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The Effectiveness of Telehealth In The Improving Glycaemic Control Among Patients With Type Two Diabetes Mellitus During The Era Of The Covid-19 Pandemic

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Abstract

Background: During the COVID-19 pandemic, it is challenging for diabetic patients to personally visit their physicians. These challenges have encouraged the use of telehealth to communicate to their physicians. Studies have shown that there is an emerging interest in using telehealth for diabetic patients during pandemics. However, the findings from the published articles are not reviewed systematically. Therefore, a systematic review was undertaken to evaluate the effectiveness of telehealth in improving glycaemic control among patients with type two diabetes mellitus during the era of the COVID-19 pandemic.

Methods: An electronic systematic literature search was carried out using PubMed and CINAHL. All the studies focusing the impact of telemedicine or telehealth, conducted on people diagnosed with type 2 diabetes mellitus, and carried out during COVID-19 pandemic. The primary outcome was a change in glycaemic control assessed by HbA1c levels. Whereas the primary exposure or intervention was telehealth or telemedicine use during the COVID-19 pandemic.

Results: Nine articles were incorporated into the review. The findings of the studies showed that seven out of nine studies have found that the HbA1c values improved significantly during the ≥ 6 months study period with $p < 0.001$. While two studies did not find any statistically significant results ($p > 0.05$) with no change in HbA1c values or glycaemic value in patients who use or not telemedicine facilities. The findings revealed that different telemedicine models such as remote consultations with physicians, video conferences, integrated virtual clinics, and phone calls with text messages were effective in improving glycaemic control as measured by the change in HbA1c levels.

Conclusion: Telemedicine or telehealth consultation is a feasible and effective source for attaining adequate glycaemic control during the COVID-19 pandemic. This allows for a remote and flexible approach to managing hyperglycaemia in diabetic patients, promote self-management in patients, thereby preventing them from the development of diabetic related complication.

Keywords: Telemedicine, hyperglycaemia, Diabetes Mellitus, COVID-19, Systematic review

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1. Introduction

Type 2 Diabetes Mellitus (T2DM) is a growing concern globally in the health system and studies have shown that the aetiology of T2DM is multifactorial and is mainly caused by the complex interactions between genetic, social, behavioural, and environmental factors [1]. Uncontrolled T2DM contributes to lethal complications such as renal failure, visual impairments, cardiovascular diseases, and sometimes lower limb amputation[2]. These complications can be prevented with adequate self-management and appropriate control of blood glucose levels[3]. Self-management includes compliance with prescribed medicines, lifestyle changes such as daily physical activity, better weight control to avoid obesity, and self-monitoring of blood glucose levels[4]. Such self-management, mainly adequate glycaemic control requires formal education or training for diabetic patients[4]. However, such training or education can be done either in-person or remotely using technology such as telehealth interventions[5].

Telemedicine is defined as a medical and health care offered remotely using audio-visual technology [6]. The need for telehealth interventions is even higher during the COVID-19 pandemic, where it may be difficult for diabetic patients to visit health care professionals in person[7]. During the COVID-19 pandemic, there was a shift in the provision of care due to lockdowns and fear of spreading the infection[8]. As a result, there has been a need to find ways and strategies to deliver uninterrupted care to patients anywhere that is cost-effective[9]. Studies have also shown that during the pandemic there is limited physical activity, people took irregular diet, and inadequate self-management caused blood glucose management more difficult. At the peak time during the COVID-19 pandemic, non-emergency or outpatient face-to-face medical treatment could no longer offer in most of the hospitals and clinics to the people with T2DM [9].

While the scientific community is encouraged to use telehealth for diabetic patients, the impact of telehealth on the self-management of T2DM remains controversial[10, 11]. On the one hand, the evidence suggests a beneficial effect of telehealth in the self-management of T2DM. Whereas on the other hand, studies also show no significant beneficial effect of telehealth in improving the outcomes among diabetic patients. Further, there have been studies reported from different countries assessing the effectiveness of telemedicine on glycaemic control. However, these studies are not synthesized and summarized collectively in a form of review, mainly during the era of COVID-19. Hence, there was a need to review studies assessing the impact of telehealth on self-management of diabetes, mainly during COVID-19. If telemedicine is proven useful, the intervention could be commonly disseminated to medical practice and might help to reduce the burden of diabetes and associated complications, mainly during the pandemic.

