Effectiveness of Connected Care Versus Conventional Care in Reducing Glycemic Parameters in Patients with Type 2 Diabetes Mellitus: A Prospective Cohort Study

Junaid Naina Mappilathayyil[1], Karthika Ranjan Sreedevi[1], Anugraha John Nelson[2], Sivalingam Swamynathan[2], Jothydev Kesavadev[3], Jahnara Jaffar[4]

[1]Assistant Professor, Department of Pharmacology, Kanyakumari Medical Mission Research Centre and Hospitals, St. Joseph University, Tamil Nadu, India, [2]Assistant Professor, Department of Community Medicine, Kanyakumari Medical Mission Research Centre and Hospitals, St. Joseph University, Tamil Nadu, India, [3]Jothydev's Diabetes & Research Centre, Trivandrum, Kerala, India, [4]Assistant Professor, Department of Ophthalmology, Kanyakumari Medical Mission Research Centre and Hospitals, St. Joseph University, Tamil Nadu, India

Abstract

Background: Telemedicine has emerged as a promising strategy for optimizing diabetes care, yet comparative evidence with conventional approaches in the Indian context remains limited. This study evaluated the effectiveness of connected care versus conventional care in improving glycemic and non-glycemic parameters among individuals with type 2 diabetes mellitus (T2DM). **Materials and Methods:** A retrospective cohort study was conducted among 504 adults with T2DM, equally assigned to connected care (n=252) or conventional care (n=252). In the connected care model, participants engaged in self-monitoring of blood glucose (SMBG), transmitted readings digitally to the clinic, and received timely feedback from healthcare providers. Conventional care participants underwent periodic laboratory investigations and routine in-person consultations. The primary endpoint was the change in glycated hemoglobin (HbA1c) from baseline to 3 months. Secondary outcomes included lipid profile, liver enzymes, renal parameters, blood pressure, weight, and body mass index (BMI). **Results:** Both groups exhibited significant reductions in HbA1c at 3 months; however, the decline was greater in the connected care group (mean HbA1c 6.9 ± 0.8 vs. 7.5 ± 0.8; p=0.012). Additionally, total cholesterol, low-density lipoprotein (LDL), triglycerides, and hepatic enzymes [Aspartate aminotransferase (AST/SGOT) and Alanine aminotransferase (ALT/SGPT)] were significantly lower in the connected care group compared to conventional care. Modest but non-significant reductions were noted in body weight, BMI, systolic, and diastolic blood pressure. Hypoglycemia incidence was lower in connected care, with 37.6% versus 30% of participants reporting no events. **Conclusion:** Connected care demonstrated superior effectiveness over conventional care in improving glycemic control and selected cardiometabolic parameters. Incorporating telemedicine into diabetes management may serve as a valuable adjunct to standard care, particularly in resource-limited regions with restricted access to specialized services.

Keywords: Connected care, Telemedicine, Type 2 diabetes mellitus, HbA1c, Lipid profile, Self-monitoring of blood glucose.

INTRODUCTION

Diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia, arising from inadequate insulin secretion, impaired insulin action, or a combination of both mechanisms.[1] Type 2 diabetes mellitus (T2DM), which accounts for nearly 90% of diabetes cases, is primarily defined by insulin resistance coupled with progressive β-cell dysfunction.[2] In the early phase, compensatory hyperinsulinemia maintains near-normal glycemia; however, as β-cell function declines, overt hyperglycemia ensues.[3]

Globally, diabetes prevalence has increased alarmingly, with 537 million adults affected in 2021—equivalent to one in ten adults. Projections indicate a further rise to 643 million by 2030 and 783 million by 2045, with almost half of all cases undiagnosed, the majority being T2DM.[4] In India alone, an estimated 77 million adults are currently living with T2DM, according to World Health Organization (WHO) data.[5]

