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Medication and Lifestyle Adherence among Older Adults with Type 2 Diabetes Receiving Telenursing Versus Traditional Outpatient Care: A Cross-Sectional Comparative Study

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ABSTRACT

Introduction: Older adults with type 2 diabetes mellitus face multimorbidity and other age-related barriers to adherence, and Saudi evidence comparing telenursing with traditional outpatient nursing care is limited. **Methods:** An analytical cross-sectional comparative study of 743 adults aged 60 years and older at Hafr Al-Batin Diabetes Center, Saudi Arabia, recruited by convenience sampling (telenursing, n = 362; traditional outpatient, n = 381). Medication adherence was measured with the Arabic Adherence to Refills and Medications Scale and lifestyle modification with the Perceived Adherence Lifestyle Modification Questionnaire; item-level *p* values were adjusted using the Benjamini-Hochberg procedure and a multivariable logistic regression model was fitted. **Results:** Total medication adherence (d=0.10), total lifestyle modification (d=−0.06) and mean HbA1c (d = −0.10) were comparable between the groups. After correction for multiple testing, telenursing participants forgot their medication more often (d=0.22) and were less likely to refill a prescription before running out (d=0.31), both small effects. Care modality was not independently associated with adherence category after adjustment (adjusted odds ratio 1.37, p = 0.062). **Conclusion:** The modalities were comparable on every summary measure, differences being confined to specific behaviours with small effect sizes. As the design was cross-sectional and non-randomized, these findings describe associations and do not establish equivalence. Telenursing appears feasible for routine follow-up and may benefit from structured medication reminders and refill follow-up.

Keywords: Lifestyle; Lifestyle Modification; Medication Adherence; Older Adults; Telenursing; Type 2 Diabetes Mellitus

INTRODUCTION

Type 2 diabetes mellitus (T2DM) affects an estimated 589 million adults worldwide, a figure projected to reach 853 million by 2050 (Genitsaridi *et al*., 2026), and Saudi Arabia carries a particularly high burden, affecting about one quarter of adults (Alwadeai & Alhammad, 2023). Older adults carry a disproportionate share and, because of age-related physiological change, multimorbidity, and functional limitation, are more likely to experience inadequate glycemic control, complications, and hospitalization (American Diabetes Association Professional Practice Committee[ADAPPC], 2024, 2025).

Effective management depends on medication adherence and lifestyle modification, the extent to which medication taking, diet and activity correspond with agreed clinical recommendations (Sabaté, 2003). Poor adherence is common and is associated with poor glycemic control, disease progression and hospitalization (Hisni & Nurani, 2025), and is harder for older adults because of polypharmacy, cognitive decline, limited physical ability and low health literacy (Mulyaningsih *et al*., 2026). The two domains are linked, and nurse-delivered education improves both (Agustina *et al*., 2026).

Interest in telenursing for chronic disease management has grown since the COVID-19 pandemic. It can improve access, continuity and convenience, particularly for people with limited mobility (Lo Monaco *et al*., 2025), nurses delivering self-management education, medication counseling and reminders, lifestyle guidance and psychosocial support by telephone and video. Comparative evidence is thinner than it appears. The meta-analyses showing benefit compare protocol-driven telehealth with usual care rather than with face-to-face

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nursing: across 18 studies telehealth improved medication adherence in T2DM with a standardized mean difference of 0.50 (Gurcay *et al*., 2024), and across 20 studies it improved HbA1c, self-management and the medication-adherence component of self-care (Liu *et al*., 2024). Direct comparisons with in-person care are far fewer: a review of synchronous telemedicine versus in-person primary care found only seven eligible studies, three comparing groups directly (Mabeza *et al*., 2022)—biomarkers rather than adherence behavior, and structured programs rather than routine telenursing.

Saudi Arabia has incorporated telenursing into its Vision 2030 health transformation strategy and virtual services have expanded rapidly (Alabdulaali *et al*., 2025; Saudi Ministry of Health, 2023), but Saudi research has focused on glycemic control or satisfaction. No identified study has compared medication-taking and lifestyle behavior between older adults receiving routine telenursing and routine face-to-face follow-up in an Arabic-speaking population, so whether routine telenursing, delivered without reminder systems or behavioral protocols, is associated with the same adherence as face-to-face care is untested. That is the question addressed here.

Aim of the Study

Two research questions were addressed: whether medication adherence, as a total score and as a category, differs between older adults with T2DM receiving telenursing and those receiving traditional outpatient nursing care; and whether lifestyle modification, as a total score and as a perceived-adherence classification, differs between them. The design being observational, the study describes associations rather than estimating an effect.

METHODOLOGY

Study Design

An analytical cross-sectional comparative design was used to compare patient-reported adherence across two care delivery models at a single point in time (Setia, 2016), participants receiving whichever modality they were already using. The study is reported in accordance with the STROBE statement (von Elm *et al*., 2007).

