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Evaluation of the Medical Utilization of the Telemedicine Pilot Project for Patients With Diabetes Based on Korean National Health Insurance Claims Data

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ABSTRACT

Background: Numerous studies have explored blood sugar management in patients with diabetes through telemedicine. However, since the implementation of the telemedicine pilot project, no studies have assessed changes in healthcare utilization for diabetes. This study examined medical outcomes and utilization among diabetes patients comparing telemedicine to traditional in-person care, focusing on medical utilization, care continuity, prescription adherence, and safety.
Methods: This study used data from the National Health Insurance Service to identify patients with diabetes who did or did not receive telemedicine. We analyzed medical utilization, medical sustainability, prescription continuity, and safety through propensity score matching (PSM). To evaluate the telemedicine pilot project's impact, changes and differences in outcome indicators were calculated using a Difference-in-Differences (DID) approach.
Results: After PSM, the total number of patients in the telemedicine group (Tele_G) and the face-to-face treatment group (Control_G) was 59,954 each. Medical utilization of telemedicine decreased in both groups, but the DID was 0.16 (−0.04 in Tele_G vs. −0.20 in Control_G, $P < 0.001$). Medical continuity also differed significantly between the Tele_G and Control_G (all $P < 0.001$). The DIDs for the ratio of diabetes medication prescription days and appropriate prescription continuation rate were 0.95 (−0.72 vs. −1.67, $P < 0.001$) and 1.26 (−1.80 vs. −3.07, $P < 0.001$), respectively, with statistically significant differences. There were no significant differences in hospitalization experience for safety assessment (DID = −0.14, $P = 0.139$) or emergency room visits (DID = 0.00, $P = 0.950$).
Conclusion: DID analysis revealed the potential of the telemedicine pilot project, with slightly lower continuity than face-to-face care; hence, it is acceptable as a supplementary service. To improve this, a telemedicine system specializing in diabetes and blood glucose management is needed, along with a clear protocol that allows patient blood glucose data to be integrated into the telemedicine platform.

Keywords: Delivery of Health Care; Diabetes Mellitus; Telemedicine; Korea

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INTRODUCTION

Globally, telemedicine has gained significant attention as a solution to challenges in healthcare accessibility and efficiency.[1] In response, Korea launched a telemedicine pilot project on June 1, 2023, creating an opportunity to evaluate the broader impact of telemedicine on the healthcare system.[2] This telemedicine pilot project builds on Korea's strong foundation of research, which has demonstrated the feasibility and effectiveness of telemedicine, particularly in managing chronic conditions such as type 2 diabetes mellitus (T2DM).[3-8]

Diabetes management, requiring continuous monitoring and timely interventions, is particularly well-suited for telemedicine.[9] By eliminating geographical and physical barriers, telemedicine can significantly enhance access to care for patients with diabetes.[5] Furthermore, it promotes self-management through consistent engagement, empowering patients to actively manage their condition.[10,11] Despite these advantages, questions remain about the comparability of telemedicine to traditional in-person care, particularly regarding patient compliance, continuity of care, and overall safety. Addressing these concerns is critical to ensuring that telemedicine meets the rigorous standards required for effective diabetes care.

To date, no research has specifically evaluated telemedicine pilot projects. This study focused on patients with diabetes to explore differences in medical outcomes and utilization between those receiving telemedicine and those receiving traditional in-person care. Specifically, it examines key aspects such as medical utilization, continuity of care, prescription adherence, and safety. These indicators are vital for assessing care quality, especially for chronic diseases like diabetes, where sustained engagement and precise interventions are essential to prevent complications and improve outcomes.

METHODS

Study population

The National Health Insurance Corporation operates a data-sharing service for policy establishment and academic research using national health information data. This study was conducted using Korean National Health Insurance Service (NHIS) data. Because the National Health Insurance Corporation's claims data are provided after being anonymized, patient consent was not required. Patients who received outpatient treatment for diabetes from June 1 to December 14, 2023, were eligible. Diabetes was defined as patients taking diabetes medication among those diagnosed with International Classification of Diseases-10 codes E11–E14. Patients who received at least one non-face-to-face medical treatment during the study period were categorized as telemedicine group (Tele_G), while those who received in-person care were categorized as control group (Control_G).

Study design

Sociodemographic factors, including sex, age, health insurance subscriber classification (local household head/member, employee subscriber/dependent, or medical benefit recipient), and health insurance premium quintile (0, 1–5, 6–10, 11–15, 16–20), were considered covariates. Clinical factors included severity, calculated using the Charlson comorbidity index (CCI; CCI < 3, $3 \leq$ CCI < 6, ≥ 6) based on illness records from the past year.[12] Additionally, hypertension history and smoking status were taken into consideration.