Uncontrolled diabetes is a key driver of serious microvascular complications such as neuropathy, retinopathy, and nephropathy, as well as macrovascular complications including cerebrovascular accidents and cardiovascular disease.[6] Cardiovascular disease is particularly worrisome, with nearly two-thirds of individuals with diabetes at risk of myocardial infarction or stroke.[7] Globally, diabetes remains a leading cause of blindness, end-stage renal disease requiring dialysis or transplantation, and non-traumatic lower-limb amputations.[8]

Telemedicine gained significant prominence during the coronavirus (COVID-19) pandemic, reaching wider populations. Ghosh et al,[9] defined telemedicine as "healing at a

distance." Evidence from India demonstrates that telemedicine is an efficient, cost-effective, and practical tool in diabetes management.[9–12] By bridging geographical gaps, it extends care to underserved communities, enhancing both accessibility and affordability.[10] In intensive T2DM management, it has also proven to be cost-effective.[11]

The present study evaluates the effectiveness of connected care where patients undertake self-monitoring of blood glucose (SMBG), transmit results to their clinic, and receive timely feedback compared with conventional care, which primarily depends on face-to-face consultations and periodic laboratory evaluations.

MATERIALS AND METHODS

Study Design and Setting: This prospective observational study was conducted among individuals with type 2 diabetes mellitus (T2DM) attending the Diabetology Outpatient Department of a tertiary diabetes care center in Trivandrum, Kerala, between January 2023 and December 2023. The overall study duration was one year, with recruitment completed within the first 8 months once the required sample size was reached. Each participant attended two in-person visits: the baseline assessment and a follow-up visit at three months. During enrollment, patients were counseled on the importance of self-monitoring of blood glucose (SMBG) in optimizing glycemic control and preventing diabetes-related complications.

Inclusion Criteria: Adults (>18 years) with T2DM and HbA1c >6.5% who provided informed consent were eligible. Patients assigned to the connected care group either possessed a functional glucose meter or agreed to obtain one, had the technical knowledge to operate it, and were willing to report SMBG values through SMS, email, WhatsApp, telephone, Zoom, or other digital platforms. Those unwilling or unable to use SMBG or preferring standard care (periodic laboratory investigations and in-person consultations only) were enrolled in the conventional care group. Reasons for opting out of connected care were recorded.

Exclusion Criteria: Patients with other types of diabetes, severe cognitive impairment, pregnancy, anemia/hemoglobinopathies, terminal illness, or life expectancy less than six months were excluded.

Intervention and Follow-up: Connected care participants (Group 1) were trained in proper SMBG techniques, including fasting glucose (measured immediately on waking) and postprandial glucose (two hours after meal initiation). They were advised to record at least four glucose values every two weeks—one fasting and three postprandial, either on the same day or staggered—and report them through digital channels. Monitoring frequency was individualized, with no upper limit. Based on reported values, participants received feedback in the form of treatment modifications, lifestyle counseling, and diabetes education. Conventional care participants (Group 2) continued routine follow-up with laboratory testing and in-person consultations.

Outcome: Primary outcome: Change in HbA1c (%) from baseline to 3 months, measured using NGSP-certified equipment.

Secondary outcomes: Changes in total cholesterol, LDL, HDL, triglycerides, AST/SGOT, ALT/SGPT, serum creatinine, estimated glomerular filtration rate (CKD-EPI 2021 equation), systolic and diastolic blood pressure, height, body weight, and BMI. Baseline demographic, clinical, and laboratory data were collected at enrollment, and follow-up data were obtained at the 3-month visit.

Sample Size Calculation: Categorical variables were summarized as frequencies and percentages, while continuous variables were expressed as mean (SD) or median (IQR), depending on normality. Baseline group comparisons used chi-square or Fisher's exact tests for categorical variables and independent t-test or Mann–Whitney U test for continuous variables. Univariate analyses identified factors associated with HbA1c reduction, followed by multiple linear regression including significant covariates. Statistical significance was set at $p < 0.05$. Analyses were performed using R version 3.2.1.

