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The influence of telemedicine in primary healthcare on diabetes mellitus control and treatment adherence in Riyadh region

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ABSTRACT

Several studies have found that telemedicine has the potential to enhance the outcomes of patients with diabetes. This study aimed to determine the impact of telemedicine on the clinical outcomes of patients with type 2 diabetes mellitus (T2DM) in Saudi Arabia. We conducted a cross-sectional study among T2DM patients in selected primary healthcare centers in Riyadh, Saudi Arabia, from March 1, 2023, to August 20, 2023. We looked at how telemedicine affected HbA1c control, adherence, the number of diabetic complications, and polypharmacy using adjusted multivariable logistic regression models. Among the 583 patients, 140 (24.05 %) received care via telemedicine, while 442 (75.95 %) received in-person care. Patients who utilized telemedicine had significantly better glycemic control than those who received in-person care only (AOR = 5.123, 95 % CI = 3.107–8.447). Telemedicine also showed positive effects on treatment adherence (AOR = 2.552, 95 % CI = 1.6284–4.2414). Telemedicine can effectively reduce diabetic complications (AOR = 0.277, 95 % CI = 0.134–0.571). Regarding polypharmacy, patients with telemedicine use were less likely to report polypharmacy (AOR = 0.559, 95 % CI = 0.361–0.866). Telemedicine is considered one of the factors that improve HbA1c management and might increase therapeutic adherence and reduce diabetic complications and polypharmacy.

1. Introduction

Chronic diseases have developed as a major health issue worldwide, affecting individuals, healthcare systems, and the global economy (Airhihenbuwa et al., 2021). Diabetes is one of the most dangerous conditions affecting public health worldwide (Akhtar et al., 2022). In 2019, 9.3 percent (463 million) of individuals worldwide had diabetes, according to the International Diabetes Federation (IDF). Without effective prevention strategies, the figure is expected to rise to 10.2 % (578 million) by 2030 and 10.9 % (700 million) by 2045 (Akhtar et al., 2022).Table 1.Table 2.

Diabetes mellitus (DM) is one of the diseases with alarmingly high prevalence rates in Saudi Arabia, with an 18.7 % prevalence (IDF, 2022). Diabetes is a chronic metabolic condition that has major economic consequences (Espinoza et al., 2022). The illness affects millions of people worldwide and is associated with a wide spectrum of macrovascular and microvascular problems that significantly contribute to the cardiovascular burden of diabetes mellitus, resulting in higher morbidity and mortality rates (Dal Canto et al., 2019). As a result, the economic burden of diabetes in Saudi Arabia is significant, with the disease being over ten times that of those without it (Alhowaish, 2013).

Telemedicine has acquired worldwide recognition as a viable tool for tackling healthcare concerns, particularly in patient outcomes and resource-constrained situations (Amjad et al., 2023). Consequently, the Saudi Ministry of Health (MOH) has increased its investment in digital and e-health services. Saudi Vision 2030 has driven these investments, with special emphasis on healthcare reform to address healthcare demands (Alamri et al., 2022). The MOH started the first nationwide

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telemedicine project, known as the Saudi Telemedicine Network (STN), in 2011, covering all healthcare facilities (HCF) and devoting a large amount of funding to it (Alaboudi et al., 2016). Furthermore, the convergence between the country's vision and the implementation of e-health technology in Saudi Arabia strengthens the MOH's commitment to improving its healthcare standards, quality, accessibility, and equitability. As a result, telemedicine is regarded as a perfect solution for people with different healthcare demands who want consistent healthcare services, as well as innovative communication and information technology, such as patients with diabetes. Furthermore, telemedicine can reduce costs and improve the efficiency of healthcare delivery.

Several studies have shown that telemedicine may help diabetes patients do better, especially when it comes to managing their blood sugar and lowering their glycosylated hemoglobin (HbA1c) levels (AlMutairi et al., 2021; De Groot et al., 2021; Su et al., 2016). Many hospitals and health centers in Saudi Arabia have called for the use of telemedicine to ensure that patients with diabetes receive necessary health treatment in a timely and effective manner. We have not yet assessed the outcomes of patients with DM in Saudi Arabia resulting from such efforts. Therefore, we conducted this study to investigate the impact of telemedicine on the outcomes of patients with type 2 diabetes mellitus (T2DM) in Saudi Arabia. We hope that our findings will help policymakers implement telemedicine as a method to replace the services provided by traditional in-person care for patients with T2DM.