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Effectiveness evaluation of telemedicine pilot project

To reduce confounding factors between the groups, propensity score matching (PSM) was conducted before applying the Difference-in-Differences (DID) analysis.[13] The independent variables used in the double difference analysis were whether or not the policy was used (Control_G = 0; Tele_G = 1), before and after policy implementation (before policy implementation = 0, after policy implementation = 1), and whether or not the policy was used as an interaction term before and after policy implementation (time).

Medical utilization

Medical utilization was measured by the number of outpatient visits. For both groups, the number of visits to medical institutions (number of claims) for T2DM, as a common condition, was recorded.

Medical sustainability

Medical sustainability was assessed using three indices: 1) the Continuity of Care Index (COC), measuring care consistency from the same provider; 2) the Most Frequent Provider Continuity (MFPC), indicating the proportion of care provided by the most-visited provider; and 3) the Modified, Modified Continuity Index (MMCI), measuring continuity of care across providers. All indices ranged from 0 to 1, with higher values indicating better continuity of care.

Continuity of prescriptions

Continuity of prescriptions was measured using two indicators: 1) the Medication Possession Ratio and 2) the appropriate prescription persistence rate. The prescription day rate was calculated as the total number of days patients with diabetes were prescribed medications during the study period. Results from the research period (June 1, 2023, to December 14, 2023) were compared with those from the prior period (June 1, 2022, to December 14, 2022). The proportion of patients in the appropriate prescription persistence group was defined as the percentage of participants with a daily prescription rate ≥ 80%, reflecting proper medication adherence.

Safety

Safety was evaluated by assessing hospitalization or emergency treatment for T2DM, a condition classified as part of Ambulatory Care Sensitive Conditions, for which hospitalization or emergency visits are generally preventable with proper outpatient care. These metrics were used to evaluate the appropriateness (quality) of diagnosis and chronic disease management. Appropriateness can thus be assessed through these measures.[14]

DID

DID analysis was employed to compare differences between the two matched groups. DID estimates the net effect of implementing the telemedicine pilot project. It distinguishes between the Tele_G and Control_G, comparing outcomes before and after the project's implementation. The analysis aims to isolate the pure policy impact by calculating changes and differences in outcome indicators during the post-implementation period.[15] The DID method assumes that, without the policy, the Tele_G and Control_G would have followed parallel trends over time. Therefore, factors explaining differences in results between the two groups should remain unchanged, except for the policy's implementation.[16] In this study, PSM was performed before applying the DID analysis to determine the confounding factors between the two groups and ensure balanced group distributions. The independent variables in the DID analysis were whether or not the policy was used (face-to-face treatment users = 0, telemedicine users = 1), before and after policy implementation (before policy implementation = 0, after policy implementation = 1), and whether or not the policy was used (policy). It was set as an interaction term before and after policy implementation (time).

Statistical analysis

Continuous variables were expressed as means with standard deviations (SDs) and compared using Student's *t*-test. Categorical variables were presented as frequencies and percentages, with comparisons conducted using the χ^2 test. Outcome variables were reported as the mean of all paired differences. To address potential confounding factors, a propensity score (PS) analysis was conducted to create a matched cohort of patients differing in their use of telemedicine versus face-to-face medical treatment but otherwise similar in measured baseline characteristics. The PS, defined as the conditional probability of receiving telemedicine treatment given a set of covariates, was estimated using a logistic regression model. The baseline covariates included age, sex, Health Insurance Subscriber Classification, Health Insurance Premium, residential area, CCI, hypertension history, and smoking status. Patients in the telemedicine and face-to-face groups were matched 1:1 using nearest-neighbor matching without replacement, employing a greedy matching algorithm. A caliper of 0.2 SD of the logit of the PS was used. The balance between groups was assessed using standardized mean differences (SMDs), with a threshold of ≤ 0.10 indicating adequate balance. All statistical analyses were performed using SAS (version 9.4; SAS Institute, Cary, NC, USA). Two-tailed *P* values < 0.05 were considered statistically significant.

Ethics statement

This study was approved by the Research Ethics Review Committee of the Korea Institute of Health and Medical Research (NECA IRB 23-020). No informed consent was required from patients due to the nature of public data from NHIS.