Furthermore, the findings of this systematic review gave evidence to endocrinologists,

diabetologists, nutritionists, physicians, and policymakers to broadly understand the role of telemedicine in the management of T2DM and help them to make inferences about evidence and set recommendations to address the high burden of T2DM. In line with the above statements, this study aimed to conduct a systematic review of the studies assessing the effectiveness of telehealth in improving glycaemic control among patients with T2DM during the era of the COVID-19 pandemic.

2. Subjects and Methods

This systematic review focused on assessing the evidence on the effect of telemedicine on improving glycaemic control among patients with T2DM. This systematic review was carried out according to an updated Preferred Reporting Items for Systematic Reviews and Meta-Analyses- PRISMA guidelines (19).

2.1 Eligibility Criteria

The review was undertaken to systematically synthesize the evidence from published research studies conducted during the era of the COVID-19 pandemic. Inclusion criteria of the studies consist of; if a research article on assessed the effectiveness of telemedicine in improving glycaemic control among T2DM patients, published in the English language in a peer-reviewed journal and specifically conducted during the era of COVID-19.

Using the PICO framework[12], the eligibility criteria were grouped into four categories including population, intervention, comparison, and outcome[12]. The population for the current review was people diagnosed with T2DM. The exposure or intervention for this review was use of telemedicine during COVID-19 period. A telemedicine, which was defined as any form of consultation that requires a computer technology or virtual or remote connection with a health care professional such as via mobile phones, zoom or WhatsApp, or any other digital medium that did not require an in-person meeting with physicians or doctors. The primary outcome was the improvement in blood glucose levels or change in glycaemic control assessed by HbA1c levels. However, few secondary outcomes such as body mass index (BMI), blood glucose, blood pressure, lipid profile, time in range (TIR), total cholesterol, triglycerides, high density lipoprotein, and incidence of hypoglycaemia were also measured. Lastly, the comparison or control group was either no intervention at all or any in-person visits or traditional ways to visit a doctor or health care professional during COVID-19 pandemic for T2DM consultations.

2.2 Information sources and search strategy

An electronic systematic literature search was performed according to the eligibility criteria discussed above, using two large electronic databases PubMed and CINAHL. These databases were explored using a detailed search strategy including search terms or combinations as shown in table 1.

Likewise, reference lists of the selected articles were also searched within these databases to identify other relevant articles and to exclude the chances of missing articles.

The research articles were searched using a combination of search terms set out for the defined research question. Four major concepts were defined including Telehealth, Diabetes, glycaemic control, and COVID-19. In addition, their synonyms such as Telemedicine, Diabetes Mellitus, Type 2 Diabetes Mellitus, and T2DM were used as well. Moreover, a combination (AND, OR) germane was used to combine the major concepts of the research question. Additionally, truncation (*) mark and indexed keywords in the Medical Subject Headings (MeSH) were also used for the identification of other relevant research studies with the similar root word and to ensure uniform search terms, respectively. For example, a combination of (Telehealth OR Telemedicine*) AND (Diabetes OR "Diabetes Mellitus" OR "Type 2 Diabetes Mellitus" OR DM) AND ("Self-management" OR management) AND (COVID-19 OR Pandemic*) were used to search the relevant articles in each database (table 1).

Table (1) Search strategy using MeSH term

Date December 2019 up to April 2022
#1 MeSH Term: [type 2 diabetes] explode in titles/abstracts
#2 MeSH Term: [T2DM] explode in titles/abstracts
#3 MeSH Term: [telemedicine] explode in titles/abstracts
#4 MeSH Term: [telehealth] explode in titles/abstracts
#5 MeSH Term: [COVID-19] explode in titles/abstracts
#1 OR #2 AND #3 OR #4 AND #5

2.3 Study selection

A citation management system (Endnote software) was used to manage records exported from all the electronic databases. After making groups in the Endnote software by the name of the database (PubMed or CINAHL), the duplicates were removed from the endnote file from both databases. This was followed by screening the unique studies obtained from both databases. All the studies were first screened based on study titles in the Endnote. The selected studies were then assessed by their abstracts. In the last the full-text studies were shortlisted, retrieved and screened according to the inclusion criteria. The detail process of search strategy and study selection was reported in the following PRISMA flow (figure 1).

2.4 Data collection process

A customized data extraction sheet was filed for the eligible studies with the full-text articles. The parameters involved in the data extraction form consists of the author's name and reference, publication year, country of study, study type, study population, sample size, study design, diagnosis of the study participants, the age distribution of the study participants, gender of the study participants, type of intervention given, type of outcomes assessed in the study, key findings, the conclusion of authors, and

study limitations.

