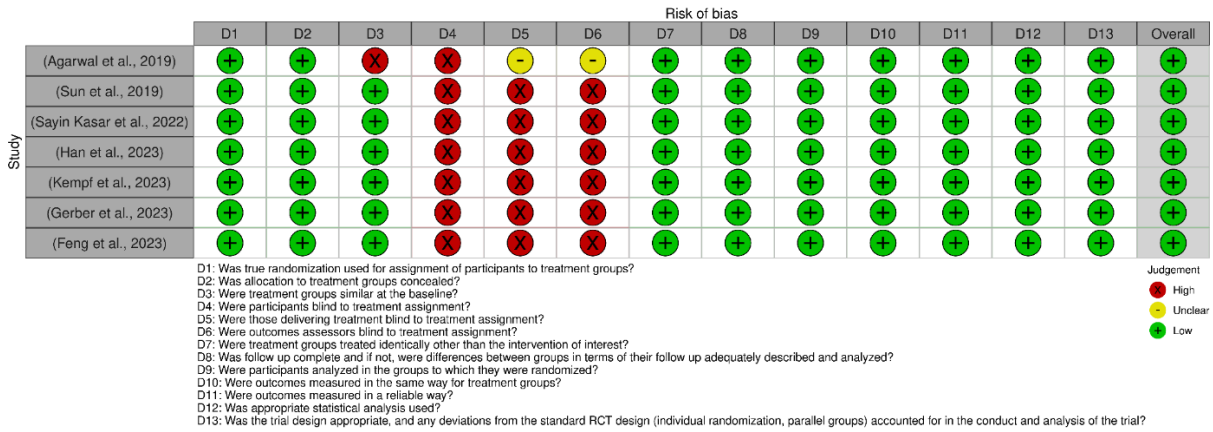

Figure 2a: Risk of bias for RCT studies.

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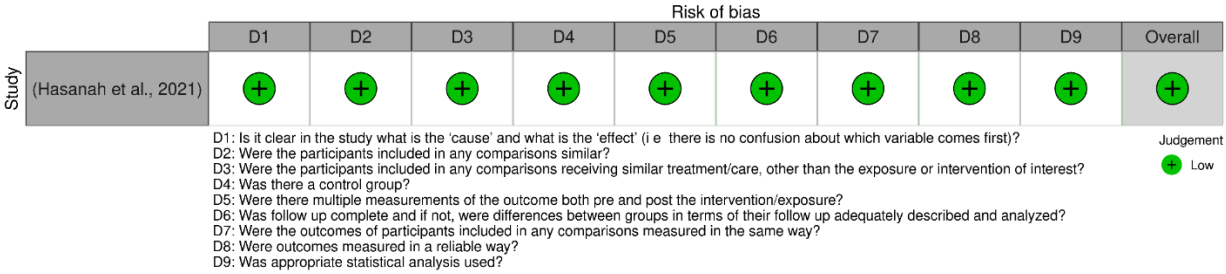

Figure 2b: Risk of bias for quasi-experimental studies.

Individual Outcomes of the Studies

The examination of telemedicine interventions across the eight studies revealed varied impacts on the primary targeted outcome, HbA1c levels. Agarwal et al. (2019) did not identify significant changes in HbA1c levels at the 3-month mark, emphasizing the nuanced nature of intervention effects. Conversely, Sun et al. (2019) reported a noteworthy and statistically significant reduction in HbA1c levels at 6 months within the intervention group compared to both baseline and the control group. This positive outcome suggests the potential efficacy of telemedicine in achieving glycaemic control. Similarly, Sayin Kasar et al. (2022) documented a statistically significant decrease in HbA1c values in the intervention group, reinforcing the potential impact of telemedical interventions on glycaemic outcomes.

Han et al. (2023) contributed to the narrative by revealing lower unadjusted mean HbA1c values at 6 months for the intervention group in comparison to the control group. This finding, coupled with a notable difference in the percentage of readings in range (RIR) within the intervention group, underscores the potential of telemedicine in fostering favourable glycaemic outcomes. Kempf et al. (2023) further supported these trends, demonstrating a treatment superiority in HbA1c reduction for the TeLIPro group, reaffirming the positive impact of tailored telemedical interventions on glycaemic control.

Gerber et al. (2023) presented a compelling longitudinal perspective, illustrating a significant improvement in HbA1c over the initial 12 months in the intervention group compared to the waiting list control group. Notably, the intervention group maintained its benefit even as the control group received the same intervention in the subsequent 12 months. Feng et al. (2023) and Hasanah et al. (2021) added to this collective narrative by reporting significant reductions in HbA1c levels for the intervention groups, reinforcing the potential for telemedicine to positively influence glycaemic control.