Setting

The study was conducted at Hafr Al-Batin Diabetes Center, a specialized facility within Hafr Al-Batin Health Cluster, Saudi Arabia, which delivers care through two virtual clinics by telephone and video and two face-to-face outpatient clinics, alongside endocrinology consultation, diabetic foot care, nutritional counseling and pharmaceutical services.

Both modalities were routine services rather than a study-specific intervention. Telenursing was provided by qualified nurses through scheduled telephone and video consultations and the traditional group received the same core services in person: self-management education, medication review and reminders, lifestyle counseling and review of self-monitored blood glucose. Frequency, duration and content followed each patient's management plan rather than a fixed schedule.

Participants and Sampling

The eligible population comprised 11,859 older adults with T2DM registered at the center, taken from its own 2024 appointment records on the Ministry of Health Mawid platform (telenursing, N = 3,953; traditional outpatient, N = 7,906). Slovin's formula, $n = N / (1 + Ne^2)$, with a 5% margin of error, applied separately to each subpopulation (Sevilla *et al*., 1992), gives minimum samples of 363 and 381; the achieved telenursing sample was 362, one short of that minimum.

Participants were recruited by convenience sampling from patients attending appointments during the data collection period, recruitment continued until the calculated sample size was reached in each group. In total 362 telenursing and 381 traditional outpatient patients consented, met every eligibility criterion and completed all instruments, and all 743 were analyzed: none was excluded after data collection and there were no missing data on either outcome. The number approached was not recorded separately from the number

recruited, so no response rate can be reported.

Participants were eligible if they were aged 60 years or older, had T2DM for at least six months, had received their current modality for at least three months, were cognitively able to consent and complete the tools, and could read and respond in Arabic or English. They were excluded if they had dementia or other severe cognitive impairment, an acute psychiatric condition, hearing or visual impairment preventing completion, or had used both modalities in the preceding three months.

Data Collection Tools

Three tools were used, each available in Arabic and English so participants could respond in their preferred language. A structured questionnaire recorded sociodemographic and clinical data, including comorbidities, diabetes duration, medication type and most recent HbA1c. The Adherence to Refills and Medications Scale (ARMS) has 12 items scored 1 to 4, totaling 12 to 48, where **lower** scores indicate better adherence and totals classify adherence as good (12-16), moderate (17-24) or poor (25-48) (Kripalani *et al*., 2009); the validated Saudi Arabic version was used (Alammari *et al*., 2021). The Perceived Adherence Lifestyle Modification Questionnaire (PALM-Q) has 18 items scored 1 to 4, totaling 18 to 72, where **higher** scores indicate better adherence and totals classify adherence as non-adherence (≤ 31), unpredictable (32-53) or presumed adherence (≥ 54) (Nor *et al*., 2022) — the opposite direction to the ARMS, signaled wherever the two appear together.

No Arabic PALM-Q existed, so it was translated by forward and back translation, reviewed for content and cultural appropriateness by three community health nursing professors, and pilot tested in 30 patients meeting the study criteria who were not in the main sample. The Arabic ARMS was adopted on the basis of its performance in Saudi Arabia (alpha 0.802; test-retest intraclass correlation 0.97) (Alammari *et al*., 2021). Internal consistency for the Arabic PALM-Q was 0.64 in the pilot, below the conventional 0.70 threshold; no item was removed, because the instrument was used as published and its developers validated it with Rasch measurement rather than alpha (Nor *et al*., 2022).

Data Collection Procedure

Data was collected over two months, between 15 February and 15 April 2025, by the investigator and trained research assistants. Administration was standardized in three respects: every data collector received the same briefing on reading items aloud verbatim without prompting; the instruments were given in a fixed sequence; and the same wording introduced the study and the response options in both groups. Traditional outpatient participants completed the questionnaire during a clinic visit, by interviewer administration where reading or vision made self-completion difficult, and telenursing participants by telephone or secure online survey after their consultation.

Data Analysis

Data was analyzed using Stata version 17. Continuous variables were compared using independent samples *t*-tests and categorical variables using chi-square tests, or a Monte Carlo Fisher-Freeman-Halton exact test where more than 5% of expected counts fell below five. Effect sizes accompany every test: mean differences with 95% confidence intervals and Cohen's d for continuous outcomes, prevalence differences and odds ratios for categorical outcomes, with telenursing as the index group (Cohen, 1988). The 12 ARMS items, the 18 PALM-Q items and the correlate analyses each formed a family of related tests, so p values within each family were adjusted using the Benjamini-Hochberg procedure and reported as q values, each correlate family comprising 22 tests, one per variable examined (Benjamini & Hochberg, 1995). A binary logistic regression was then fitted, with medication adherence dichotomized as moderate-to-high versus poor and regressed on care modality, age, sex, education, diabetes duration, income and employment ($p < 0.05$, two-tailed); age was entered in completed years and duration as the four-level ordinal score.