2.5 Quality assessment of included studies

The Newcastle–Ottawa Scales (NOS) were applied for quality assessment of each retrieved full-text article [13]. The NOS for observational studies have three main domains: selection, comparability, and outcome ascertainment [13]. The maximum score each eligible study can achieved is ten, which represent the quality of that study. Based on the scoring a good study scored between 7-10 points, satisfactory studies scored between 5-6 points, while unsatisfactory studies had scores between 0-4 points.

2.6 Synthesis of included studies

The findings of the review were synthesised narratively. At first, a descriptive analysis of all the final retrieved articles were performed and their main characteristics such as title of the article, author, year of publication, country, objective/aim of the study, sample size, study design, key findings, and conclusion of authors were also recorded. Each included study was read and reviewed multiple times to extract data. The retrieve relevant information based on the above-mentioned parameters were than tabulated. This was followed by grouping the key findings into three different themes.

3. Results

A total of 199 records were identified in two databases (PubMed and CINAHL). After removing 18 duplicates, the remaining 181 unique studies were left whose titles and abstracts were screened. During this process of reviewing abstracts and titles, 35 abstracts and titles were found to be irrelevant and not related to the topic of interest at all. Hence, we had 146 eligible abstracts, of which 125 did not meet the eligibility criteria. Consequently, 21 full texts were thoroughly read and reviewed for eligibility. Following a comprehensive review of the research articles based on the eligibility criteria, nine articles were recruited into the review (Figure 1).

3.1.Study characteristics

Studies were conducted in different countries across the globe, and articles were found both from developed and developing countries. More specifically, we had two studies from the United States (n=2), two from Saudi Arabia (n=2), and one each from Germany, Australia, India, China, and Italy as shown in Table 2. Regarding the year of publication, almost half of the studies (n=4) were recently published in 2022 and 2021, followed by one study being published in 2019. Overall, the sample size of the included studies was ranging from 115 to 57961 individuals diagnosed with T2DM. Regarding the gender distribution of the participants, the findings revealed that both males and females participated in the respective studies (Table 2). Overall, the proportion of males was found to be higher than the proportion of females, and it ranged from 48% to 95%, whereas the proportion of females ranged from 5% to 52%.