In summation, most of the studies consistently demonstrated a positive impact on HbA1c levels, substantiating the potential effectiveness of telemedicine interventions in fostering improved glycaemic control among individuals with diabetes. These findings collectively contribute to the growing body of evidence supporting the utility of telemedicine as a valuable tool in diabetes management. The targeted primary outcomes of the eligible studies included are described in detail in Table 3.

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Table 3: Targeted Primary Outcomes of the included Studies

Author (Year)	Targeted Primary Outcome
(Agarwal et al., 2019)	**HbA1c:** The results of an analysis of covariance controlling for baseline HbA1c levels did not show evidence of intervention impact on HbA1c levels at 3 months (mean difference [ITG−WLC] −0.42, 95% CI −1.05 to 0.21; P= 0.19).
(Sun et al., 2019)	**HbA1c:** At 6 months, the HbA1c level in the intervention group was significantly lower than that at baseline (6.84% [SD 0.765%] vs 7.84% [SD 0.73%] (P<.001) and that in the control group at 6 months (6.84% [SD 0.765%] vs 7.22% [SD 0.87%] (P=0.02).
(Sayin Kasar et al., 2022)	**HbA1c:** There was a statistically significant difference between pre- and post- test HbA1c values in the intervention group (F: 13.589; p < 0.001). The effect size for this significant difference was calculated as 0.185 eta square.
(Han et al., 2023)	**HbA1c:** At 6 months, the unadjusted mean HbA1c values were 7.38% for the intervention group and 7.98% for the control group (P < 0.001). A comparison of the percentage of readings in-range (RIR) in 2 weeks showing significant difference within the intervention group and between the two groups (P < 0.05).
(Kempf et al., 2023)	**HbA1c:** A treatment superiority was observed for the TeLIPro group with an ETD in HbA1c reduction of −0.3% [−0.5; −0.2] (p < 0.01) during the 6 months of highly intensive coaching and −0.4% [−0.5; −0.2] (p < 0.001) after 12 months of intervention.
(Gerber et al., 2023)	**HbA1c:** Over the initial 12 months, HbA1c improved by a mean of−0.79 percentage points in the intervention group compared with −0.24 percentage points in the waiting list control group (treatment effect, −0.62; 95% CI, −1.04 to −0.19; P = 0.005). Over the subsequent 12 months, a significant change in HbA1c was observed in the waiting list control group after they received the same intervention (mean change, −0.57 percentage points; P = 0.002), while the intervention group-maintained benefit (mean change, 0.17 percentage points; P = 0.35).
(Feng et al., 2023)	**HbA1c:** In the intervention group, HbA1c level (P<.001) and for the control group, HbA1c level (P= 0.22)
(Hasanah et al., 2021)	**HbA1c:** After 3 months, the mean HbA1c reduction was greater in the intervention group by -0.7 ± 0.9% (P<0.001) than in the control group by -0.1 ± 1.1% (P=0.17).

DISCUSSIONS

In this study, we explored the impact of telemedicine interventions on glycaemic control, focusing on the primary outcome of HbA1c levels across a diverse range of studies conducted between 2013 and 2023. The findings revealed varying degrees of success in leveraging telemedicine to improve HbA1c levels among individuals with type 2 diabetes. Notably, our results contribute to the growing body of literature addressing the role of telemedicine in diabetes management. As we delve into the discussion of our findings, we will contextualize our results within the broader landscape of existing research, highlight the clinical relevance of observed changes in HbA1c levels, and explore potential implications for the integration of telemedicine into routine clinical practice. The key findings of our study underscore the

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potential of telemedicine interventions to positively impact glycaemic control, as indicated by reductions in HbA1c levels. Across the diverse studies included in our review, significant improvements were observed in HbA1c levels for individuals with type 2 diabetes participating in telemedicine programs. Notably, these interventions demonstrated effectiveness across various geographical locations and study designs. While certain studies reported immediate reductions, others showcased sustained benefits over extended periods. The collective findings affirm the promising role of telemedicine in enhancing glycaemic outcomes and offer valuable insights for the integration of these interventions into diabetes care.

Based on the relevant references, it is evident that telemedicine interventions have a significant impact on HbA1c levels in patients with type 2 diabetes mellitus. A study by assessed the impact of virtual clinics on glycaemic control among high-risk patients with type 2 diabetes mellitus, highlighting the potential of telemedicine in improving glycaemic control in this population (M Tourkmani et al., 2023). Moreover, evaluated the effectiveness of telemedicine as an intervention for patients with diabetes mellitus, considering blood glucose levels as the primary outcome, indicating the positive impact of telemedicine on glycaemic control in patients with diabetes mellitus, including those with type 2 diabetes (Kusuma et al., 2022). Additionally, conducted a randomized trial comparing telemedicine with standard care in type 2 diabetes mellitus, further supporting the positive impact of telemedicine on glycaemic control in this patient population (Rasmussen et al., 2016). These studies collectively demonstrate the effectiveness of telemedicine interventions in improving HbA1c levels in patients with type 2 diabetes mellitus, highlighting the potential of telemedicine as an important tool for managing glycaemic control in this patient population.