Ethical Considerations

The protocol received preliminary approval from the Scientific Research Ethics Committee, Faculty of Nursing, Cairo University, Egypt, on 30 September 2024, the decision being issued on 3 November 2024 under

study number 2024-09-10, and final approval from the same committee on 23 April 2025.

Approval for data collection in Saudi Arabia was granted by the Institutional Review Board of Riyadh Second Health Cluster, Ministry of Health, on 10 February 2025 (IRB log number 25-073E; category: exempt; KACST registration H-01-R-012, OHRP/NIH registration IRB00010471, Federal Wide Assurance FWA00018774). Informed consent was obtained from all participants after the purpose, voluntary nature, right of withdrawal and data protection arrangements had been explained, in writing for in-person participants and digitally for the telenursing group. Data were anonymized.

RESULTS

Participant Characteristics

The groups were comparable on most sociodemographic variables, with no differences in age, sex, marital status, education or income (all $p > 0.05$; Table 1). Age was recorded and compared in five-year bands rather than as a mean, and the distributions did not differ ($\chi^2 = 1.69$, $p = 0.639$), the largest band in both groups being 75 years and over (29.0% and 32.3%); the pooled mean was 70.24 ± 5.99 years. Employment was the one difference ($\chi^2 = 23.04$, $p < 0.001$): 30.1% of the telenursing group were in paid employment against 18.4% of the traditional group (odds ratio 1.91, 95% CI 1.36 to 2.70).

Table 1: Sociodemographic Characteristics by Care Modality (n = 743)

Personal data	Telenursing group (n=362)		Traditional group (n=381)		χ2	*P*-value
	No.	%	No.	%		
Age in years						
60 -< 65	82	22.6	74	19.4	1.69	0.639
65- < 70	103	28.5	105	27.6		
70 - < 75	72	19.9	79	20.7		
≥ 75	105	29.0	123	32.3		
Total age $\bar{X}$ ± SD= 70.24±5.994						
Gender						
Male	195	53.9	213	55.9	0.31	0.577
Female	167	46.1	168	44.1		
Marital status						
Married	324	89.5	336	88.2	0.56	0.905
Widowed	12	3.3	16	4.2		
Divorced	16	4.4	19	5.0		
Separated	10	2.8	10	2.6		
Education						
No formal education	46	12.7	48	12.6	1.26	0.737
Primary	61	16.8	60	15.7		
Secondary	203	56.1	207	54.3		
Higher education (e.g., college, university)	52	14.4	66	17.3		
Employment status						
Employed	109	30.1	70	18.4	23.04	.000*
Unemployed	227	62.7	299	78.5		
Retired	26	7.2	12	3.1		
Monthly Household Income						
Insufficient to meet household needs	57	15.7	52	13.6	5.87	0.053
Sufficient to meet household needs	230	63.5	221	58.0		
More than sufficient to meet household needs	75	20.7	108	28.3		

*Note: Column percentages within each modality. "Not in paid employment" covers those not working and not drawing a retirement pension. *p < 0.05*

The groups were similar in diabetes duration, family history, smoking and HbA1c category (all $p > 0.05$; Table 2), and mean HbA1c was comparable (8.22 ± 1.03% versus 8.33 ± 1.10%; mean difference −0.10 percentage points, 95% CI −0.26 to 0.05; $d = -0.10$). Principal comorbid condition differed ($\chi^2 = 25.12$, $p < 0.001$), hypertension being more common under telenursing (61.0% versus 43.3%; odds ratio 2.05) and kidney disease under traditional care (18.9% versus 13.3%; odds ratio 0.66). Medication type also differed ($\chi^2 = 7.22$, $p = 0.027$), driven by the residual "other agents" category (8.0% versus 14.2%; odds ratio 0.53) rather than by insulin use (odds ratio 1.18, 95% CI 0.87 to 1.58).

Table 2: Clinical Characteristics by Care Modality (n = 743)

Medical data	Telenursing group (*n*=362)		Traditional group (*n*=381)		*χ2*	*P*-value
	No.	%	No.	%		
Other medical conditions or chronic diseases						
Cardiovascular disease	35	9.7	52	13.6	25.11	0.000*
Hypertension	221	61.0	165	43.3		
Kidney disease	48	13.3	72	18.9		
Neuropathy	25	6.9	31	8.1		
Retinopathy	19	5.2	31	8.1		
Other	14	3.9	30	7.9		
HbA1C						
<7.0% = good control	32	8.8	32	8.4	2.076	0.354
7.0–8.5% = higher risk of complications	227	62.7	222	58.3		
>8.5% = poor control	103	28.5	127	33.3		
	$\bar{X}$	SD	$\bar{X}$	SD	*t*-test	*p*-value
	8.22	1.033	8.32	1.102	-1.314	0.189
Total $\bar{X}$ ± SD= 8.275 ±1.069						
Family history of Type II diabetes						
Yes	80	22.1	87	22.8	0.05	0.810
No	282	77.9	294	77.2		
Duration of Type II diabetes						
Less than one year	66	18.2	46	12.1	6.50	0.090
One to two years	103	28.5	115	30.2		
From three years to five years	102	28.2	127	33.3		
More than five years	91	25.1	93	24.4		
The type of drug currently used						
Insulin injections	145	40.1	138	36.2	7.22	0.027*
Oral anti diabetic medication	188	51.9	189	49.6		
Others	29	8.0	54	14.2		
Smoking						
Smoker	67	18.5	85	22.3	1.65	0.437
Former smoker	47	13.0	48	12.6		
Non-smoker	248	68.5	248	65.1		

