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Sick-Day Knowledge, Recalled Education, and Intended Medication Management Among Adults Prescribed Sodium–Glucose Cotransporter 2 Inhibitors in Jenin, Palestine: A Cross-Sectional Study

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Abstract

Sodium–glucose cotransporter 2 (SGLT2) inhibitors can precipitate diabetic ketoacidosis with normal or mildly elevated glucose, particularly during acute illness, fasting, volume depletion, or surgery; safe use therefore depends on patients recognizing when to seek advice and temporarily withhold treatment. This clinic-based cross-sectional survey evaluated sick-day knowledge and intended self-management among 207 adults with type 2 diabetes prescribed an SGLT2 inhibitor in Jenin, Palestine. A structured, interviewer-administered Arabic questionnaire assessed five knowledge domains, attitudes, recalled sick-day education, intended action during acute illness, previous continuation during illness, and information sources. Associations were examined using chi-square testing, logistic regression, and HC3-robust linear regression; a strict knowledge-scoring sensitivity analysis was performed. The mean Knowledge Score was 2.44 out of 5 (SD 1.56). Only 48.8% recalled receiving sick-day education, 77.3% reported an appropriate intended action, and 70.4% reported previously continuing treatment during illness. Recalled education was associated with appropriate intended action both before adjustment (OR 5.71, 95% CI 2.59–12.60) and after adjustment for age, gender, educational attainment, and diabetes duration (adjusted OR 5.39, 95% CI 2.39–12.13). Older age was associated with lower knowledge ($b = -0.301$, $p = 0.003$), whereas the positive association with educational attainment was not retained under strict scoring. Recognition of ketoacidosis without marked hyperglycemia and preoperative withholding was limited. These findings support standardized Arabic sick-day counseling, particularly for older adults, using written instructions, teach-back, and involvement of relatives or caregivers, with consent. Prospective studies should assess observed behavior and clinical outcomes rather than relying solely on recalled education and hypothetical intended actions.

Keywords: Sodium-glucose cotransporter 2 inhibitors, sick-day management, diabetic ketoacidosis, patient knowledge, medication safety, type 2 diabetes mellitus.

1. Introduction

1.1 Background

Sodium-glucose cotransporter 2 inhibitors are established therapies for type 2 diabetes because they improve glycemic control and provide important cardiovascular and kidney benefits in appropriately selected patients. Despite these benefits, they are associated with uncommon but potentially serious diabetic ketoacidosis. Unlike conventional diabetic ketoacidosis, SGLT2 inhibitor-associated ketoacidosis may develop when blood glucose is normal or only moderately elevated, which can delay recognition and treatment [1].

Acute illness, reduced oral intake, vomiting, dehydration, prolonged fasting, surgery, and relative insulin deficiency are recognized precipitating circumstances. Current guidance recommends avoiding or temporarily withholding SGLT2 inhibitors during severe acute illness, prolonged fasting, and other situations associated with ketosis or volume depletion. Before elective surgery, treatment should generally be withheld for three days for most agents and four days for ertugliflozin. Therapy should be restarted only after the precipitating risk has resolved and the patient is clinically stable with adequate oral intake [2,3].

Safe implementation of these precautions depends on patients recognizing relevant risk situations, understanding that normal or mildly elevated glucose does not exclude ketoacidosis, knowing when to seek clinical advice, and receiving clear instructions about withholding and restarting treatment. However, sick-day guidance is not consistently delivered across healthcare systems, and the content, format, and implementation of available resources vary. A systematic scoping review found many sick-day educational resources but limited evidence concerning their implementation and effects on clinical outcomes, while subsequent international consensus work emphasized the need for consistent, understandable, and actionable guidance [4].

Clear communication may be particularly important for older adults, who may benefit from simplified explanations, repetition, large-print instructions, and scenario-based teach-back. With the patient's consent, relatives or caregivers who assist with medication management may also need to receive the instructions so that they can support appropriate action during acute illness. Nevertheless, education should be provided systematically to all patients rather than being restricted according to age or educational attainment.