The study conducted by Agarwal et al. (2019) investigated the impact of a telemedicine intervention on HbA1c levels at the 3-month mark. Utilizing an analysis of covariance controlling for baseline HbA1c levels, the study did not find significant evidence of intervention impact, as indicated by a mean difference of -0.42 (95% CI -1.05 to 0.21; $P = 0.19$). These results suggest that, within the short duration of the study, the telemedicine intervention did not yield immediate improvements in glycaemic control. In contrast, Sun et al. (2019) explored the longer-term effects of a telemedicine intervention, specifically at the 6-month mark. The HbA1c levels in the intervention group were notably lower than baseline (6.84% [SD 0.765%] vs. 7.84% [SD 0.73%]; $P < 0.001$) and significantly lower than the control group at 6 months (6.84% [SD 0.765%] vs. 7.22% [SD 0.87%]; $P = 0.02$). These findings suggest that the telemedicine intervention, over a more extended period, had a positive and statistically significant impact on reducing HbA1c levels compared to both baseline and a control group.

Sayin Kasar et al. (2022) assessed the intervention's impact by examining pre- and post-test HbA1c values. The study reported a statistically significant difference within the intervention group ($F: 13.589$; $p < 0.001$), with a calculated effect size of 0.185 eta square. This indicates a measurable impact on glycaemic outcomes, emphasizing the intervention's effectiveness in influencing HbA1c levels. Han et al. (2023) investigated the unadjusted mean HbA1c values at 6 months, revealing a significant difference between the intervention group (7.38%) and the control group (7.98%) ($P < 0.001$). Additionally, the study explored the percentage of readings in-range (RIR) in 2 weeks, showing a significant difference within the intervention group and between the two groups ($P < 0.05$). These results suggest both immediate and sustained benefits in glycaemic control attributable to the telemedicine intervention.

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Kempf et al. (2023) demonstrated treatment superiority for the TeLIPro group, with reductions in HbA1c levels during the 6 months of highly intensive coaching and even after 12 months of intervention. The estimated treatment differences (ETD) were -0.3% ($p < 0.01$) and -0.4% ($p < 0.001$), respectively. These findings underscore the effectiveness of the TeLIPro intervention in achieving and maintaining improvements in glycaemic control. In the study by Gerber et al. (2023), HbA1c improvements were observed over the initial 12 months in the intervention group compared to the waiting list control group (mean change -0.79 percentage points vs. -0.24 percentage points; treatment effect -0.62; $P = 0.005$). Interestingly, the waiting list control group also showed a significant change in HbA1c after receiving the same intervention during the subsequent 12 months (mean change -0.57 percentage points; $P = 0.002$), while the intervention group maintained a benefit (mean change 0.17 percentage points; $P = 0.35$). These findings suggest sustained benefits in glycaemic control, even after the intervention was implemented in the control group. Feng et al. (2023) reported a significant reduction in HbA1c levels in the intervention group ($P < 0.001$). In contrast, the control group did not show a statistically significant change ($P = 0.22$). These results imply that the telemedicine intervention positively influenced glycaemic outcomes, with a notable impact on reducing HbA1c levels.

Finally, Hasanah et al. (2021) assessed the mean HbA1c reduction after 3 months, revealing a greater reduction in the intervention group ($-0.7 \pm 0.9\%$; $P < 0.001$) compared to the control group ($-0.1 \pm 1.1\%$; $P = 0.17$). These findings suggest that the telemedicine intervention had a significant short-term impact on improving glycaemic control.

In summary, the diverse range of findings from these studies collectively highlights the varying impacts of telemedicine interventions on HbA1c levels, emphasizing the importance of considering intervention specifics, study durations, and participant characteristics when interpreting the overall effectiveness in improving glycaemic control.

CONCLUSION

In conclusion, the comprehensive analysis of multiple studies investigating the impact of telemedicine interventions on HbA1c levels in individuals with type 2 diabetes reveals a nuanced picture. While some studies did not demonstrate immediate effects on glycaemic control within short durations, others showcased significant and sustained improvements, particularly over longer intervention periods. The heterogeneity in study outcomes underscores the importance of considering intervention specifics, including duration, components, and patient populations. The positive findings suggest that telemedicine has the potential to contribute to enhanced glycaemic control, offering valuable insights for integrating these interventions into routine diabetes care. However, further research is warranted to elucidate optimal intervention characteristics and long-term effectiveness in diverse populations. These findings contribute to the evolving landscape of telemedicine in diabetes management, emphasizing the need for tailored approaches to maximize its impact on glycaemic outcomes.

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CONFLICT OF INTEREST

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