Ethical Considerations: The study was approved by the Institutional Ethics Committee of Jothydev's Diabetes and Research Centre, Trivandrum (IEC/JDC/703/2022; approval date: 05 July 2022). Written informed consent was obtained from all participants.

RESULTS

A total of 504 people with T2DM were included in the study, among whom 252 received connected care (Group A) and the remaining 252 received conventional care (Group B). Group A comprised 120 males (47.6%) and 132 females (52.4%), while group B had 109 (43.2%) males and 133 (56.8%) females. There were no significant differences in demographics across the two study groups [Table 1].

Table 1: Baseline characteristics of the participants			
Parameter	Group A (connected care)	Group B (conventional care)	p-value
Number (no.)	252	252	-
Age	54.5±16.2	53.89±14.25	0.654
Gender (male/female)	120/132	109/133	0.487
Duration of T2DM (years)	10.9±5.7	11.5±6.4	0.267

HbA1c	8.6±1.3	8.5±1.4	0.406
TC	202.85±27.8	204.7±25.8	0.439
Reported complications (yes/no)	132/120	123/128	0.325
Reported comorbidities (yes/no)	183/69	180/72	0.87
Treatment Regimen (no (%))			0.125
Premix + OAD	140 (60.9)	104 (51.7)	
Basal + OAD	45 (19.5)	68 (33.8)	
Basal bolus + OAD	30 (13.0)	20 (10.0)	
OAD only	15 (6.5)	9 (4.4)	
T2DM, Type 2 diabetes mellitus; HbA1c, Glycated hemoglobin; TC, Total cholesterol; OAD, Oral antidiabetic drug			

At 3 months, HbA1c, TC, LDL, TG, SGOT/AST, SGPT/ALT, and BW were significantly lower in both groups compared to baseline. TG was significantly lower in group B compared to baseline, and creatinine levels remained the same in both groups at baseline and post 3 months. EGFR was significantly reduced in group A, and not in group B for 3 months. Even through weight, BMI, SBP, and DBP are slightly reduced in both groups at 3 months, it was not significant [Table 2].

Table 2: Within-group comparison between baseline and post-3 months

Parameter	Group A (connected care) N=230			Group B (conventional care) N=201		
	Baseline	3 months	p-value	Baseline	3 months	p-value
HbA1c	8.6±1.3	6.9±0.8	<0.001*	8.5±1.4	7.5±0.8	<0.001*
TC	202±27.8	148.8±14.8	<0.005*	204.7±25.8	185.5±11.4	0.035*
HDL	42.2±9.3	45.4±6.1	0.065	42.7±9.4	44.9±6.2	0.068
LDL	123.5±17.6	75.25±9.8	<0.001*	124.5±15.0	110.3±18.2	0.024*
TG	245.5±59.9	165.7±29.1	<0.005*	243.0±58.4	200.3±34.2	0.041*
SGOT/AST	47.4±10.8	36.2±11.5	<0.05*	47.8±10.8	42.7±7.8	0.048*
SGPT/ALT	45.9±10.7	34.5±11.2	0.062	47.1±10.5	41.5±9.8	0.043*
Creatinine	1.1±0.2	1.0±0.1	0.074	1.1±0.2	1.0±0.1	0.067
eGFR	72.2±3.2	74.5±4.8	0.04*	70.1±1.2	72.2±8.2	0.72
Weight	80.5±11.9	78.5±11.8	0.41	81.5±11.7	80.2±12.3	0.049*
BMI	29.7±4.5	28.9±4.5	0.41	30.0±4.6	29.5±4.0	0.46
SBP	131±17.1	130.2±11.6	0.32	129.6±17.6	128.2±11.9	0.39
DBP	81.3±11.3	80.1±8.7	0.25	80.0±11.3	78.5±9.0	0.21
*Statistically significant (p<0.05)						
HbA1c, Glycated hemoglobin; TC, Total cholesterol; HDL, High density lipoprotein; LDL, Low density lipoprotein; TG, Triglycerides; SGOT/AST, Aspartate aminotransferase; SGPT/ALT, Alanine aminotransferase; eGFR, Estimated glomerular filtration rate; BMI, Body mass index; SBP, Systolic blood pressure; DBP, Diastolic blood pressure.						