2. Methods

2.1. Study design and study population

Primary healthcare settings are considered the optimal choice for recruiting individuals with chronic diseases due to their critical role in providing comprehensive and ongoing care. Between March 1, 2023, and August 20, 2023, we conducted a cross-sectional study in selected primary healthcare centers across all 17 municipalities in Riyadh. This questionnaire was eligible for adult males and females aged $\geq$ 18 years who had been diagnosed with type 2 diabetes and were not pregnant.

Table 1
Characteristics of the study population (n = 583).

Characteristics	Total		In-person care only		Telemedicine care		P value
	N = 583	(%)	N = 442	(%) = 75.95	N = 140	(%) = 24.05	
Age group, year							0.0004
≤ 30	104	17.87	62	14.03	42	30	
31—39	56	9.62	30	6.79	26	18.57	
40—49	82	14.09	60	13.57	22	15.71	
50—59	146	25.09	132	29.86	14	10	
60—69	92	15.81	76	17.19	16	11.43	
≥ 70	102	17.53	82	18.55	20	14.29	
Sex							<0.0001
Female	252	43.3	158	35.75	94	67.14	
Male	330	56.7	284	64.25	46	32.86	
Marital status							<0.0001
Married	472	81.1	376	85.07	96	68.57	
Not married	110	18.9	66	14.93	44	31.43	
Educational status							<0.0001
Less than primary education	104	17.87	84	19	20	14.29	
Primary education	48	8.25	38	8.6	10	7.14	
Intermediate education	114	19.59	104	23.53	10	7.14	
Secondary education	196	33.68	148	33.48	48	34.29	
Higher education	120	20.62	68	15.38	52	37.14	
Employment status							<0.0001
Employed	214	36.77	140	31.67	74	52.86	
Unemployed	368	63.23	302	68.33	66	47.14	
Type of treatment							0.5
Oral hypoglycemic agent	344	59.11	264	59.73	80	57.14	
Only insulin	132	22.68	98	22.17	34	24.29	
Oral hypoglycemic agent and insulin	106	18.21	80	18.1	26	18.57	
Comorbidities							
Dyslipidemia	298	51.2	210	47.51	88	62.86	0.0015
Hypertension	358	61.51	246	55.66	112	80	<0.0001
Asthma	68	11.68	60	13.57	8	5.71	0.0116
Thyroid disease	26	4.47	8	1.81	18	12.86	<0.0001
Kidney Disease	32	5.5	18	4.07	14	10	0.0073
Congestive Heart Failure	78	13.4	44	9.95	34	24.29	<0.0001
Psychiatric disease	70	12.03	66	14.93	4	2.86	<0.0001
Arthritis	136	23.37	94	21.27	42	30	0.0333
Anemia	16	2.75	10	2.26	6	4.29	0.202
Outcomes							
Glycemic control							<0.0001
Good glycemic control	230	39.52	142	32.13	88	62.86	
Poor glycemic control	352	60.48	300	67.87	52	37.14	
Adherence status							<0.0001
Adherent	330	56.7	228	51.58	102	72.86	
Not adherent	252	43.3	214	48.42	38	27.14	
Diabetic complications							<0.0001
No complications	460	79.04	330	74.66	130	92.86	
With complications	122	20.96	112	25.34	10	7.14	
Polypharmacy							<0.0001
No	270	46.39	184	41.63	86	61.43	
Yes	312	53.61	258	58.37	54	38.57	

Table 2
Factors associated with telemedicine care.

Characteristics	Adjusted OR	95 % CL		P-value
Age group, year				
≤ 30	Reference			
31–39	1.148	0.572	2.304	0.4
40–49	0.806	0.413	1.574	0.05
50–59	0.151	0.075	0.305	<0.0001
60–69	0.261	0.13	0.526	0.0006
≥ 70	0.328	0.17	0.635	0.001
Sex				
Female	4.213	2.704	6.564	<0.0001
Male	Reference			
Marital status				
Not married	Reference			
Married	0.383	0.246	0.596	<0.0001
Educational status				
Less than primary education	Reference			
Primary education	0.677	0.277	1.653	0.4
Intermediate education	3.072	1.144	8.252	0.8
Secondary education	3.35	1.648	6.81	0.03
Higher education	5.179	2.558	8.488	0.0002
Employment status				
Employed	4.357	2.708	7.011	<0.0001
Unemployed	Reference			
Type of treatment				
Oral hypoglycemic agent	Reference			
Only insulin	1.234	0.754	2.018	0.4
Oral hypoglycemic agent and insulin	0.998	0.583	1.71	0.6
Comorbidities (Reference = No)				
Dyslipidemia	1.87	1.265	2.762	0.001
Hypertension	3.187	2.023	5.021	<0.0001
Asthma	0.386	0.18	0.828	0.01
Thyroid disease	8.004	3.398	18.853	<0.0001
Kidney Disease	2.617	1.266	5.41	0.009
Congestive Heart Failure	2.901	1.767	4.765	<0.0001
Psychiatric disease	0.168	0.06	0.468	0.0007
Arthritis	1.587	1.035	2.433	0.03
Anemia	1.934	0.69	5.421	0.2

Abbreviations: CI, confidence interval; AOR, adjusted odds ratio.