RESULTS

Among patients with diabetes, 1.5% (60,085/4,138,021) received telemedicine treatment, while 98.5% (4,077,936/4,138,021) were in the Control_G (**Table 1**). After PSM, which significantly reduced all SMDs to below 0.01 (data not shown), the total number of patients in the Tele_G and Control_G was 59,954 each. A total of 119,908 patients participated, with 54.8% (32,844/59,954) being male and 45.2% (27,110/59,954) female, showing no statistical difference in sex distribution. The mean age of patients in the Tele_G was 64.7 ± 13.4 years, while in the Control_G, it was 64.7 ± 13.1 years. Across both groups, the largest proportion of patients was aged 60–69 years (30.2%, 18,078/59,954), followed by those aged 50–59 years (24.4%, 14,618/59,954), ≥ 80 years (17.1%, 10,250/59,954), and 70–79 years (16.7%, 10,029/59,954). Patients with a CCI < 3 formed the majority (59.9%, 35,908/59,954). Additionally, 65.1% (39,504/59,954) had hypertension, and 64.8% (38,868/59,954) were current smokers.

Medical utilization: number of outpatient visits

The number of outpatient visits before and after policy implementation was analyzed for the 59,954 individuals in both the Tele_G and Control_G (**Table 2**). In the Tele_G, outpatient visits decreased by −0.04 (from 4.79 to 4.75 cases), while in the Control_G, outpatient visits decreased by −0.20 (from 3.92 to 3.72 cases). DID analysis revealed a statistically significant

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Table 1. Baseline characteristics

Characteristics	Before PSM (n = 4,138,021)			After PSM (n = 119,908)		
	Tele_G	Control_G	*P* value	Tele_G	Control_G	*P* value
No. of patients	60,085	4,077,936		59,954	59,954	
Sex			< 0.001			1.000
Male	32,902 (54.8)	2,287,392 (56.1)		32,844 (54.8)	32,844 (54.8)	
Female	27,183 (45.2)	1,790,544 (43.9)		27,100 (45.2)	27,100 (45.2)	
Age, yr	64.7 ± 13.4	65.4 ± 12.4	< 0.001	64.7 ± 13.4	64.7 ± 13.1	1.000
0–9	0 (0.0)	76 (0.0)	< 0.001	0 (0.0)	0 (0.0)	1.000
10–19	43 (0.1)	4,116 (0.1)		39 (0.1)	39 (0.1)	
20–29	326 (0.5)	18,562 (0.5)		302 (0.5)	302 (0.5)	
30–39	1,242 (2.1)	74,762 (1.8)		1,218 (2.0)	1,218 (2.0)	
40–49	5,445 (9.1)	316,238 (7.8)		5,420 (9.0)	5,420 (9.0)	
50–59	14,634 (24.4)	821,873 (20.2)		14,618 (24.4)	14,618 (24.4)	
60–69	18,085 (30.1)	1,308,929 (32.1)		18,078 (30.2)	18,078 (30.2)	
70–79	10,041 (16.7)	977,578 (24.0)		10,029 (16.7)	10,029 (16.7)	
≥ 80	10,269 (17.1)	555,802 (13.6)		10,250 (17.1)	10,250 (17.1)	
Health insurance subscriber classification			< 0.001			1.000
Local household head	13,438 (22.4)	932,676 (22.9)		13,411 (22.4)	13,411 (22.4)	
Local household member	7,025 (11.7)	438,742 (10.8)		6,988 (11.7)	6,988 (11.7)	
Employee subscriber	18,755 (31.2)	1,162,821 (28.5)		18,723 (31.2)	18,723 (31.2)	
Employee dependent	17,137 (28.5)	1,268,975 (31.1)		17,108 (28.5)	17,108 (28.5)	
Medical benefit recipient	3,730 (6.2)	274,722 (6.7)		3,724 (6.2)	3,724 (6.2)	
Health insurance fraction quintile			< 0.001			1.000
0	3,732 (6.2)	274,938 (6.7)		3,724 (6.2)	3,724 (6.2)	
1–5	15,247 (25.4)	969,773 (23.8)		15,210 (25.4)	15,210 (25.4)	
6–10	9,013 (15.0)	580,260 (14.2)		8,970 (15.0)	8,970 (15.0)	
11–15	14,128 (23.5)	897,809 (22.0)		14,104 (23.5)	14,104 (23.5)	
16–20	17,965 (29.9)	1,355,156 (33.2)		17,946 (29.9)	17,946 (29.9)	
Residential area			< 0.001			1.000
Seoul	8,455 (14.1)	675,527 (16.6)		8,451 (14.1)	8,451 (14.1)	
Incheon	4,228 (7.0)	239,642 (5.9)		4,222 (7.0)	4,222 (7.0)	
Gyeonggi	13,188 (22.0)	1,013,904 (24.9)		13,180 (22.0)	13,180 (22.0)	
Gangwon	928 (1.5)	148,883 (3.7)		920 (1.5)	920 (1.5)	
Sejong	275 (0.5)	19,687 (0.5)		266 (0.4)	266 (0.4)	
Daejeon	2,414 (4.0)	107,476 (2.6)		2,408 (4.0)	2,408 (4.0)	
Chungbuk	2,193 (3.7)	141,599 (3.5)		2,190 (3.7)	2,190 (3.7)	
Chungnam	2,664 (4.4)	188,998 (4.6)		2,656 (4.4)	2,656 (4.4)	
Gwangju	2,574 (4.3)	101,255 (2.5)		2,561 (4.3)	2,561 (4.3)	
Jeonbuk	3,638 (6.1)	161,479 (4.0)		3,627 (6.1)	3,627 (6.1)	
Jeonnam	3,509 (5.8)	179,130 (4.4)		3,501 (5.8)	3,501 (5.8)	
Daegu	4,327 (7.2)	186,852 (4.6)		4,312 (7.2)	4,312 (7.2)	
Ulsan	1,076 (1.8)	80,885 (2.0)		1,068 (1.8)	1,068 (1.8)	
Busan	3,303 (5.5)	282,912 (6.9)		3,295 (5.5)	3,295 (5.5)	
Gyeongbuk	4,020 (6.7)	243,872 (6.0)		4,013 (6.7)	4,013 (6.7)	
Gyeongnam	2,903 (4.8)	259,607 (6.4)		2,900 (4.8)	2,900 (4.8)	
Jeju	390 (0.7)	46,228 (1.1)		384 (0.6)	384 (0.6)	
CCI			< 0.001			1.000
CCI < 3	35,941 (59.8)	2,418,275 (59.3)		35,908 (59.9)	35,908 (59.9)	
3 ≤ CCI < 6	15,634 (26.0)	1,042,013 (25.6)		15,575 (26.0)	15,575 (26.0)	
6 ≤ CCI	8,510 (14.2)	617,648 (15.2)		8,471 (14.1)	8,471 (14.1)	
Missing	0 (0.0)	0 (0.0)		0 (0.0)	0 (0.0)	
Hypertension history	39,113 (65.1)	2,529,956 (62.0)	< 0.001	39,054 (65.1)	39,054 (65.1)	1.000
Smoking status			< 0.001			1.000
Current smoking	38,889 (64.7)	2,829,637 (69.4)		38,868 (64.8)	38,868 (64.8)	
Non-smoking	12,262 (20.4)	725,483 (17.8)		12,201 (20.4)	12,201 (20.4)	
Missing	8,934 (14.9)	522,816 (12.8)		8,885 (14.8)	8,885 (14.8)	