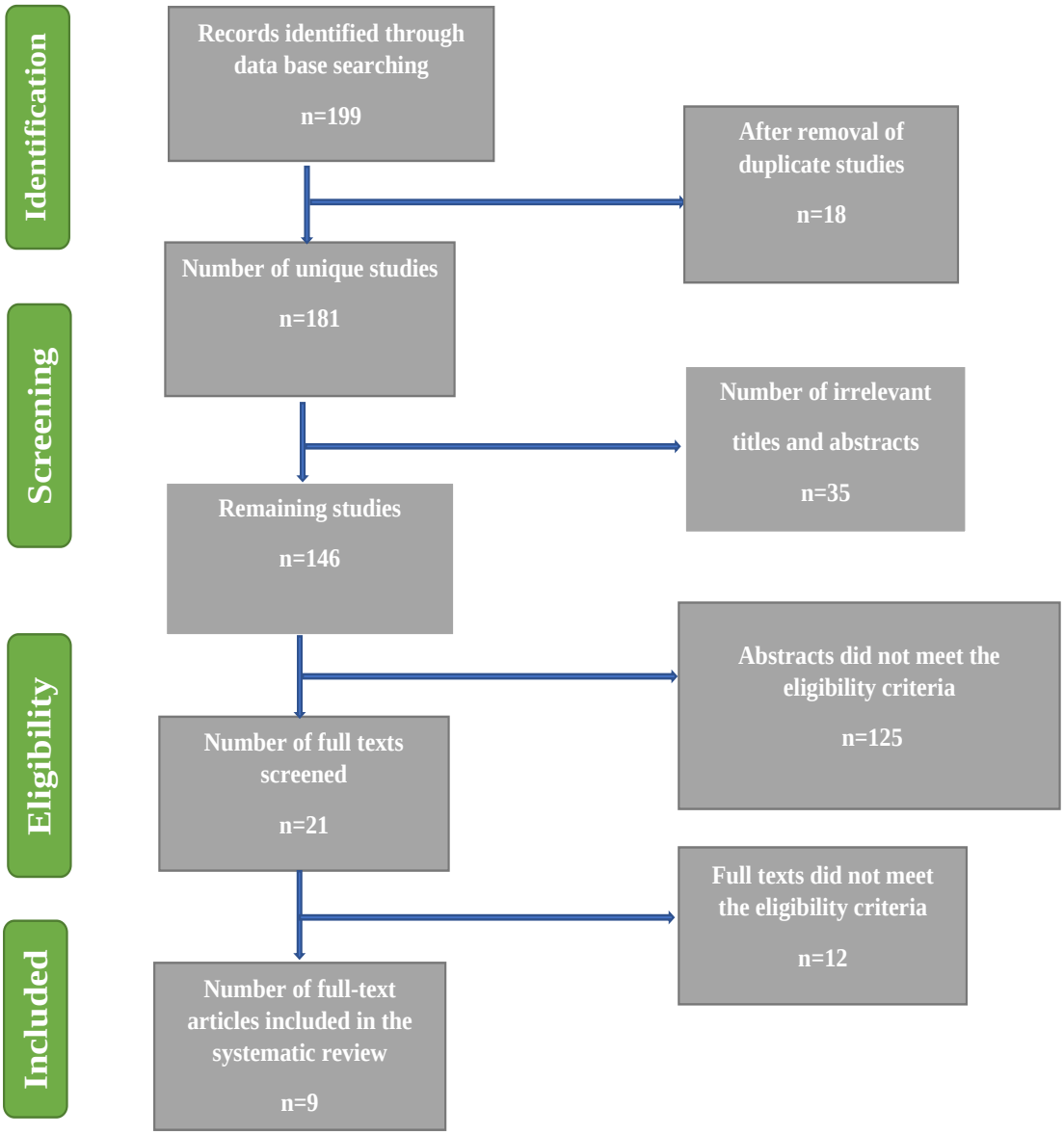

Figure 1: Flow chart summarizing the identification and selection of papers for systematic review

With respect to the type of study, there were mixed study designs. For example, two studies were Randomized Controlled Trials (RCTs), five were retrospective cohort studies, one was a prospective cohort study, and one was mixed-methods implementation study. Almost all studies mentioned their outcome, which was mainly a change in Haemoglobin A1c (HbA1c) (Table 2). Also, it was found that almost all the included studies used validated and reliable methods to measure the outcome of interest.

Table (2) Basic characteristics of the included articles (n=9)

Study Year Country	Intervention/Exposure	Sample size	Study Design	Participants Diagnosis	Mean age (Years)	Gender	Primary outcome
Kobe, BS et al[14] 2022 United States	Advanced Comprehensive Diabetes Care (ACDC):	230	Mixed-methods implementation study	Patients with clinic-refractory, uncontrolled T2DM	58.9 ± 6.8 years	Males: 95% Females: 5%	Haemoglobin A1c (HbA1c)
Mukherjee et al[15] 2022 United States	Telehealth, primarily via telephone	181	Retrospective cohort study	Outpatients with uncontrolled type 2 diabetes mellitus	56.3 ± 11.2 years	Males: 52.3% Females: 47.7%	Haemoglobin A1c (HbA1c)
Scoccimarro et al[16] 2022 Italy	telemedicine, allowing remote physician contact with patients,	269	Retrospective chart review	Outpatients with uncontrolled type 2 diabetes mellitus	68.3 ± 8.4 years	Males:62.3% Females: 36.7%	Difference in HbA1c and body weight
Imai et al[17] 2022 Australia	telehealth consultations: telehealth included phone and videoconference	57961	Retrospective cohort study	Patients with T2DM	65 to 80 years	Males: 54.56% Females: 45.4%	change in HbA1c levels
Dutta et al[18] 2021 India	Video consultation	96	Retrospective cohort study	Patients diagnosed with T2DM and uncontrolled hyperglycaemia	55.4 ± 13.8	Males: 53.7% Females: 46.3%	Haemoglobin A1c (HbA1c)
AlMutairi et al[19] 2021 Saudi Arabia	Telemedicine care model	200	Retrospective chart review	Outpatients with uncontrolled type 2 diabetes mellitus	> 18 years old	Males: 48% Females: 52%	Haemoglobin A1c (HbA1c)
Tourkmani et al[20] 2021 Saudi Arabia	pre-/post telemedicine care intervention	130	A prospective single cohort	Outpatients with uncontrolled type 2 diabetes mellitus	57 ± 12	Not reported	Haemoglobin A1c (HbA1c)
Kang et al[21] 2021 China	mobile phone WeChat app	180	randomized controlled study	Outpatients with uncontrolled type 2 diabetes mellitus	48.24 ± 12.5	Males: 63.3% Females:36.7 %	Serum glucose, Blood pressure, BMI, TIR Hypoglycaemia
Storch et al [22] 2019 Germany	A telemedicine-assisted self-management program	115	Randomized controlled trial	Patients diagnosed with T2DM	58.9 ±6.8	Males: 80% Females: 20%	Haemoglobin A1c (HbA1c)