We included only patients who regularly visited primary care clinics for follow-up visits. We excluded individuals who did not maintain glycated hemoglobin (HbA1c) levels throughout the previous 12 months from the study.

2.2. Sample size determination and sampling techniques

The International Diabetes Federation (IDF) reported a diabetes prevalence rate of 18.7 % in Saudi Arabia in 2021 (IDF, 2022). We used the Raosoft online sample size calculator from Raosoft, Inc., USA, to determine the sample size for our study. We calculated a sample size of 385 people based on a 95 % significance level and a 5 % margin of error. We first solicited 622 people from primary healthcare centers, and 606 agreed to participate, yielding an 89.7 % response rate. A total of 583 people were included in the study, with 23 individuals having significant missing data. The investigators used convenience sampling, approaching all T2DM patients who met the inclusion criteria and were followed up during the data collection period until the requisite sample size was reached.

2.3. Ethical consideration

The MOH's Institutional Review Board (IRB Log Number 22–490) authorized this study, which adhered to the ethical criteria of the Declaration of Helsinki. Before participation, all participants provided written consent with specified secrecy and anonymity. Participants were also informed that their participation was entirely optional and that they could withdraw at any moment without consequences.

2.4. Data collection instruments and procedures

The participants provided information through face-to-face interviews using a standardized questionnaire during their visit to the primary healthcare facility. There were four parts to the questionnaire: sociodemographic information like age, gender, marital status, level of education, and employment; clinical information like type of treatment, comorbidities, and other medications; information on healthcare service use and telemedicine use in the past year; and the Arabic version of the the Medication Adherence Report Scale (MARS-5). We obtained HbA1c levels from the participants' medical records.

2.5. Telemedicine use

In our research group, we sought to assess the efficacy of telemedicine by examining the extent to which participants engaged with healthcare professionals over the previous 12 months via two-way synchronous communication methods, such as vid***eo conferencing, phone calls, or mobile apps. We divided the study population into two groups based on their responses: those who used telemedicine services and those who received only in-person care. To ensure that everyone could effectively access and engage in telemedicine, we excluded those who did not have a constant internet connection or who had major cognitive impairments.

2.6. Outcome measures

2.6.1. Glycemic control

The researchers found the average of the two HbA1c readings that person had taken before. Based on this average, they put the patients into two groups: the good control group (HbA1c ≤ 7 % or ≤ 53 mmol/mol) and the bad control group (HbA1c > 7 % or > 53 mmol/mol).

2.6.2. Adherence status

In order to evaluate adherence to diabetes treatment regimens, patients were asked to recall their consumption over the past two weeks using the MARS-5. The MARS-5 has been found to be more sensitive to changes in adherence behavior. The scores for each of the five questions are added together to get a total score ranging from 5 to 25 points. A total score of fewer than 25 points indicates that the patient is not adhering to the medicine (Horne and Weinman, 2002).

2.6.3. Diabetic complications

We focused on chronic complications that manifested after the correct diagnosis of T2DM and were clearly associated with diabetes. To identify these complications, we asked the patients if their doctor had ever informed them that they had diabetes-related conditions. Retinopathy, nephropathy, lower-extremity amputation, ischemic heart disease, and cerebrovascular disease were the most prevalent complications.

2.6.4. Polypharmacy

During the interviews, the participants disclosed the number and frequency of their daily medications. Polypharmacy is defined as the daily ingestion of five or more medications, including prescription, non-prescription, or over-the-counter (OTC) drugs.

2.7. Data quality assurance

We translated the questionnaire and checklist from English to Arabic (the local language) and back to English for consistency. Field specialists evaluated and confirmed the structure of the questionnaire to ensure the accuracy of the results. Data collectors and supervisors received one-day training on the objectives and data collection process to ensure

consistency and reliability throughout the interviews. We conducted a pilot study with 30 patients, which represented 5 % of the total sample size. Changes were implemented based on the opinions of the specialists. Supervisors verified the completeness, accuracy, clarity, and consistency of the data daily after the data collection. The principal investigator monitored the overall activities.