Values are presented as numbers (percentages) for categorical variables and means ± standard deviations for continuous variables.
PSM = propensity score matching, Tele_G = telemedicine group, Control_G = control group, CCI = Charlson Comorbidity Index.

Table 2. Utilization of medical care measured by the number of outpatient visits

Variables	Tele_G	Control_G	DID (*P* value)
Total	59,954	59,954	
2022	4.79	3.92	
2023	4.75	3.72	
△2023–2022	−0.04	−0.20	0.16 (*P* < 0.001)
Age, yr			
50–59	14,618	14,618	
2022	4.69	3.80	
2023	4.68	3.61	
△2023–2022	−0.01	−0.19	0.18 (*P* < 0.001)
60–69	18,078	18,078	
2022	4.83	3.87	
2023	4.83	3.69	
△2023–2022	0.00	−0.19	0.19 (*P* < 0.001)
70–79	10,029	10,029	
2022	5.05	4.14	
2023	4.97	3.95	
△2023–2022	−0.08	−0.18	0.10 (*P* = 0.018)
≥ 80	10,250	10,250	
2022	4.84	4.19	
2023	4.66	3.91	
△2023–2022	−0.18	−0.28	0.11 (*P* = 0.023)

Tele_G = telemedicine group, Control_G = control group, DID = difference-in-differences.

difference between the groups ($P < 0.001$). In a comparative analysis of individuals ≥ 50 years who actively received telemedicine for diabetes, the DID was 0.18 (−0.01 vs. −0.19, $P < 0.001$) for those aged 50–59 years, 0.19 (0.001 vs. −0.19, $P < 0.001$) for those aged 60–69 years, 0.10 (−0.08 vs. −0.18, $P = 0.018$) for those aged 70–79 years, and 0.11 (−0.18 vs. −0.28, $P = 0.023$) for those aged ≥ 80 years, all showing significant differences.