3.2.Key findings on the role of telemedicine in the management of diabetes mellitus

In general, table 3 summarizes the relevant key findings of the studies, the authors' main conclusion, and the limitations of the eligible studies. The findings of the studies are divided into three main themes such as findings by: 1) type of country (high-income versus low-middle income countries), 2) type of the outcome assessment and impact of telemedicine on primary and secondary outcomes, and 3) type of telehealth or telemedicine that was administered to diabetic patients.

Table (3) The summary of key findings and conclusion from eligible studies (n=9)

Study Year Country	Key findings	Conclusion of authors	Limitations	Q.A score
Kobe, BS et al[14] 2022 United States	Mean baseline HbA1c =9.56% Improved HbA1c= 8.14% at 6 months (− 1.43%, 95% CI: − 1.64, − 1.21; P < 0.001). - At 12 months (− 1.26%, 95% CI: − 1.48, −1.05; P < 0.001) -18 months (− 1.08%, 95% CI − 1.35, − 0.81; P < 0.001).	Even in rural places, comprehensive telehealth interventions can be successfully implemented. ACDC resulted in long-term glycaemic control improvements in a previously resistant population.	Because this is a single-arm study concentrating on a predominantly rural, male, veteran group with clinic-refractory T2D, the results should be viewed with caution. A modest sample size was used.	9
Mukherjee et al[15] 2022 United States	-Median HbA1cs reduced from 10.2% to 9.2% -24.6% achieved a HbA1c less than or equal to 8% (n = 138, p < 0.0001)	The impact of appointment-based interventions on healthcare quality was positive; 83.3 percent were significant (improved treatment), 1.9 percent were very significant (averted serious organ malfunction), and 0.4 percent were highly significant (prevented death).	Because this was not a follow-up research, timing cannot be determined. Sample size is small.	9
Scoccimarro et al[16] 2022 Italy	No difference in HbA1c and body weight between patients with or without appointments during lockdown (HbA1c − 4.4 ± 15.1% and − 2.6 ± 15.8%, p = 0.36, and body weight − 1.2 ± 4.2% and − 0.6 ± 3.4%, p = 0.34, respectively); among those with appointments. -No significant differences were observed in HbA1c and weight between patients who missed their visit, those receiving a traditional visit, or a telehealth visit (p = 0.75)	During the lockdown, most type 2 diabetes patients' HbA1c and body weight did not worsen. Telemedicine may have mitigated the detrimental effects of lockdown, implying that telemedicine may play a role in the future, independent of home confinement.	The estimations' reliability is limited by the tiny sample size. A single university hospital that accepts only the most challenging cases is not indicative of all diabetic patients. No information on telemedicine's actual efficacy. Because of the retrospective character of the study, it was impossible to analyse perceived barriers and acceptability of teleconsultations.	8
Imai et al[17] 2022 Australia	There was no change in 6-monthly HbA1c levels between telemedicine users and patients who exclusively received face-to-face consultations. - Glycaemic control (i.e., 53 mmol/mol) before pandemic, after 6-month testing probability was 52.3 percent (95%CI; 51.5 - 53.2) for those who used telehealth consultations - 53.1 percent (95 percent CI; 51.9 - 54.3) for those who did not.	T2DM patients made extensive use of telehealth GP visits. Diabetes monitoring care delivered via telehealth could be as beneficial as face-to-face consultations.	Other crucial diabetic care information, such as electronic prescribing and specialist consultations, is unavailable.	8
Dutta et al[18] 2021 India	The video consultation group achieved glycaemic control quicker as compared to patients during in-person clinic visits (p = 0.018).	Telemedicine is a successful means of consultation for achieving glycaemic control during the COVID-19 pandemic, probably due to the ability to follow up quickly without the risk of COVID-19	There was no medical record of comorbidities, lipid profiles, medicine dosages, or follow-up.	8