1.2 Objectives

This study aimed to evaluate SGLT2 inhibitor sick-day knowledge, attitudes, recalled sick-day education, intended self-management during acute illness, previous medication continuation during illness, and primary information sources among adults with type 2 diabetes attending diabetes clinics in Jenin, Palestine. The primary analytic objective was to examine the association between recalled sick-day education and a prespecified appropriate intended action during acute illness. Secondary objectives were to examine the associations of age, gender, educational attainment, and diabetes duration with the five-item Sick-Day Knowledge Recognition Score and to evaluate the robustness of these findings using a stricter scoring rule for multiple-response knowledge items.

2. Related Work

Research on sick-day medication management has highlighted substantial variation in the advice provided to patients. Watson et al. identified numerous guidance documents for people with diabetes, kidney disease, or cardiovascular disease but found limited empirical evaluation of how the guidance was implemented or whether

it improved medication-management behavior and clinical outcomes. A subsequent modified Delphi process developed consensus recommendations intended to make sick-day guidance more consistent and usable in clinical practice[4]. These studies established the need for structured education but also demonstrated that the evidence supporting specific delivery strategies remains limited.

SGLT2 inhibitor-specific studies have similarly identified gaps in patient understanding. In a multicenter quality-improvement initiative, baseline awareness of sick-day rules and SGLT2 inhibitor-related ketoacidosis was low, while targeted written information improved several patient-reported knowledge and confidence measures [5]. Because this was a quality-improvement project rather than a randomized effectiveness trial, the findings support feasibility but provide limited evidence of causal effects. The SAKURA cluster-randomized trial evaluated pharmacist-delivered sick-day materials in community pharmacies and demonstrated improved patient knowledge, although significant improvements in anxiety, intended behavior, and attitudes were not observed [6]. This distinction is important because improved recognition does not necessarily ensure appropriate action during a real illness.

Studies conducted among Palestinian adults with type 2 diabetes have documented limitations in general diabetes knowledge, self-management practices, medication beliefs, and adherence. In the West Bank, greater diabetes knowledge was associated with younger age and higher educational attainment, while important gaps remained between knowledge, attitudes, and reported practices [7]. Other Palestinian studies found that knowledge and beliefs about medicines were related to adherence and identified continuing challenges in long-term medication use [8,9]. However, these studies did not examine SGLT2 inhibitor-specific sick-day safety.

Consequently, evidence remains limited regarding whether Palestinian patients receiving SGLT2 inhibitors recognize high-risk clinical situations, understand the possibility of ketoacidosis without marked hyperglycemia, or know when to seek advice and temporarily withhold treatment. There is also limited evidence concerning the association between recalled sick-day education and intended medication management in this setting. The present study addresses these gaps by examining both item-specific and overall knowledge, intended action, recalled previous behavior, and factors associated with knowledge in adults attending diabetes clinics in Jenin.

3. Methodology

3.1 Data Collection

A clinic-based cross-sectional survey was conducted from March 30 to May 23, 2026, at two endocrinology and diabetes care sites in Jenin, Palestine: Dr. Waddah Abed Private Clinic and Dr. Bayan Abu Al-Rub Clinic/Ibn Sina Specialized Hospital.

Adults aged 18 years or older were eligible if they had type 2 diabetes, were currently prescribed an SGLT2 inhibitor, attended one of the participating sites during the recruitment period, and provided informed consent. Potential participants were approached consecutively during routine clinic visits. A total of 207 questionnaires were completed.

For sample size calculation, the Palestinian Ministry of Health dispensing records for Jenin indicated the use of approximately 1,000 dapagliflozin tablets per month. These tablet-consumption data were used only to assess recruitment feasibility and were not treated as a source-population denominator. Consecutive recruitment continued throughout the predefined study period.

Participation was voluntary and anonymous. Before questionnaire administration, potential participants received an explanation of the study and were asked whether they consented to participate. Consent was documented as an affirmative response to the first questionnaire item before the interview proceeded. No directly identifying personal information was collected, and only records with documented consent were included.

3.2 Experimental Setup

This was an observational survey and did not involve an experimental intervention. This subsection therefore describes development and administration of the survey instrument and the prespecified variable definitions. A structured, interviewer-administered Arabic-language questionnaire was developed by the investigators after reviewing SGLT2 inhibitor prescribing information, published sick-day recommendations, and patient-education literature [2,4,6,10]. The questionnaire was not directly translated or adapted from a single validated instrument.