*Note: Mean HbA1c 8.28 ± 1.07%. Column percentages within each modality. Comorbidity was recorded as a single principal condition per participant, the one identified as mainly affecting their health, so the categories are mutually exclusive and sum to the group total. *p* < 0.05*

Medication Adherence

Total ARMS scores did not differ (mean difference 0.42, 95% CI −0.16 to 0.99; $d = 0.10$; $p = 0.159$), indicating comparable overall adherence (Table 3). Two items differed after correction, both favoring traditional care and both small: telenursing participants forgot their medication more often ($d = 0.22$) and were less likely to refill before running out ($d = 0.31$). By ARMS category, good, moderate and poor adherence were recorded for 31 (8.6%), 222 (61.3%) and 109 (30.1%) telenursing and 31 (8.1%), 257 (67.5%) and 93 (24.4%) traditional participants ($\chi^2(2) = 3.34$, $p = 0.188$); collapsed to moderate-to-high versus poor, 253 (69.9%) and 288 (75.6%) met the criterion.

Table 3: ARMS Items and Total Score by Care Modality (n = 743)

ARMS Item	Telenursing M (SD)	Traditional M (SD)	Mean Difference (95% CI)	*d*	*q*	Favors
Forget to take Medication	2.36 (1.09)	2.12 (1.09)	0.24 (0.08, 0.40)	0.22	0.016*	Traditional
Decide to stop Medication	1.20 (0.40)	1.24 (0.43)	−0.03 (−0.09, 0.03)	−0.08	0.445	—
Forget to Pack Medicines	1.23 (0.42)	1.18 (0.38)	0.05 (0.00, 0.11)	0.13	0.237	—
Medication-taking rate	2.18 (1.06)	2.22 (0.97)	−0.05 (−0.19, 0.10)	−0.05	0.634	—
Stop medication without Advice	1.67 (1.01)	1.79 (1.03)	−0.12 (−0.27, 0.02)	−0.12	0.237	—
Stop Medication when Feeling Better	1.88 (1.14)	1.96 (1.15)	−0.07 (−0.24, 0.09)	−0.06	0.538	—
Stop Medication when Feeling Unwell	2.45 (1.10)	2.38 (1.17)	0.07 (−0.09, 0.23)	0.06	0.538	—
Miss Doses Carelessly	2.29 (1.08)	2.16 (1.01)	0.13 (−0.02, 0.28)	0.12	0.237	—
Change Doses without Advice	2.02 (1.19)	2.15 (1.28)	−0.13 (−0.31, 0.05)	−0.11	0.289	—
Forget Multi-daily Doses	2.03 (1.14)	1.99 (1.15)	0.05 (−0.12, 0.21)	0.04	0.634	—
Delay Refill due to Cost	1.38 (0.87)	1.35 (0.87)	0.02 (−0.10, 0.15)	0.03	0.705	—
Refill before Running Out	1.69 (1.04)	1.42 (0.65)	0.26 (0.14, 0.39)	0.31	< 0.001*	Traditional
Total ARMS score	**22.39 (4.25)**	**21.97 (3.79)**	**0.42 (−0.16, 0.99)**	**0.10**	—	—

*Note: Mean difference = telenursing minus traditional. On the ARMS a higher score indicates poorer adherence, so a positive difference favors the traditional group. q = p adjusted across the 12 items (Benjamini-Hochberg); items count as significant only at q < 0.05, and "Favors" is shown only for those. * q < 0.05*

Lifestyle Modification

Total PALM-Q scores were comparable (mean difference −0.23, 95% CI −0.77 to 0.31; $d = -0.06$; $p = 0.399$), as was the perceived-adherence classification: 260 telenursing participants (71.8%) and 295 traditional participants (77.4%) were classified presumed adherent and the rest unpredictable, none in either group as non-adherent $\chi^2(1) = 3.09$, $p = 0.079$). Six of the 18 items differed after correction (Table 4), three favoring each group and all small. The item on continuing medication while using herbal remedies was significant before correction ($p = 0.038$) but not after ($q = 0.098$); the remaining 11 did not differ.