Medical sustainability

The three medical sustainability indicators—COC, MMCI, and MFPC—all demonstrated high values close to 1.000 (**Table 3**). For COC, medical sustainability in the Tele_G decreased by 0.008 (from 0.960 to 0.952), while it increased in the Control_G by 0.001 (from 0.954 to 0.955), resulting in a statistically significant difference between the groups (DID = −0.009, $P < 0.001$). For both MMCI and MFPC, medical sustainability decreased in the Tele_G (−0.004 in MMCI and −0.005 in MFPC), while slight increases were observed in the Control_G (+0.001 in MMCI and MFPC). Statistically significant differences were noted

Table 3. Medical sustainability based on various formulas

Variables	Tele_G (n = 59,954)	Control_G (n = 59,954)	DID (*P* value)
COC			
2022	0.960	0.954	
2023	0.952	0.955	
△2023–2022	−0.008	0.001	−0.009 (< 0.001)
MMCI			
2022	0.976	0.974	
2023	0.972	0.975	
△2023–2022	−0.004	0.001	−0.005 (< 0.001)
MFPC			
2022	0.977	0.976	
2023	0.972	0.977	
△2023–2022	−0.005	0.001	−0.006 (< 0.001)

Tele_G = telemedicine group, Control_G = control group, DID = difference-in-differences, COC = continuity of care index, MMCI = modified, modified continuity index, MFPC = most frequent provider continuity.

between the Tele_G and Control_G for both indicators (DID for MMCI = −0.005, DID for MFPC = −0.006, $P < 0.001$ for both).

Continuity of prescriptions

Ratio of the number of prescription days

The ratio of diabetes medication prescription days before and after the implementation of the telemedicine pilot project policy decreased by 0.72% (from 96.10 to 95.37) in the Tele_G and by 1.67% (from 96.18 to 94.51) in the Control_G (**Table 4**). The DID between the groups was 0.95 (−0.72 vs. −1.67, $P < 0.001$), indicating statistical significance. For patients aged 50–59 years, the DID was 0.93 (−0.17 vs. −1.11, $P < 0.001$), while for those aged 60–69 years, it was 0.87 (−0.24 vs. −1.11, $P < 0.001$). Among those aged 70–79 years, the DID was 1.03 (−0.93 vs. −1.96, $P = 0.001$), and for patients aged ≥ 80 years, it was 0.86 (−2.43 vs. −3.28, $P = 0.011$). These results demonstrated statistically significant differences in all age groups between the Tele_G and Control_G.

Ratio of those who continue to receive appropriate prescriptions (≥ 80%)

The proportion of appropriate prescription continuation rates (≥ 80%) decreased by 1.80% (from 90.51 to 88.71) in the Tele_G and by 3.07% (from 91.06 to 87.99) in the Control_G. The DID between the groups was 1.26 (−1.80 vs. −3.07, $P < 0.001$), showing statistical significance. The DID for those aged 60–69 years was 1.90 (−0.67 vs. −2.57, $P < 0.001$), indicating a significant difference. The DID for those aged 50–59 years was 0.93 (−1.00 vs. −1.92, $P = 0.083$), for those aged 70–79 years was 0.49 (−2.86 vs. −3.35, $P = 0.355$), and for those aged ≥ 80 years was 0.71 (−4.95 vs. −5.66, $P = 0.218$). However, no statistically significant difference was observed between the Tele_G and Control_G in these age groups.

Safety

Hospital admission rate

Hospital admissions due to diabetes during the process of receiving treatment (**Table 5**) increased by 0.09 cases (from 1.06 to 1.15) in the Tele_G and by 0.23 cases (from 1.38 to

Table 4. Comparison of the impact of telemedicine on prescription persistence in patients with diabetes