The questionnaire was pilot-tested with 15 adults who met the study eligibility criteria. The pilot assessed item clarity and comprehensibility, cultural appropriateness, suitability of the response options, approximate administration time, and feasibility of interviewer administration. Only minor wording changes were made, and the pilot participants were not included in the main analytical sample.

The instrument collected age, gender, educational attainment, diabetes duration, and the prescribed SGLT2 inhibitor. Five knowledge items assessed recognition of: (a) temporary withholding during severe illness; (b) clinical situations requiring temporary withholding; (c) SGLT2 inhibitor-associated diabetic ketoacidosis despite normal or moderately elevated blood glucose; (d) warning symptoms requiring medical attention; and (e) preoperative withholding. Three attitude items assessed the perceived importance of knowing when to withhold treatment, perceived ability to manage treatment during illness, and preference for written instructions. Additional items assessed recalled sick-day education, intended action during an acute illness involving vomiting or fever, previous continuation of treatment during illness, primary information source, and desire for further information.

The five knowledge items were scored dichotomously and summed up to produce the Sick-Day Knowledge Recognition Score, ranging from 0 to 5, with higher scores indicating greater recognition. Two items used a select-all-that-apply format. Under the primary scoring rule, an item was scored as recognized when at least one clinically appropriate option was selected; otherwise, it was scored as not recognized. Because this rule neither required selection of every appropriate response nor penalized simultaneous inappropriate selection, it represented partial recognition rather than complete mastery. The strict sensitivity rule required selection of all clinically appropriate responses without selecting 'do not know.' No externally validated cutoff was used to classify knowledge as low, moderate, high, adequate, or inadequate; the score was analyzed continuously, and item-level responses were reported separately.

Temporarily withholding the SGLT2 inhibitor or contacting a physician or pharmacist was classified as an appropriate intended action. Continuing treatment or responding 'do not know' was classified as inappropriate. This outcome represented stated intention rather than observed behavior. Recalled sick-day education was considered present when participants reported previously being told when to withhold their SGLT2 inhibitor during illness. Medication names recorded in Arabic or English, including combination products, were harmonized into active-ingredient categories before analysis.

Internal consistency of the five dichotomously scored knowledge items was assessed using the Kuder-Richardson Formula 20 and was 0.69 in the analytical sample. The three dichotomized attitude items showed low internal consistency ($\alpha = 0.27$) and were therefore reported separately without a composite attitude score. Criterion validity, construct validity, and test-retest reliability were not evaluated. Accordingly, the questionnaire was regarded as an investigator-developed, pilot-tested instrument with preliminary reliability evidence rather than a fully validated measure. The administered Arabic questionnaire and its English translation are provided in Supplementary File 1.

3.3 Analysis Methods

Categorical variables were summarized as frequencies and percentages, with available case denominators reported when responses were missing. The Sick-Day Knowledge Recognition Score was summarized using the mean, standard deviation, median, interquartile range, and observed range. Item-level knowledge responses and the three attitude items were described separately. No missing values were imputed.

For the primary analysis, Pearson's chi-square test assessed the association between recalled sick-day education and appropriate intended action. Univariable binary logistic regression estimated the unadjusted odds ratio and 95% confidence interval. A multivariable logistic regression model then estimated the adjusted odds ratio after controlling for age band, gender, educational attainment, and diabetes-duration category.

For the secondary analysis, multiple linear regression with HC3 heteroscedasticity-robust standard errors modeled the Sick-Day Knowledge Recognition Score as a function of age band, gender, educational attainment, and diabetes duration. Age band, educational attainment, and diabetes duration were assigned increasing ordinal values. Their coefficients therefore represent the estimated average change in Knowledge Score associated with moving one category higher and assume a constant increment across adjacent categories. This parsimonious coding was prespecified for the available sample size. Variance inflation factors were examined to assess multicollinearity. Recalled sick-day education was not included as a predictor in this four-predictor knowledge model.