At the end of the study, HbA1c, TC, LDL, TG, SGOT/AST, and SGPT/ALT were significantly lower in group A, compared to group B [Figure 1].
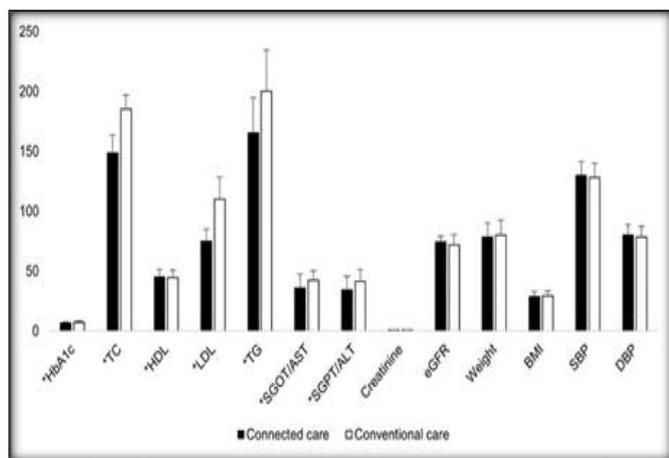

Figure 1: Comparison of clinical variables between group A and group B at the end of 3 months

*Statistically significant (p<0.005)
HbA1c, Glycated hemoglobin; TC, Total cholesterol; HDL, High density lipoprotein; LDL, Low density lipoprotein; TG, Triglycerides; SGOT/AST, Aspartate aminotransferase;

SGPT/ALT, Alanine aminotransferase; eGFR, Estimated glomerular filtration rate; BMI, Body mass index; SBP, Systolic blood pressure; DBP, Diastolic blood pressure.

A majority percentage of population had no incidence of hypoglycemia (< 70mg/dl) in group A (37.6%), compared to group B (30%) (Figure 2). However, in group B, hypoglycemia was evaluated based on symptoms like tiredness, excessive sweating, increased heart rate, shivering, excess hunger etc.
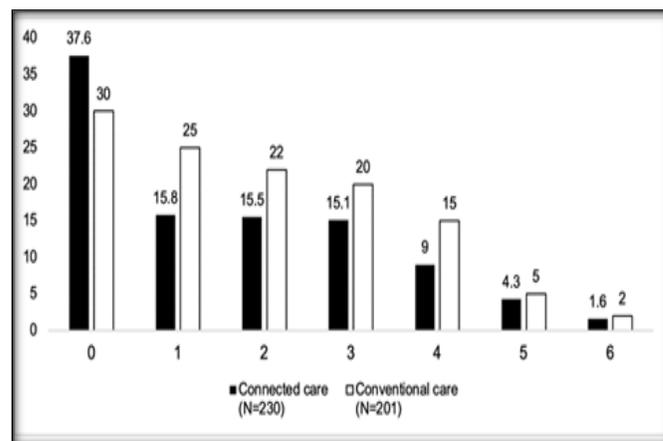

Figure 2: Incidence of Hypoglycemia in group A and group

DISCUSSION

In this study of 504 individuals with T2DM, both groups demonstrated significant reductions in HbA1c after three months. However, the improvement was more pronounced in the connected care group (6.9 ± 0.8 vs. 7.5 ± 0.8; p = 0.012). These findings are consistent with existing literature. Rasmussen et al. reported in a study of 40 T2DM patients that telemedicine achieved a greater percentage reduction in HbA1c compared to standard care (14.6% vs. 10.6%; p = 0.016) over six months.[13]