Table 4: PALM-Q Items Differing After Correction, and Total Score, by Care Modality (n = 743)

PALM-Q item	Telenursing M (SD)	Traditional M (SD)	Mean difference (95% CI)	*d*	*q*	Favors
Increase vegetables per meal	3.51 (0.62)	3.37 (0.70)	0.14 (0.04, 0.23)	0.20	0.021*	Telenursing
Avoid unnecessary food temptations	3.14 (0.80)	3.38 (0.63)	−0.24 (−0.34, −0.14)	−0.33	< 0.001*	Traditional
Do not overeat after exercise	2.77 (1.06)	2.57 (0.86)	0.20 (0.06, 0.34)	0.21	0.021*	Telenursing
Make time for physical activity	3.22 (0.89)	3.53 (0.53)	−0.31 (−0.42, −0.21)	−0.43	< 0.001*	Traditional
Able to exercise alone	3.22 (1.04)	3.03 (0.99)	0.19 (0.05, 0.34)	0.19	0.030*	Telenursing
Motivated to exercise	2.92 (1.03)	3.17 (0.78)	−0.25 (−0.38, −0.12)	−0.27	0.001*	Traditional
Total PALM-Q score	**55.65 (4.18)**	**55.88 (3.30)**	**−0.23 (−0.77, 0.31)**	**−0.06**	—	—

*Note: Mean difference = telenursing minus traditional. On the PALM-Q a higher score indicates **better** adherence, the opposite of the ARMS, so a positive difference favors the telenursing group. q = p adjusted across all 18 items (Benjamini-Hochberg). The 12 items not shown did not differ. *q < 0.05*

Association between Lifestyle and Medication Adherence

In the traditional outpatient group, lifestyle classification was associated with medication adherence level ($\chi^2(2) = 13.23$, $p = 0.001$; Cramér's $V = 0.19$), but in the opposite direction to the one a reinforcing relationship would predict: the proportion showing unpredictable lifestyle adherence fell as medication adherence worsened, from 11 of 31 with good adherence (35.5%) through 66 of 257 with moderate adherence (25.7%) to 9 of 93 with poor adherence (9.7%). No such association appeared in the telenursing group ($\chi^2 = 3.45$, $p = 0.178$). The effect is small, rests on cells of 11 and 9 participants, and was neither pre-specified nor adjusted.

Correlates of each outcome were examined within each group, 22 tests per family. No medication adherence association survived correction (smallest $q = 0.157$ for income and smoking in the traditional group); for lifestyle adherence, education, income, employment, and comorbidity survived in the telenursing group, and diabetes duration in the traditional group. These exploratory analyses are superseded by the model below.

Multivariable Analysis

A binary logistic regression was fitted with medication adherence dichotomized as moderate-to-high versus poor (Table 5; 541 of 743 met the criterion). After adjustment, no variable was independently associated with the adherence category. The adjusted odds ratio for traditional care was 1.37 (95% CI 0.98 to 1.90, $p = 0.062$), barely moving from its unadjusted value of 1.33 (95% CI 0.96 to 1.84).

Table 5: Multivariable Logistic Regression of Medication Adherence (Moderate-to-High versus Poor) (n = 743)

Variable	Adjusted OR	95% CI	*p*
Care modality (traditional vs telenursing)	1.37	0.98 to 1.90	0.062
Age (per additional year)	1.02	0.99 to 1.05	0.231
Sex (female vs male)	1.10	0.79 to 1.53	0.566
Education (primary or less vs secondary or higher)	0.86	0.60 to 1.23	0.406
Diabetes duration (per one-category increase)	1.04	0.88 to 1.22	0.650
Income (not enough vs enough or more)	1.12	0.70 to 1.80	0.635
Employment (in paid employment vs not)	1.35	0.90 to 2.01	0.145

Note: The odds ratio for diabetes duration is per one-category increase. Comorbidity profile and medication type were not entered as covariates

DISCUSSION

The two modalities were comparable on every summary measure: total ARMS and PALM-Q scores did not differ, the intervals around both contained only values of no clinical importance, and mean HbA1c was similar. Expressing medication adherence as a category did not change the picture, the interval crossing the null before and after adjustment. The reading is consistent across the summed scores, both classifications and the adjusted model, and accords with the small comparative literature, in which telenursing and synchronous telemedicine achieve glycemic outcomes at least as good as in-person care (AkbariRad *et al*., 2023; Mabeza *et al*., 2022). The interval is nevertheless compatible with a modest advantage for face-to-face care, and the study was not powered to resolve a difference of that size.

At the item level, telenursing participants forgot medication more often and were less likely to refill before running out, both differences surviving correction but both small. They contrast with the structured telehealth models behind the pooled adherence benefit noted earlier, which incorporated reminder systems, motivational interviewing and behavioral reinforcement (Gurcay *et al*., 2024; İşleyen *et al*., 2025). Capacity to use remote services may contribute higher e-health literacy is associated with better self-care among Saudi adults with T2DM (AlShehri & Khojah, 2025). Routine telenursing without structured adherence support may therefore be insufficient to change daily medication taking.