		exposure in the clinic or hospital.		
AlMutairi et al[19] 2021 Saudi Arabia	-Intervention group- mean reduction inHbA1c = 1.82 (95% CI = 1.56–2.09, p < 0.001), -Traditional care model had a mean reduction of 1.54 (95% CI = 1.23–1.85, p < 0.001).	Telemedicine is a cost-effective way to manage type 2 diabetes patients who are poorly managed. As a result, telemedicine can be broadened and integrated into standard diabetic care.	The trial period was brief; therefore, the long-term influence of the care paradigm could not be determined. It was undertaken at one facility and involved 200 patients due to feasibility, resources, and problems during the COVID-19 epidemic.	7
Tourkmani et al[20] 2021 Saudi Arabia	After 4 months, the HbA1c decreased significantly from 9.98 ±1.33 to 8.32 ±1.31 (mean difference 1.66 ±1.29; CI =1.43–1.88; p <0.001).	In COVID-19 pandemic, the current study discovered that telemedicine therapy had a significant favourable influence on glucose control among high-risk diabetic patients. It showed that telemedicine may be successfully integrated into diabetic care to replace many of the traditional in-person care appointments.	Patients were not assigned to telemedicine at random; instead, a pre-post telemedicine care study was conducted, which may not have adjusted for unknown confounders. To isolate the effect of integrated care on glycaemic control, other key factors such as health consciousness or health-seeking behaviour of diabetic patients could not be controlled for. Patients were followed for a short time and the impact of telemedicine could not be determined in long run	7
Kang et al[21] 2021 China	The control group's BMI and postprandial blood glucose (PBG) were considerably greater at 3 months than at baseline (p = 0.001), while TIR dropped (p = 0.05). Blood pressure in the control group did not alter significantly from baseline, whereas blood pressure in the intervention group fell (p = 0.05). Fasting blood glucose (FBG) and PBG fell in the intervention group compared to their baseline values, while TIR increased, both of which were statistically significant (p= 0.001). At 3 months, the intervention group's FBG, PBG, and TIR were better than the control group's (p = 0.05). The incidence of hypoglycaemia was not different between the two groups.	TIR can be increased through remote management without raising the risk of hypoglycaemia. During the COVID-19 outbreak, remote management can reduce weight gain and increase patient self-management and compliance.	We were unable to conduct large-scale remote management due to a lack of doctors and the associated costs.	7
Storch et al [22] 2019 Germany	The authors discovered a significant decrease in HBA1C in the intervention group (p = 0.01) using the results of two-way mixed ANOVA.	T2DM patients may benefit from telemedicine-assisted self-management programs, which may provide new therapy and disease preventive choices.	The selection of the sample from a private health insurance company, which hinders the representativeness of the	6

	-After three months, intervention group participants had a lower HbA1c value than control group participants (p = 0.038) -There was a significant interaction term between time and therapy on HbA1C value, F (1, 104) = 17.26, p = 0.01. - The intervention group had a lower self-management scale score and BMI than the control group.		sample with respect to the general diabetes population. Account should also be taken for the high technology commitment values with respect to the selective sample.	

3.3.Findings by type of the outcome measured (primary versus secondary outcomes)

Overall, the main or primary outcome of these studies was change in HbA1c. However, the authors of the five studies (out of nine) assessed the impact of telemedicine on different secondary outcomes such as blood glucose, blood pressure, BMI, lipid profile, Time In Range (TIR) and incidence of hypoglycaemia. For example, Kang et al. (2021) found a positive impact of mobile phone WeChat app on TIR, postprandial blood glucose and body mass index[21]. Mobile phone WeChat app significantly improved the BMI (25.35 kg/m2 to 25.52 kg/m2) , Postprandial Blood Glucose PBG(14.5 mmol/l to 15.7 mmol/l), and TIR (33 % to 28%) after three months of exposure to intervention ($p < 0.001$)[21]. Additionally, the intervention decreased the blood pressure in the intervention group from the baseline ($p<0.05$). In the intervention group, fast blood glucose (FBG) and PBG decreased compared with their baseline values, and the TIR level increased, both of which were statistically significant ($p < 0.001$). Similarly, Dutta et al. (2021) assessed the impact of video consultation on HbA1c, lipid profile, fasting blood glucose levels, and postprandial plasma glucose[18]. Authors found a positive and significant effect of video consultation on postprandial plasma glucose ($p = 0.049$). However, there was no significant difference in HbA1c ($p =0.882$), lipid profile ($p = 0.19$) and fasting blood glucose levels ($p = 0.76$) between two groups[18].