Meta-analyses also reinforce this evidence. A systematic review including 32 RCTs (5108 participants) demonstrated a significant reduction in HbA1c with telemedicine (MD = −0.70; p < 0.01).[13] Similarly, Suhlrie et al,[14] reported reductions in HbA1c across 11 studies (MD = −0.07%), with a stronger effect observed among individuals with overweight or obesity (MD = −0.13%, 95% CI −0.21 to −0.05, I² = 28%). Notably, these improvements were more consistent in short- and medium-term interventions (<12 months) than in long-term studies (≥12 months). De Groot et al,[15] in a meta-analysis of 43 studies, confirmed a significant HbA1c reduction (−0.486%; p < 0.001) with telemedicine interventions, while an umbrella review also highlighted a clinically meaningful HbA1c decline of ≤ −0.5%.[16]

Our study also found significant reductions in TC, LDL, TG, SGOT/AST, and SGPT/ALT in the connected care group compared with conventional care. Contrastingly, a meta-analysis of 21 RCTs (10,732 patients) reported no significant differences in TC (−0.10 mmol/L), LDL (0.08 mmol/L), or TG (−0.08 mmol/L) with telemedicine, though it still recommended its use for improving glycemic control.[17]

While weight, BMI, SBP, and DBP reductions were not statistically significant in our study, previous evidence has reported mixed results. Some meta-analyses demonstrated significant improvements in weight,[14,15,17] BMI,[14,15,17] SBP,[17] and DBP.[15,17] Conversely, Timpel et al,[16] analyzing 46 studies, concluded that telemedicine did not produce a clinically meaningful impact on blood pressure, while Eberle et al,[18] suggested that evidence regarding blood pressure and body weight remains limited despite some positive findings. Another meta-analysis similarly found no significant effect of telemedicine on BMI (MD = −0.27; p = 0.35).[19]

Importantly, our study noted a lower incidence of hypoglycemia in the connected care group, with 37.6% reporting no events compared to 30% in conventional care. This aligns with a meta-analysis of 14 studies (N = 1324), which reported a significant reduction in hypoglycemic episodes with telemedicine (OR = 0.42; p < 0.00001).[19] Furthermore, an Indian retrospective study involving 1000 T2DM patients found that 84% of individuals using telemedicine reported no hypoglycemic events over six months, supporting its effectiveness in reducing treatment-related adverse outcomes.[11]

Overall, our findings strengthen the growing body of evidence that telemedicine or connected care enhances glycemic control, improves selected metabolic outcomes, and reduces the risk of hypoglycemia in T2DM, particularly in resource-constrained settings.

CONCLUSION

With the global rise in diabetes prevalence, innovative strategies are essential to improve care delivery and outcomes. Telemedicine offers a practical and effective approach for managing T2DM, particularly in underserved and rural populations where access to comprehensive care is limited. Findings from this study demonstrated significant benefits of connected care in improving glycemic control and selected metabolic parameters, supporting evidence from previous research worldwide. We recommend integrating telemedicine into standard diabetes management for patients willing to engage in connected care. Healthcare providers should actively adopt and promote telemedicine services to optimize diabetes outcomes and enhance patient-centered care.

Conflicts of interest
There are no conflicts of interest.