The lifestyle findings show the same pattern, in line with evidence that telehealth supports self-management when behavioral support is regular (Alsahli *et al*., 2025; Ruiz-León *et al*., 2025). The six surviving item-level differences split three to each group, suggesting that remote care may suit behaviors that are task-oriented and individually manageable, whereas face-to-face contact may better support those depending on motivation and negotiation (Ma *et al*., 2022; Xiao & Han, 2023). The association between lifestyle classification and medication adherence in the traditional group ran counter to the expectation that self-management behaviors cluster. A behavioral explanation is implausible; a reporting one is not. Both instruments are self-reported and the PALM-Q showed a pronounced ceiling, no participant being classified non-adherent. Participants willing to disclose missed doses may be equally candid about lifestyle lapses, while those presenting their medication taking favorably may present diet and activity favorably too, which would produce this pattern without any difference in behavior. The findings are small, fragile and unadjusted.

The groups also differed at baseline in comorbidity profile and medication type. As the medication-type difference was driven by the residual category rather than by insulin use, insulin cannot serve as evidence that the traditional group carried greater complexity of disease. Baseline imbalance nevertheless remains a substantive threat, since comorbidity and medication type were not among the covariates and residual confounding by disease severity cannot be excluded (AlQassab *et al*., 2024).

Self-selection deserves particular emphasis, because patients chose their own modality. Employed participants were almost twice as likely to be receiving telenursing, most plausibly reflecting the convenience of remote appointments, and the same mechanism can act on characteristics never measured: confidence with telephone and video contact, distance from the center and mobility may draw patients toward telenursing, while those needing closer supervision, or judged by their clinicians to need in-person review, may remain in the clinic. Any of these could be associated with adherence independently of modality, and the comorbidity imbalance is consistent with such channeling by clinical need. Adjustment reaches only what was recorded, so this compares two populations as they use the two services, not two ways of treating the same patient.

Limitations

Several limitations qualify these findings. The cross-sectional design cannot establish causation, so these are associations only. Participants were not randomized and differed at baseline in employment, comorbidity,

and medication type; bivariate comparisons are unadjusted, and the model adjusted for sociodemographic characteristics and diabetes duration only, leaving residual confounding by disease severity possible. Both modalities were routine practice, so the frequency, content, and intensity of encounters varied and were not measured.

Both measures are self-reported and open to recall and social desirability bias, which may differ face to face and by telephone, and no objective indicator such as refill records was available. Internal consistency for the Arabic PALM-Q was 0.64; measurement error of that magnitude attenuates differences toward the null, so the absence of a total-score difference there is weaker evidence of similarity than the ARMS comparison, and that instrument also showed a marked ceiling, with no participant classified non-adherent.

Finally, Slovin's formula estimates sample size rather than conferring representativeness, recruitment was by convenience, and the calculation used a margin of error rather than a target effect size, so the implied precision overstates how far the sample represents the wider population. The number approached was not recorded separately from the number recruited, so no response rate can be given or non-response bias assessed, and age was recorded in bands, so group-specific means are unavailable. Category-level intervals were unadjusted for multiplicity, and surviving item-level findings remain exploratory, and the interval around the adjusted odds ratio spans both no difference and a modest advantage for face-to-face care, so this null result should not be read as equivalence. The single-center setting limits transferability.

Future Scope

Future research should use multicenter designs, probability sampling, and longitudinal or randomized approaches able to establish whether telenursing produces sustained change, with adjustment for comorbidity burden and insulin use; an Arabic PALM-Q with demonstrated internal consistency and objective adherence indicators also warrant examination.

CONCLUSION

Among older adults with type 2 diabetes attending a single Saudi diabetes center, medication adherence, lifestyle modification, and glycemic control were comparable between telenursing and traditional outpatient care, on the summed scores, on both classifications, and on medication adherence as a dichotomy, where the association with care modality did not reach significance before or after adjustment. Differences emerged only in specific behaviors—medication forgetting, prescription refilling, and physical activity—all with small effect sizes. Given the cross-sectional, non-randomized design and the self-selection of patients into each modality, these results describe associations and should not be read as establishing equivalence. Telenursing can reasonably be integrated into diabetes follow-up for older adults to improve access and continuity, with structured medication reminders, refill monitoring and physical activity counseling to strengthen adherence support, and periodic face-to-face review for patients needing closer monitoring.

CRediT Authorship Contribution Statement

O.A.A.: Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft. **N.M.A.:** Writing - review and editing, Supervision**. B.O.:** Conceptualization, Methodology, Formal analysis, Investigation, Writing - original draft, Supervision.

AI Assistance Declaration

Generative artificial intelligence tools were used for language editing only. They were not used for data collection, data analysis or interpretation of results.

Conflict of Interest

The authors declare that they have no competing interests.