2.8. Statistical analyses

We used SAS (version 9.4; SAS Institute, Inc., Cary, NC, USA) to analyze the data. We summarized demographic and clinical baseline characteristics overall and by study arm. We reported the quantity and percentage of categorical variables. We used univariate and logistic regression analyses to identify predictive indicators for the outcomes. A logistic regression model included all predictors with a p-value < 0.20 in univariate analysis. We selected the most applicable model using a stepwise method. We started with a comprehensive model that included all independent variables chosen based on univariate analysis. We then individually excluded all non-significant variables until all parameters attained a significance level of at least 0.05. Interactions between the independent variables were not considered. We calculated the 95 % confidence intervals (CIs) using adjusted odds ratios (AORs). Participants with missing data were not considered in any data analysis when reporting the proportion of participants in the categories stated. Statistical significance was set as the statistical significance level.

3. Results

3.1. Characteristics of the study population

The survey included 583 people from various backgrounds. Approximately 25.09 % of the participants were between the ages of 50 and 59 years old. The majority of participants (56.7 %) were men, 81.1 percent were married, and they had completed secondary school (33.68 %). Furthermore, a substantial proportion of the participants (63.23 %) were unemployed. Only 140 (24.05 %) received care via telemedicine, while 442 (75.95 %) participants had in-person sessions. Our study found that 62.86 % of patients in the telemedicine group and 32.13 % in the in-person care group had satisfactory glycemic control. Furthermore, those who used telemedicine services adhered to treatment procedures at a higher rate (72.86 %) than those who received only in-person care (51.58 %). The study found that participants who received in-person care (74.66 %) had fewer problems than telemedicine participants (92.86 %). Furthermore, the proportion of people who did not practice polypharmacy was higher among those who chose telemedicine (61.43 %) than among those who preferred in-person care (41.63 %).

3.2. Factors associated with telemedicine care use

A multivariate logistic regression analysis was used to investigate the factors affecting telemedicine utilization. Telemedicine use was predicted by several important demographic and health-related characteristics. Individuals aged $\geq$ 50 years were less likely to use telemedicine than those aged 30 years and younger [adjusted odds ratio (AOR) = 0.151, 95 % confidence interval (CI) = 0.075–0.305 for 50–59 years; AOR = 0.261, 95 % CI = 0.13–0.526 for 60–69 years; AOR = 0.328, 95 % CI = 0.17–0.635 for those aged $\geq$ 70 years]. Females were also more likely to use telemedicine (AOR = 4.213, 95 % CI = 2.704–6.564), and those with higher levels of education had even higher odds (AOR = 3.35, 95 % CI = 1.648–6.81 for secondary education and AOR = 5.179, 95 % CI = 2.558–8.788 for higher education). We also found that working participants were more likely to use telemedicine than unemployed people (AOR = 4.357, 95 % CI = 2.708–7.011). Furthermore, individuals with comorbidities, such as dyslipidemia, hypertension, thyroid disease, kidney disease, congestive heart failure, and arthritis, were more likely to use telemedicine than those with asthma or psychiatric conditions.

The findings of the logistic regression analysis illustrate the importance of telemedicine in improving clinical outcomes for patients with diabetes. Telemedicine patients showed considerably better glycemic control than those who solely got in-person care (AOR = 5.123, 95 % CI = 3.107–8.447). Telemedicine has also been proven to improve treatment adherence (AOR = 2.552, 95 % CI = 1.6284–4.2414). Diabetes complications can be effectively reduced with telemedicine (AOR = 0.277, 95 % CI = 0.134–0.571). Patients who used telemedicine were less likely to report polypharmacy (AOR = 0.559, 95 % CI = 0.361–0.866) (Table 3).

4. Discussion

This is the first study of its kind to examine the impact of telemedicine on the outcomes of T2DM patients in Saudi Arabia, which would potentially indicate how telemedicine operates within Saudi Arabia's exceptional healthcare system and infrastructure. The findings of this study have optimistic implications for the integration of telemedicine in the management of patients with T2DM.

Our research shows that using telemedicine to help people with DM has a positive effect on their health, which is in line with what other studies have found (AlMutairi et al., 2021; De Groot et al., 2021; Su et al., 2016; Zhang et al., 2022; Lee et al., 2019; Santos et al., 2022; Aberer et al., 2021; Rosta et al., 2023). Patients who used telemedicine had substantially better glycemic control than those who received only in-person care. It is plausible that patients can adhere to their diabetes treatment plans if they have virtual appointments with their healthcare providers, during which they can receive direction, pose questions, and receive feedback. This method permits patients to make necessary adjustments and adhere to their treatment plans. This indicates that incorporating telemedicine into healthcare delivery may be an effective strategy for improving diabetes management and achieving optimal health outcomes.