In contrast, AlMutairi et al. (2021) did not evaluate the impact of telemedicine care model on any other biomarkers except HbA1c but the authors assessed the cost-effectiveness of chosen telemedicine care model[19]. There was a significant effect of telemedicine care model on HbA1c ($p < 0.001$) and authors also found that there was a higher cost associated with telemedicine care model[19]. More precisely, the incremental cost associated with of telemedicine care model was SAR 669.07 (US$178.42) [95% CI = SAR 593.7 (US$158.32)–SAR 1013.64 (US$270.30)]. The resulting incremental cost-effectiveness ratio was estimated to be SAR 2372.52 (US$632.67) per 1% reduction in the level of HbA1c[19].

Scoccimarro et al. (2022) assessed the effect of telehealth visits on HbA1c and lipid profile including blood cholesterol, triglycerides, high density lipoprotein cholesterol, and body mass index[16]. The authors neither found a significant effect of on telehealth visits HbA1c when compared with traditional visits (P-value: 0.99) nor a substantial reduction on total cholesterol (P-value: 0.67), high density lipoprotein cholesterol (P-value: 0.94), and triglycerides (P-value: 0.83)[16]. Moreover, telehealth visits did not significantly reduce the BMI when compared to the traditional visits (P-value: 0.91). In contrast, Storch et al. (2019) found a significant and positive effect of telemedicine-assisted self-management program on HbA1c (P<0.01), BMI (0.036), and diabetes self-management score (P<0.01)[22]. Between subject differences found that as compared to control group, the patients in the telemedicine-assisted self-management program had reduced levels of HbA1c, BMI, and improved scores for self-management[22].

3.4. Findings of quality assessment

While assessing the quality of all eligible articles, the average score was 7.625 suggesting the good quality of the included studies. Five of the studies (55.6%) scored between 8 to 9 indicating the excellent quality of the studies, while 3 studies (33.3%) scored 7, indicating good quality and only one study scored 6 as shown in Table 3. These findings suggests that overall quality of the included studies was good, meaning that these studies were less likely to be affected by the problems of internal validity that could bias the results of individual studies.

4. Discussion

Overall, there is no clear conclusion about what type of telemedicine model was better than other because the number of studies was low. However, it seems that different telehealth or telemedicine care models were proven to be effective in improving the primary outcome of HbA1c in diabetic patients. For example, telehealth care models such as Advanced Comprehensive Diabetes Care (ACDC), phone-based telehealth, telemedicine-assisted self-management program including training on different components representing major problem areas with importance on healthy diet, physical activity, self-management, emergency, clinical, and stress management by phone calls, telehealth included phone and video-conference, mobile phone WeChat app, telemedicine care model including patients who were attending the virtual integrated care clinics, and video consultations were found to be effective against hyperglycaemia among diabetic patients. In contrast, study conducted in Italy used the telehealth in the form of remote consultations with physicians and did not find positive effect on hyperglycaemia among diabetic patients.

The current systematic review provides new perceptions into the clinical impact of implementing

telehealth services to a high-risk group patients diagnosed with uncontrolled or refractory type two DM during COVID-19 pandemic. In general, the findings revealed that different telemedicine models such as remote consultations with physicians, video conferences, integrated virtual clinics, and phone calls with text messages were effective in improving the glycaemic control as measured by change in HbA1c levels.

Telehealth is believed to improve the quality of care even before the time of pandemic. While during pandemic few studies are carried out, the importance of telehealth is illustrated by several reviews and meta-analysis conducted on studies published before pandemic. Over the last one-decade, numerous studies have been supporting the utility of telehealth for diabetic patients[23]. For example, before pandemic, a review of four systematic reviews was conducted recently. The findings of that review revealed that telehealth interventions produced a significant though small improvement in HbA1c levels compared with the traditional or usual care[24]. However, the authors made a need of high-quality primary studies and randomized controlled trials to make definitive conclusions about the feasibility of implementing telemedicine[24]. Likewise, another systematic review and meta-analysis examined the effect of health information technology on glycaemic control in diabetic patients[25]. The authors found that health information technology can successfully improve the blood glucose levels and can provide glycaemic benefit to diabetic patients[25].