Variables	Ratio of the No. of prescription days			Ratio of those who continue to receive appropriate prescriptions		
	Tele_G	Control_G	DID (*P* value)	Tele_G	Control_G	DID (*P* value)
Total	59,954	60		59,954	60	
2,022	96	96		91	91	
2,023	95	95		89	88	
△2023–2022	−0.72	−1.67	0.95 (*P* < 0.001)	−1.80	−3.07	1.26 (*P* < 0.001)
50–59, yr	14,618	14,618		14,618	14,618	
2,022	94	95		89	89	
2,023	94	94		88	87	
△2023–2022	−0.17	−1.11	0.93 (*P* < 0.001)	−1.00	−1.92	0.93 (*P* = 0.083)
60–69, yr	18,078	18,078		18,078	18,078	
2,022	97	97		93	93	
2,023	97	96		92	90	
△2023–2022	−0.24	−1.11	0.87 (*P* < 0.001)	−0.67	−2.57	1.90 (*P* < 0.001)
70–79, yr	10,029	10,029		10,029	10,029	
2,022	98	98		94	94	
2,023	97	97		91	91	
△2023–2022	−0.93	−1.96	1.03 (*P* = 0.001)	−2.86	−3.35	0.49 (*P* = 0.355)
≥ 80, yr	10,250	10,250		10,250	10,250	
2,022	98	98		93	94	
2,023	96	95		88	88	
△2023–2022	−2.43	−3.28	0.86 (*P* = 0.011)	−4.95	−5.66	0.71 (*P* = 0.218)

Tele_G = telemedicine group, Control_G = control group, DID = difference-in-differences.

Table 5. Safety comparison of telemedicine

Variables	Hospital admission rate			Emergency room visit rate		
	Tele_G	Control_G	DID (*P* value)	Tele_G	Control_G	DID (*P* value)
Total	59,954	59,954		59,954	59,954	
2022	1.06	1.38		0.05	0.15	
2023	1.15	1.61		0.06	0.17	
△2023–2022	0.09	0.23	−0.14 (P = 0.139)	0.01	0.02	0.00 (P = 0.950)
50–59, yr	14,618	14,618		14,618	14,618	
2022	0.55	0.99		0.01	0.11	
2023	0.54	1.07		0.03	0.12	
△2023–2022	−0.01	0.08	−0.09 (P = 0.543)	0.02	0.01	0.01 (P = 0.752)
60–69, yr	18,078	18,078		18,078	18,078	
2022	0.80	1.17		0.03	0.13	
2023	0.88	1.44		0.03	0.13	
△2023–2022	0.08	0.27	−0.19 (P = 0.219)	0.00	0.00	0.01 (P = 0.896)
70–79, yr	10,029	10,029		10,029	10,029	
2022	1.71	1.75		0.11	0.15	
2023	1.79	1.89		0.07	0.15	
△2023–2022	0.08	0.14	−0.05 (P = 0.851)	−0.04	0.00	−0.04 (P = 0.564)
≥ 80, yr	10,250	10,250		10,250	10,250	
2022	2.02	2.12		0.08	0.20	
2023	2.33	2.83		0.15	0.27	
△2023–2022	0.31	0.71	−0.40 (P = 0.179)	0.07	0.07	−0.01 (P = 0.905)

Tele_G = telemedicine group, Control_G = control group, DID = difference-in-differences.

1.61) in the Control_G before and after the implementation of the telemedicine pilot project. However, the DID between the groups was −0.14 (0.09 vs. 0.23, P = 0.139), showing no statistical significance. Among patients aged 50–59, 60–69, 70–79, and ≥ 80 years, the DID was −0.09 (P = 0.543), −0.19 (P = 0.219), −0.05 (P = 0.851), and −0.40 (P = 0.179), respectively. No significant differences were observed between the Tele_G and Control_G in any age group.

Emergency room visit rate

Emergency room visit rate did not differ significantly between the Tele_G and Control_G, with the DID being 0.00 (0.01 vs. 0.02, P = 0.950). Even when comparing the DID across all age groups > 50 years, no statistically significant difference was observed between the Tele_G and Control_G. For those aged 50–59 years (DID = 0.01, P = 0.752), 60–69 years (DID = 0.01, P = 0.896), 70–79 years (DID = −0.04, P = 0.564), and ≥ 80 years (DID = −0.01, P = 0.905), no significant difference was observed between the Tele_G and Control_G across all age groups.

DISCUSSION

This study, conducted from June to December 2023, matched telemedicine users for diabetes management with non-telemedicine users using PSs to ensure comparable characteristics. Medical utilization (number of outpatient visits), differences in medical continuity, prescription persistence (prescription days rate, prescription continuation group ratio), and safety were assessed to evaluate changes before and after the telemedicine pilot project. The study utilized the DID concept, addressing the limitations of simple pre-post comparisons, which cannot account for natural changes over time or external influences.[17] DID is an analytical method that estimates the net effect of implementing the telemedicine pilot project. This method distinguishes between the Tele_G and Control_G, analyzing changes in outcome indicators before and after the implementation of the pilot project.[18] By identifying differences attributable to the policy, DID calculates the pure policy impact.[15] The DID method assumes that, without the policy intervention, both groups would have followed a parallel trend over time. By comparing changes under this assumption, DID isolates the policy's true effect and is widely used to evaluate policy effectiveness.