Medication adherence is critical for the control and treatment of various health disorders. It entails taking medications as prescribed by a healthcare provider at the appropriate time and in an appropriate manner. Adherence to medication schedules can help increase treatment effectiveness, prevent problems, and lower the risk of hospitalization (FDA, 2016). Compared with traditional in-person care, the current study found that using telemedicine had a positive effect on treatment adherence. Bingham et al. say that telehealth includes phone outreach and special tools made to help people learn more about health. They also say that eHealth and telehealth medication adherence interventions were linked to higher rates of medication possession and/or higher percentages of days covered (Bingham et al., 2021). Aberer et al. (2021) found that telemedicine has a beneficial impact on therapy adherence in diabetes treatment.

Diabetic complications refer to a variety of health issues that can

Table 3
Effect of telemedicine on study outcomes.

Outcomes	AOR	95 % CL		P-value
		Lower limit	Upper limit	
Glycemic control				
Good glycemic control	5.123	3.107	8.447	<0.0001
Poor glycemic control				
Adherence status				
Adherent	2.552	1.628	4.214	<0.0001
Not adherent				
Diabetic complications				
No complications				
With complications	0.277	0.134	0.571	0.0005
Polypharmacy				
No				
Yes	0.559	0.361	0.866	0.0091

develop as a result of uncontrolled diabetes over time. These complications include cardiovascular complications, kidney problems, eye problems, nerve damage, and foot problems (Deshpande et al., 2008). The present study demonstrated that the utilization of telemedicine is an effective approach to mitigating diabetic complications. Telemedicine increases medication adherence and ensures that patients take the correct dose of prescribed medication, thereby reducing the need for multiple medications and preventing polypharmacy. Furthermore, telemedicine improves glycemic control and reduces plasma glucose variability, which plays a crucial role in preventing complications associated with diabetes. According to De Groot et al., the delivery of health services through remote communication and technology decreases disease complications, hospital admissions, and related economic costs (De Groot et al., 2021). According to Nittari et al., utilizing telemedicine for regular follow-up visits can be beneficial for the straightforward monitoring of patients with chronic diabetes. This approach allows for prompt identification and management of complications or worsening symptoms (Nittari et al., 2023).

Although our study offers valuable insights, it is important to acknowledge its limitations. We only analyzed data from institutions located in major metropolitan areas. This means that we must consider the possibility that some limitations to telemedicine usage, such as poor broadband connectivity or a lack of technological proficiency, may be more common among people living in rural regions than in our sample population. Despite efforts to consider patient risk factors, we cannot completely rule out the possibility of unmeasured confounding factors. Third, there may be a potential selection bias, as individuals with improved diabetes control may be more likely to choose telemedicine visits, thereby avoiding in-person examinations. Fourth, the observed differences in medication adherence among groups are likely due to pre-existing variations in adherence rather than the use of telemedicine. Finally, it is important to acknowledge that the diabetic complications drawn in the study were exclusively derived from patient-reported data; no verification with medical records was conducted. Consequently, a significant possibility exists that the precision of your discoveries could be compromised.

In Saudi Arabia, it is crucial to develop comprehensive telemedicine guidelines to ensure the safe, effective, and ethical provision of telemedicine services. These guidelines should ensure that only qualified healthcare professionals deliver telemedicine services and that appropriate technologies are used while maintaining quality standards. In addition, there should be a clear policy on financial reimbursement for telemedicine services. Currently, private health insurance companies offer varying coverage of telemedicine services. Clear reimbursement guidelines enable patients to access affordable telemedicine services. Finally, guidelines should address patient privacy concerns, as telemedicine services involve the transmission of sensitive personal health information. Guidelines should establish safeguards to protect patients' privacy and confidentiality.

5. Conclusion

Our research has shown that telemedicine care is highly beneficial for patients with T2DM, as it significantly improves glycemic control and therapeutic adherence and reduces diabetic complications and polypharmacy. Therefore, this study found that telemedicine can effectively replace some in-person services in the diabetic care system. Therefore, policymakers in Saudi Arabia's healthcare sector must establish comprehensive telemedicine guidelines that prioritize quality care, address financial reimbursement concerns, and ensure patient privacy.

Declaration of competing interest

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

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Disclosure

The authors declare no conflicts of interest.

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