REFERENCES

1. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care. 2013 Jan;36 Suppl 1(Suppl 1):S67-74.
2. Galicia-Garcia U, Benito-Vicente A, Jebari S, Larrea-Sebal A, Siddiqi H, Uribe KB, et al. Pathophysiology of Type 2 Diabetes Mellitus. Int J Mol Sci. 2020 Aug 30;21(17):6275.
3. Cerf ME. Beta cell dysfunction and insulin resistance. Front Endocrinol (Lausanne). 2013;4:37.
4. Magliano DJ, Boyko EJ, IDF Diabetes Atlas 10th edition scientific committee. IDF DIABETES ATLAS [Internet]. 10th ed. Brussels: International Diabetes Federation; 2021 [cited 2025 Aug 27]. (IDF Diabetes Atlas). Available from: http://www.ncbi.nlm.nih.gov/books/NBK581934/
5. WHO. Diabetes in India [Internet]. 2025 [cited 2025 Aug 27]. Available from: https://www.who.int/india/diabetes
6. Cade WT. Diabetes-related microvascular and macrovascular diseases in the physical therapy setting. Phys Ther. 2008 Nov;88(11):1322–35.
7. International Diabetes Federation. Diabetes and cardiovascular disease. [Internet]. International Diabetes Federation, Brussels, Belgium; 2016 [cited 2025 Aug 27]. Available from: www.idf.org/cvd
8. World Health Organization. Global report on diabetes [Internet]. World Health Organization; 2016 [cited 2025 Aug 27]. Available from: https://www.who.int/publications/i/item/9789241565257
9. Ghosh A, Gupta R, Misra A. Telemedicine for diabetes care in India during COVID19 pandemic and national lockdown period: Guidelines for physicians. Diabetes Metab Syndr. 2020;14(4):273–6.
10. Pradeepa R, Rajalakshmi R, Mohan V. Use of Telemedicine Technologies in Diabetes Prevention and Control in Resource-Constrained Settings: Lessons Learned from Emerging Economies. Diabetes Technol Ther. 2019 June;21(S2):S29–216.

11. Kesavadev J, Shankar A, Pillai PBS, Krishnan G, Jothydev S. Cost-effective use of telemedicine and self-monitoring of blood glucose via Diabetes Tele Management System (DTMS) to achieve target glycosylated hemoglobin values without serious symptomatic hypoglycemia in 1,000 subjects with type 2 diabetes mellitus--a retrospective study. Diabetes Technol Ther. 2012 Sept;14(9):772–6.

12. Dhediya R, Chadha M, Bhattacharya AD, Godbole S, Godbole S. Role of Telemedicine in Diabetes Management. J Diabetes Sci Technol [Internet]. 2022 Feb 28 [cited 2025 Aug 27];17(3):775–81. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10210114/

13. Xie W, Dai P, Qin Y, Wu M, Yang B, Yu X. Effectiveness of telemedicine for pregnant women with gestational diabetes mellitus: an updated meta-analysis of 32 randomized controlled trials with trial sequential analysis. BMC Pregnancy Childbirth. 2020 Apr 6;20(1):198.

14. Suhlrie L, Ayyagari R, Mba C, Olsson K, Torres-Aparcana H, James S, et al. The effectiveness of telemedicine in the prevention of type 2 diabetes mellitus: a systematic review and meta-analysis of interventions. Diabetes & Metabolic Syndrome: Clinical Research & Reviews [Internet]. 2025 May 1 [cited 2025 Aug 27];19(5):103252. Available from: https://www.sciencedirect.com/science/article/pii/S1871402125000694

15. De Groot J, Wu D, Flynn D, Robertson D, Grant G, Sun J. Efficacy of telemedicine on glycaemic control in patients with type 2 diabetes: A meta-analysis. World J Diabetes. 2021 Feb 15;12(2):170–97.

16. Timpel P, Oswald S, Schwarz PEH, Harst L. Mapping the Evidence on the Effectiveness of Telemedicine Interventions in Diabetes, Dyslipidemia, and Hypertension: An Umbrella Review of Systematic Reviews and Meta-Analyses. J Med Internet Res. 2020 Mar 18;22(3):e16791.

17. Alfarwan N, Hodkinson A, Panagioti M, Hassan L, Kontopantelis E. Clinical and cost-effectiveness of telemedicine among patients with type 2 diabetes in primary care: A systematic review and meta-analysis. Diabet Med. 2024 Aug;41(8):e15343.

18. Eberle C, Stichling S. Clinical Improvements by Telemedicine Interventions Managing Type 1 and Type 2 Diabetes: Systematic Meta-review. J Med Internet Res. 2021 Feb 19;23(2):e23244.

19. Hu Y, Wen X, Wang F, Yang D, Liu S, Li P, et al. Effect of telemedicine intervention on hypoglycaemia in diabetes patients: A systematic review and meta-analysis of randomised controlled trials. J Telemed Telecare. 2019 Aug;25(7):402–13.