In terms of medical utilization, a more significant decrease was observed in the Tele_G compared to the Control_G. This may reflect positive factors, such as improved medical efficiency and patient preference, as well as negative factors, including unintended consequences of telemedicine. Telemedicine reduces the need for hospital visits by enabling patients to receive care more conveniently. For example, efficient medical services can be provided based solely on blood sugar data, eliminating the need for direct hospital visits.[19] This is particularly relevant for patients whose diabetes is well-managed, reducing the frequency of face-to-face checkups. However, some patients may prefer telemedicine due to its convenience or to avoid the time and effort of visiting a hospital. These preferences could result in fewer hospital visits, even when face-to-face care might be more beneficial. Such trends could distort patient decisions based on the inconvenience of hospital visits, emphasizing the importance of preserving doctors' autonomy.[20] The 2024 telemedicine guidelines address this by specifying that doctors can refuse telemedicine and recommend face-to-face care without it being considered a refusal of treatment.[21] Additionally, telemedicine may reduce the total number of visits for certain patients, as simpler cases are managed remotely, while complex evaluations are postponed until face-to-face appointments. For instance, patients relying exclusively on telemedicine might miss health issues or diagnoses that could have been identified during in-person care. Thus, fewer visits may not always equate to better health outcomes. In conclusion, the reduction in hospital visits among telemedicine users likely results from a combination of efficient healthcare delivery and patient-centered factors. While minimizing unnecessary visits is a positive outcome, it is essential to ensure that this trend does not obscure gaps in care continuity or unresolved health issues. Further research should investigate whether fewer visits are associated with better health outcomes or signify behavioral changes requiring monitoring and intervention.

In terms of medical sustainability, both the telemedicine and non-Tele_Gs demonstrated high continuity, with values close to 1. However, while medical continuity remained consistently high in the Control_G before and after the pilot project, a declining trend was observed in the Tele_G. This decline in continuity within the Tele_G warrants serious consideration. In telemedicine, where face-to-face interactions with medical staff are absent, communication becomes inherently less dynamic. This reduction in interaction depth may lead to less thorough discussions of treatment plans and consultations. Consequently, patients may perceive their treatment plans as less significant, potentially reducing their motivation over time. For chronic diseases such as diabetes, continuous stimulation and encouragement are essential—not only from doctors but also for patients to maintain self-monitoring.[22,23] A lack of such reinforcement could eventually create gaps in care continuity. While diabetes management can often rely solely on data without hospital visits, the role of a reliable medical system that provides continuous and objective support remains critical.[24] Ultimately, this suggests the need for integration with a diabetes management platform that can provide patient blood glucose and related data. For telemedicine to be successfully established, a medical device or application tailored to meet the hospital's goals is essential, along with a standardized patient management platform. Additionally, gaining experience in different scenarios is required for effective blood glucose management.

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The prescription daily rate decreased in both groups; however, the decrease was more pronounced in the Control_G, suggesting that in face-to-face treatment, drug prescriptions are more flexibly adjusted to the patient's condition. In contrast, in telemedicine, physicians tended to repeat existing prescriptions without modification. This reflects a relatively cautious approach by medical professionals toward telemedicine prescribing. Such conservative behavior may stem from telemedicine's intrinsic limitations, which exclude direct physical examinations like auscultation, percussion, and palpation.[25,26] The relatively smaller decrease in prescription days in telemedicine highlights the intention of medical staff to minimize risks stemming from limited face-to-face assessments. It may also represent a strategy for closer clinical monitoring. In telemedicine settings, where physical examinations are not feasible, clinicians may feel less confident issuing new prescriptions. Ultimately, telemedicine for diabetes management has largely focused on repetitive medication prescriptions. This differs from the concept of care, where proper blood glucose management is achieved without the need for in-person hospital visits. Notably, there is still a need for a dedicated, face-to-face care system specialized in diabetes and blood glucose control.