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REFERENCES

Agustina, D., Makajil, J. D., Baddiri, B., Susanna, D., Maolinda, W., & Muthmainnah, M. (2026). Effectiveness of a diabetic educational module for the management of type 2 diabetes mellitus: A systematic review. *The Malaysian Journal of Nursing, 17*(3), 229-239. https://doi.org/10.31674/mjn.2026.v17i03.022

AkbariRad, M., Dehghani, M., Sadeghi, M., Torshizian, A., Saeedi, N., Sarabi, M., Sahebi, M., & Shakeri, M. T. (2023). The effect of telenursing on disease outcomes in people with type 2 diabetes mellitus: A narrative review. *Journal of Diabetes Research, 2023*, 4729430. https://doi.org/10.1155/2023/4729430

Alabdulaali, M. K., Aldossary, M. S., Alsubaie, M. S., Zaatari, E. S., & Alhomod, A. S. (2025). Digital transformation in telemedicine health care: A retrospective analysis of Seha Virtual Hospital outcomes in the Kingdom of Saudi Arabia. *Telemedicine and e-Health. 32*(1), 67–73. https://doi.org/10.1177/15305627251387590

Alammari, G., Alhazzani, H., AlRajhi, N., Sales, I., Jamal, A., Almigbal, T. H., Batais, M. A., Asiri, Y. A., & AlRuthia, Y. (2021). Validation of an Arabic version of the Adherence to Refills and Medications Scale (ARMS). *Healthcare, 9*(11), 1430. https://doi.org/10.3390/healthcare9111430

AlQassab, O., Kanthajan, T., Pandey, M., Francis, A. J., Sreenivasan, C., Parikh, A., & Nwosu, M. (2024). Evaluating the impact of telemedicine on diabetes management in rural communities: A systematic review. *Cureus, 16*(7), e64928. https://doi.org/10.7759/cureus.64928

Alsahli, M., Abd-Alrazaq, A., Fathy, D. M., Abdelmohsen, S. A., Gushgari, O. A., Ghazy, H. K., & Abdelwahed, A. Y. (2025). Effectiveness of patients' education and telenursing follow-ups on self-care practices of patients with diabetes mellitus: Cross-sectional and quasi-experimental study. *JMIR Nursing, 8*, e67339. https://doi.org/10.2196/67339

AlShehri, W. S., & Khojah, Y. Y. (2025). Impact of e-health literacy on diabetes self-care activities among people with type 2 diabetes attending primary healthcare centers in Makkah City, Saudi Arabia: A cross-sectional study, *2025. Cureus, 17*(7), e87968. https://doi.org/10.7759/cureus.87968

Alwadeai, K. S., & Alhammad, S. A. (2023). Prevalence of type 2 diabetes mellitus and related factors among the general adult population in Saudi Arabia between 2016-2022: A systematic review and meta-analysis of the cross-sectional studies. *Medicine, 102*(24), e34021. https://doi.org/10.1097/MD.0000000000034021

American Diabetes Association Professional Practice Committee. (2024). 2. Diagnosis and classification of diabetes: Standards of Care in Diabetes-2024. *Diabetes Care, 47*(Suppl. 1), S20-S42. https://doi.org/10.2337/dc24-S002

American Diabetes Association Professional Practice Committee. (2024). 2. Diagnosis and classification of diabetes: Standards of Care in Diabetes—2024. *Diabetes Care, 47*(Suppl. 1), S20–S42.https://doi.org/10.2337/dc25-S013

Benjamini, Y., & Hochberg, Y. (1995). Controlling the false discovery rate: A practical and powerful approach to

multiple testing. *Journal of the Royal Statistical Society: Series B (Methodological), 57*(1), 289-300. https://doi.org/10.1111/j.2517-6161.1995.tb02031.x

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Lawrence Erlbaum Associates.https://utstat.toronto.edu/~brunner/oldclass/378f16/readings/CohenPower.pdf

Genitsaridi, I., Salpea, P., Salim, A., Sajjadi, S. F., Tomic, D., James, S., Thirunavukkarasu, S., Issaka, A., Chen, L., Basit, A., Luk, A. O. Y., Ma, R. C. W., Mbanya, J. C., Ramachandran, A., Wild, S. H., Duncan, B. B., Boyko, E. J., & Magliano, D. J. (2026). 11th edition of the IDF Diabetes Atlas: Global, regional, and national diabetes prevalence estimates for 2024 and projections for 2050. *The Lancet Diabetes & Endocrinology, 14*(2), 149-156. https://doi.org/10.1016/S2213-8587(25)00299-2

Gurcay, B., Taskin Yilmaz, F., & Bilgin, A. (2024). The effectiveness of telehealth interventions on medication adherence among patients with type 2 diabetes: A meta-analysis. *Telemedicine and e-Health, 30*(1), 3-20. https://doi.org/10.1089/tmj.2023.0088