Similarly, another meta-analysis and review found analogous findings where authors only included randomized controlled trials in their review, and it was conducted before pandemic[26]. The authors found that telemedicine when combined with usual traditional care can be proven beneficial in terms of improving the glycaemic control, BMI, blood pressure and lipid profile among diabetic patients[26]. The findings of the previous reviews are consistent with the existing review. These findings collectively consider telemedicine as an innovative strategy to closely monitor the diabetic patients not only for better glycaemic control, but also to help them to self-manage their disease and prevent them from any complications.

However, in contrast to the previous reviews, the existing review added to the scientific knowledge and provided evidence that telehealth services can be utilized more effectively during the time of crisis such as pandemic. Since these pandemics may be anticipated in the future, one need to be ready and prepared to effectively use the technology and take the benefit of telehealth in managing chronic disease such as type two diabetes mellitus.

This is a unique review as it is the first of its type that assessed the effect of implementing telehealth services to a high-risk group patients diagnosed with uncontrolled T2DM with a focus on COVID-19 pandemic. The findings of this review can provide a framework to clinicians, endocrinologists,

diabetologists, nutritionists, and policymakers to use the existing technology that could be helpful for the care of diabetic patients during the time of pandemic.

Despite these strengths, there are also some limitations associated with the individual studies, and therefore, these results need to be interpreted with caution. Foremost, randomization did not use in most studies, limiting the generalisability of the study findings to other populations outside the ones chosen from registries or cohorts. Secondly, there is a persistent issue of unmeasured confounding factors in observational studies. However, this issue can be overcome by using an explicit theory regarding potential confounders by using some acyclic graphs. These graphs identify variables that need to be adjusted as potential confounders. Furthermore, most of the studies were conducted in high-income countries; therefore, it may be challenging to extrapolate the findings to the resource-constrained settings. Lastly, only nine studies were included in this review based on the eligibility criteria. As a result, the findings should be interpreted with caution, and RCTs are warranted in the future to make firm conclusions about the effectiveness of telehealth for diabetic patients.

Given the limitations of existing review, more robust evidence in the form of meta-analysis or systematic reviews with more studies is warranted. However, the findings of the current review may help to learn about the importance of telemedicine for the health of diabetic people especially during COVID-19 pandemic. These findings can provide a guideline to the researchers on the role of telehealth services in management of type two DM especially during pandemic. These results are essential to make recommendations on telemedicine design strategies in medical practice to improve glycaemic control among diabetic patients.

5. Conclusion

During the COVID-19 epidemic, telemedicine or telehealth is a realistic and useful source of consultation for achieving optimal glycaemic control. This provides for a more remote and flexible strategy to controlling hyperglycaemia in diabetic patients and preventing complications. Future research is needed to determine the impact of telehealth on long-term outcomes in diabetic patients, particularly in resource-constrained settings. This can be accomplished by undertaking epidemiological research, primarily randomized controlled trials with a higher sample size, to analyse the impact of telemedicine on diabetic patients' glucose control, self-management, and other problems.

5.1 Recommendations

First, the current review findings suggest that diabetes care monitoring can be effectively done via telehealth. The importance of telehealth is even more relevant during pandemics when diabetic patients may not be able to make in-person consultations with their physicians. Second, to ensure continuity of diabetes care, telehealth services may be an efficient and cost-effective way to help patient seek

uninterrupted care during a time of crisis. Third, since the eligible studies could not study the long-term effect of any telehealth service, it is recommended to carry out studies in the future that can assess the impact of different telehealth modalities on long-term outcomes in diabetic patients. Fourth, many researchers found a positive effect of telehealth services on glycemic index or blood glucose levels and other outcomes. Hence, telehealth services can be effectively used to improve the outcomes such as BMI, lipid profile, blood pressure, and self-management scores in diabetic patients. However, more studies are required in the future to assess the effectiveness of telehealth on these secondary outcomes. Fifth, almost all the studies tested a range of different telehealth services such as remote consultations with physicians, video conferences, integrated virtual clinics, and phone calls rather than comparing these different modalities with each other. Thus, it may be premature to conclude about the superiority of any type of telehealth service over the other. Therefore, future studies are required to compare the effectiveness of different types of telehealth services and their impact on various health related outcomes among diabetic patients. Lastly, to provide comprehensive evidence, base to policymakers and physicians, future studies should also consider evaluating the effect of telehealth on quality of care, cost-effectiveness, and quality of life among diabetic patients.

6. Declarations

6.1 Conflict of Interest Statement

The authors have no conflict of interests to declare.

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7. References

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