In the sensitivity analysis, the two select-all-that-apply items were rescored using the strict rule, and the same four-predictor HC3-robust linear regression model was repeated using the strict Knowledge Score. All tests were two-sided, and p-values below 0.05 were considered statistically significant. Interpretation prioritized effect estimates and 95% confidence intervals, particularly for secondary analyses.

Analyses were conducted in Python 3.12 using pandas 2.2.3, NumPy 2.3.5, and SciPy 1.17.0. Maximum-likelihood logistic regression and ordinary least-squares regression with matrix-based HC3 covariance estimation were implemented in the analysis code. The final analysis code and prespecified scoring rules should be retained with the study records to support reproducibility.

4. Experiments and Results

This was an observational cross-sectional survey and did not involve an experimental intervention. Accordingly, this section presents the descriptive findings, prespecified association analyses, sensitivity analysis, and interpretation of the results.

4.1 Results Overview

4.1.1 Participant characteristics

The analytical sample comprised 207 adults prescribed an SGLT2 inhibitor. The largest age groups were 51–60 years (30.4%) and 61–70 years (28.5%). Women accounted for 54.6% of the sample, 45.9% had university-level education, and 49.8% had lived with diabetes for more than five years. Dapagliflozin and empagliflozin monotherapy together accounted for 67.6% of reported SGLT2 inhibitor regimens (Table 1).

Table 1. Sociodemographic and Clinical Characteristics of Participants (N = 207)

Characteristic	n	%
Age group		
20–30 years	8	3.9
31–40 years	17	8.2
41–50 years	43	20.8
51–60 years	63	30.4
61–70 years	59	28.5
>70 years	17	8.2
Gender		
Female	113	54.6
Male	94	45.4
Formal educational level		
Primary	35	16.9
Secondary	77	37.2
University	95	45.9
Diabetes duration		
<1 year	25	12.1
1–5 years	79	38.2
>5 years	103	49.8
SGLT2 inhibitor regimen		
Dapagliflozin	74	35.7
Empagliflozin	66	31.9
Dapagliflozin/metformin	37	17.9
Ertugliflozin	19	9.2
Empagliflozin/metformin	8	3.9
Canagliflozin	3	1.4

Note: Values are n (%). Percentages may not total 100% because of rounding.

4.1.2 Knowledge, attitudes, and behavioral indicators

The mean Sick-Day Knowledge Recognition Score was 2.44 (SD = 1.56), with a median of 3 (interquartile range, 1–4) and a range of 0–5. The Kuder–Richardson Formula 20 coefficient for the five dichotomously scored knowledge items was 0.69. Recognition was lowest for SGLT2 inhibitor-associated diabetic ketoacidosis occurring with normal or modestly elevated blood glucose (23.7%) and for presurgical withholding (37.2%); warning symptoms requiring medical attention were recognized most often (77.8%) (Table 2).

Overall, 101 participants (48.8%) recalled receiving sick-day education, and 160 (77.3%) reported that they would temporarily withhold the SGLT2 inhibitor or contact a physician or pharmacist during an acute illness involving vomiting or fever. Among 206 respondents to the previous-use item, 145 (70.4%) reported having continued the medication during at least one previous illness. Because these questions assessed a hypothetical intention and recalled behavior in potentially different circumstances, the aggregate contrast does not establish an individual-level intention–behavior gap. Of 205 respondents to the information-preference item, 195 (95.1%) wanted additional information.

Table 2. Knowledge, Attitudes, Sick-Day Education, Intended Action, and Information Preferences

Domain	Indicator	n/N	%
Knowledge	Recognized temporary withholding during severe illness	97/207	46.9
	Recognized ≥ 1 situation requiring temporary withholding	122/207	58.9
	Recognized ketoacidosis without marked hyperglycemia	49/207	23.7
	Recognized ≥ 1 warning symptom requiring medical attention	161/207	77.8
	Recognized presurgical withholding	77/207	37.2
Attitude	Agreed that sick-day information is important	158/207	76.3
	Agreed that they knew how to manage treatment during illness	98/207	47.3
	Preferred written instructions	189/207	91.3
Education	Recalled receiving sick-day education	101/207	48.8
Intended action	Reported an appropriate intended action	160/207	77.3
Previous behavior	Previously continued medication during illness	145/206	70.4
Information source	Physician	120/206	58.3
	Pharmacist	48/206	23.3
	Internet	38/206	18.4
Information preference	Wanted additional information	195/205	95.1

Note. Values are n/N (%). An appropriate intended action was defined as temporarily withholding the SGLT2 inhibitor or contacting a physician or pharmacist during acute illness involving vomiting or fever. Denominators differ because of missing responses. The three attitude items are reported separately because they were not treated as a single scale.