Hisni, D., & Nurani, I. A. (2025). The effect of nurse coaching program in preventing diabetes mellitus complications behaviours and improving HbA1c in patients with type 2 DM: A pilot study. *The Malaysian Journal of Nursing, 16*(4), 122-131. https://doi.org/10.31674/mjn.2025.v16i04.012

İşleyen, E. K., Özdemir, İ. N., & Yoldemir, Ş. A. (2025). The effect of tele-nursing based motivational interviewing on self-efficacy, self-management and metabolic control parameters in individuals with type 2 diabetes: Randomized controlled study. *Irish Journal of Medical Science, 194*(2), 563-573. https://doi.org/10.1007/s11845-025-03916-5

Kripalani, S., Risser, J., Gatti, M. E., & Jacobson, T. A. (2009). Development and evaluation of the Adherence to Refills and Medications Scale (ARMS) among low-literacy patients with chronic disease. *Value in Health, 12*(1), 118-123. https://doi.org/10.1111/j.1524-4733.2008.00400.x

Liu, F., Li, J., Li, X., Yang, Z., Wang, W., Zhao, L., Wu, T., Huang, C., & Xu, Y. (2024). Efficacy of telemedicine intervention in the self-management of patients with type 2 diabetes: A systematic review and meta-analysis. *Frontiers in Public Health, 12*, 1405770. https://doi.org/10.3389/fpubh.2024.1405770

Lo Monaco, M., Profeta, A., & Corrao, S. (2025). Telenursing as an effective ally for improving patient outcomes in diabetes? An umbrella review. *Nursing Open, 12*(7), e70265. https://doi.org/10.1002/nop2.70265

Ma, Y., Zhao, C., Zhao, Y., Lu, J., Jiang, H., Cao, Y., & Xu, Y. (2022). Telemedicine application in patients with chronic disease: A systematic review and meta-analysis. *BMC Medical Informatics and Decision Making, 22*(1), 105. https://doi.org/10.1186/s12911-022-01845-2

Mabeza, R. M., Maynard, K., & Tarn, D. M. (2022). Influence of synchronous primary care telemedicine versus in-person visits on diabetes, hypertension, and hyperlipidemia outcomes: A systematic review. *BMC Primary Care, 23*(1), 52. https://doi.org/10.1186/s12875-022-01662-6

Mulyaningsih, N., Wahyuni, E. D., Hermawati, D., & Ardika, N. A. (2026). Nursing-based diabetes self-management education for controlling peripheral artery disease in type 2 diabetes: A quasi-experimental study. *The Malaysian Journal of Nursing, 17*(3), 39-46. https://doi.org/10.31674/mjn.2026.v17i03.005

Nor, N. M., Mohd Shukri, N. A., & Sidek, S. (2022). The development and validation of Perceived Adherence Lifestyle Modification Questionnaire (PALM-Q) among type 2 diabetes mellitus patients. *Human Nutrition & Metabolism, 30*, 200166. https://doi.org/10.1016/j.hnm.2022.200166

Ruiz-León, A. M., Casas, R., Castro-Barquero, S., Alfaro-González, S., Radeva, P., Sacanella, E., Casanovas-Garriga, F., Pérez-Gesalí, A., & Estruch, R. (2025). Efficacy of a mobile health-based behavioral treatment for lifestyle modification in type 2 diabetes self-management: Greenhabit randomized controlled trial. *Journal of*

Medical Internet Research, 27, e58319. https://doi.org/10.2196/58319

Sabaté, E. (Ed.). (2003). *Adherence to long-term therapies: Evidence for action*. World Health Organization. https://www.paho.org/sites/default/files/WHO-Adherence-Long-Term-Therapies-Eng-2003.pdf

Saudi Ministry of Health. (2023). *Health Sector Transformation Program achievements report 2023*. Saudi Vision 2030. https://www.vision2030.gov.sa/media/xznnx3vz/hstp-annual-report-2023-en.pdf

Setia, M. S. (2016). Methodology series module 3: Cross-sectional studies. *Indian Journal of Dermatology, 61*(3), 261-264. https://doi.org/10.4103/0019-5154.182410

Sevilla, C. G., Ochave, J. A., Punsalan, T. G., Regala, B. P., & Uriarte, G. G. (1992). *Research methods* (Rev. ed.). Rex Book Store. https://plm-library.pinnacle.edu.ph/cgi-bin/koha/opac-detail.pl?biblionumber=27383&shelfbrowse_itemnumber=32993

von Elm, E., Altman, D. G., Egger, M., Pocock, S. J., Gøtzsche, P. C., & Vandenbroucke, J. P. (2007). The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for reporting observational studies. *The Lancet, 370*(9596), 1453-1457. https://doi.org/10.1016/S0140-6736(07)61602-X

Xiao, Z., & Han, X. (2023). Evaluation of the effectiveness of telehealth chronic disease management system: Systematic review and meta-analysis. *Journal of Medical Internet Research, 25*, e44256. https://doi.org/10.2196/44256