In patients with diabetes, the rate of continuation of appropriate prescriptions > 80% was significantly lower in the Control_G than in the Tele_G, with patterns varying by age group. This suggests that, as noted earlier, telemedicine's limitations—including reduced in-person interactions and follow-up—affected prescribing continuity. Face-to-face treatment has the advantage of quickly assessing the patient's condition and immediately adjusting the medication prescription accordingly.[27] Because face-to-face treatment involves direct interaction, the patient's symptoms or condition can be more accurately assessed, making prescription changes smoother. In contrast, telemedicine often faces challenges in assessing the patient's condition in real-time.[27] Relying on patient information alone can lead to inaccurate assessments of the patient's actual health status, leading to repeated or poorly adjusted prescriptions. Our results underscore the need to develop tailored strategies to enhance telemedicine, especially for older adults who may require additional support.

Despite the short study period, there was no significant difference in hospitalization or emergency room visit rates due to diabetes between patients receiving telemedicine and those receiving face-to-face treatment. This suggests that telemedicine is as safe as in-person care for managing mild cases of diabetes. However, it is important to consider that patients with mild diabetes may have intentionally chosen or been more likely to select telemedicine. The Tele_G may have been composed of patients with mild disease or high health literacy who selected this treatment option independently; therefore, caution is needed in interpreting the results. This selection bias may have exaggerated the safety findings,[28] as patients with fewer complications tend to have lower rates of hospitalization or emergency visits, regardless of treatment modality. Ultimately, this underscores the importance of physician discretion, highlighting the potential utility of non-face-to-face diabetes management when this discretion is emphasized. This aligns with the principle of stratified care, which ensures efficient healthcare resource allocation by employing less resource-intensive interventions for less severe cases. Telehealth's capacity to provide physician discretion, timely monitoring, prescription coordination, and patient education likely contributed to stable blood sugar levels in these patients, reducing the likelihood of acute events requiring hospitalization or emergency visits.

Diabetes is one of the diseases most suitable for telemedicine.[5-7] If patients effectively communicate their blood sugar levels to medical staff, blood sugar management can generally proceed without physical examinations, auscultation, percussion, or palpation. While hospital visits remain necessary for evaluating diabetes-related complications, telemedicine significantly reduces the frequency of these visits. However, the findings of this study indicate that telemedicine alone, without any hospital visits, has certain limitations. In the current era, where patients have the autonomy to choose telemedicine, it is often used for effective blood sugar management but is also frequently chosen for convenience.[29] As telemedicine continues to expand, relying solely on traditional treatment methods—such as assessing blood sugar status via HbA1c and adjusting medications or insulin accordingly—may not fully address patient needs. Instead, integrating telemedicine with comprehensive evaluations of patient conditions, blood sugar trends, and lifestyle data is necessary. To that end, new approaches to managing patients with diabetes must be considered, and telemedicine-specific diabetes guidelines should be developed to meet these evolving demands. Such guidelines will ensure effective, personalized care in telemedicine settings.

This study, which used NHIS data retrospectively, has several limitations. First, causal relationships cannot be clearly established due to the retrospective cohort design.[30] However, as mentioned above, this study used the DID concept to evaluate policy effectiveness rather than simply comparing before and after telemedicine pilot projects. This method is widely recognized as the most effective for estimating the policy effects of telemedicine pilot projects. Second, the lack of laboratory findings objectively proving patients' clinical outcomes is a limitation. Clinical effects were analyzed solely through outpatient visits and drug prescriptions, introducing potential bias. Since most telemedicine occurred in private practices, confirming laboratory findings was challenging. Future large-scale prospective studies are needed to address this issue. Additionally, patient socioeconomic characteristics, comorbidities, and tendencies to opt for telemedicine should also be investigated.

This study is the first to examine the effectiveness of telemedicine for diabetes using NHIS data, highlighting the importance of physician discretion in determining which patients benefit most from face-to-face care. The telemedicine pilot project appears to be progressing successfully, demonstrating meaningful potential in diabetes care. While telemedicine showed comparable safety and effectiveness in managing mild diabetes, it also revealed limitations such as reduced prescription continuity and diminished depth of clinical interaction. Ensuring physician autonomy is critical for maintaining treatment consistency, patient safety, and optimal outcomes. Additionally, a "patient classification-based hybrid care model," where patients with mild/chronic diabetes are encouraged to use telemedicine and those with acute disease/multiple comorbidities are directed toward in-person care, should be considered as a policy approach. These findings provide a foundation for understanding the role of telemedicine in diabetes management and underscore the need for personalized strategies that integrate both telemedicine and in-person care based on patient needs. Ultimately, developing a telemedicine system tailored to diabetes and glucose management will be essential for improving long-term care quality.

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