4.1.3 Recalled education and intended action

An appropriate intended action was reported by 92 of 101 participants (91.1%) who recalled receiving sick-day education and by 68 of 106 participants (64.2%) who did not. The association was statistically significant, $\chi^2(1) = 21.39$, $p < 0.001$. In univariable logistic regression, recalled education was associated with higher odds of an appropriate intended action (OR = 5.71, 95% CI [2.59, 12.60], $p < 0.001$). After adjustment for age band, gender, formal educational level, and diabetes duration, the association remained statistically significant (adjusted OR = 5.39, 95% CI [2.39, 12.13], $p < 0.001$). None of the other covariates were statistically significant (Table 3).

Table 3. Multivariable Logistic Regression of Factors Associated with Appropriate Intended Action (N = 207)

Predictor	Adjusted OR	95% CI	P
Recalled sick-day education (yes vs. no)	5.39	2.39–12.13	<0.001
Age band (per category increase)	0.78	0.52–1.19	0.256
Gender (female vs. male)	1.36	0.66–2.83	0.406
Formal educational level (per category increase)	0.90	0.52–1.58	0.718
Diabetes duration (per category increase)	0.98	0.52–1.86	0.952

Note. CI = confidence interval; OR = odds ratio. All predictors were entered simultaneously. Age band, formal educational level, and diabetes duration were modeled as ordinal variables.

4.1.4 Factors associated with knowledge

The HC3-robust linear regression model was statistically significant, $F(4, 202) = 8.18$, $p < 0.001$, and explained 13.5% of the variance in Knowledge Score ($R^2 = 0.135$; adjusted $R^2 = 0.118$). After mutual adjustment, each one-category increase in age band was associated with a 0.301-point lower score (95% CI [−0.499, −0.104], $p = 0.003$), whereas each one-category increase in formal educational level was associated with a 0.396-point higher score (95% CI [0.056, 0.735], $p = 0.023$). Gender and diabetes duration were not associated with Knowledge Score. All variance inflation factors were below 2.0 (Table 4).

Table 4 HC3-Robust Multiple Linear Regression Predicting Knowledge Score (N = 207)

Predictor	b	Robust SE	95% CI	P
Age band (ordinal, 1–6)	−0.301	0.101	−0.499 to −0.104	0.003
Gender (female = 1)	0.180	0.215	−0.241 to 0.601	0.403
Formal educational level (ordinal, 1–3)	0.396	0.173	0.056 to 0.735	0.023
Diabetes duration (ordinal, 1–3)	0.031	0.156	−0.275 to 0.338	0.841

Note. CI = confidence interval; SE = standard error. All predictors were entered simultaneously. Coefficients for the ordinal variables represent the estimated mean difference in Knowledge Score associated with moving one category higher. Model $R^2 = 0.135$; adjusted $R^2 = 0.118$; all variance inflation factors < 2.0.

4.1.5 Sensitivity analysis

Applying the strict scoring rule to the two multiple-response knowledge items reduced the mean Knowledge Score to 1.39 (SD = 1.41). In the corresponding four-predictor HC3-robust model, age remained associated with

knowledge ($b = -0.303$ per age-band increase, 95% CI $[-0.504, -0.102]$, $p = 0.003$). The coefficient for formal educational level was attenuated and was no longer statistically significant ($b = 0.238$, 95% CI $[-0.065, 0.542]$, $p = 0.126$); gender and diabetes duration remained unassociated with the strict score. Thus, the inverse association with age was robust to the scoring rule, whereas the educational-level association was sensitive to how partial recognition was scored.

5. Discussion

5.1 Principal Findings

This study was a cross-sectional survey conducted in a clinic setting that aimed to identify important gaps in the sick-day knowledge of adults with type 2 diabetes in Jenin. The mean Sick-Day Knowledge Recognition Score was 2.44 points out of 5 points, and fewer than half of participants recalled receiving explicit sick-day education. Two key safety issues were under-recognized: only 23.7% recognized that SGLT2 inhibitor-associated DKA can occur in the absence of significant hyperglycemia, and only 37.2% recognized the need to withhold treatment before surgery. In contrast, 77.8% identified at least one warning sign that needed medical care. This pattern indicates limited recognition of individual safety messages rather than a full understanding of when and why treatment should be suspended.

Recalled sick-day education was strongly associated with selection of an appropriate intended action during acute illness. Participants who recalled receiving sick-day education had 5.39 times the odds of reporting an appropriate intended action. Although clinically relevant, this association cannot be assumed to be causal as the education and intended action were not measured at a different survey visit, and the exposure was self-reported. Age was an independent factor associated with a lower Knowledge Score. Under strict scoring, the association between higher levels of formal education and the Knowledge Score was reduced. In the sensitivity analysis, the age association did not change considerably, and it therefore remained the strongest demographic finding, whereas the association with educational level was more dependent on how partial recognition was scored.

While 77.3% chose the right answer in a hypothetical illness, 70.4% stated that they had taken the medicine during at least one previous illness. The study could not determine when the prior illness merited withholding, whether education occurred before the episode, or whether the same individuals had a safe intention that they did not follow through on. However, the overall contrast highlights the potential for inconsistent translation of stated intentions to actual medication management in the real world and suggests a need to evaluate observed behavior in subsequent research.

5.2 Comparison with previous evidence

It is noteworthy that ketoacidosis without significant hyperglycemia may not be immediately recognized, which may delay diagnosis and treatment of SGLT2 inhibitor-associated diabetic ketoacidosis. Another important safety measure is perioperative interruption. The general guidance is to withhold SGLT2 inhibitors for three days before elective surgery and four days before elective surgery for ertugliflozin, and then restart them when the precipitating risk has passed and the patient is clinically stable with adequate oral intake [3,10]. It is unsurprising that warning symptoms were identified more often than the underlying risk or the need to interrupt treatment. Counseling should provide a single action plan linking the precipitating situation to recognition of warning symptoms, withholding of the medication, urgent assessment, and safe restarting.

The education gap observed is consistent with recent education-specific research on SGLT2 inhibitors, although direct numerical comparisons are not suitable due to varying populations and instruments used to measure education. A study of targeted written information reported low baseline awareness of SGLT2 inhibitor sick-day rules and enhanced patient-reported knowledge following the intervention [5]. Pharmacist-provided sick-day materials in the SAKURA cluster-randomized trial did not significantly affect anxiety or behavioral intention and had a non-significant effect on attitudes [6]. In addition to the current correlation between recalled education and intended action, these studies suggest that structured education is a potential safety measure and that information alone might not be enough to affect behavioral change.

The age pattern was consistent with previous Palestinian diabetes studies, where younger age was associated with higher general diabetes knowledge, as was the educational pattern [7]. Previous research in Palestine has correlated medication knowledge and beliefs with adherence and indicated continued problems with adherence to long-term medication [8,9]. These studies, however, did not look at the safety of using SGLT2 inhibitors specifically for sick days. However, the present sensitivity analysis requires qualification: there was no association with formal educational level when full and not partial recognition was necessary. Formal education should therefore not be assumed to be a good indicator of the ability to follow the SGLT2 inhibitor sick-day guidelines.

5.3 Implications for Practice

The results are consistent with published guidance and consensus recommendations for a standardized sick-day education pathway that is initiated when a SGLT2 inhibitor is first started and reinforced at follow-up visits, medication refills, acute-illness contacts, and preoperative assessment [4]. Common situations that lead to the need for temporary withholding should be identified; the fact that ketoacidosis may occur in the absence of significant hyperglycemia should be explained, warning signs and when urgent assessment is necessary should be explained, agent-specific instructions for pre-operative precautions should be given, and clear explanations of when and how treatment should be resumed should be provided. A simple verbal explanation plus one-page written action plan, teach-back, and documentation in the clinical record would be a simple minimum standard. A large proportion of participants preferred written instructions (91.3%) and desired more information (95.1%), indicating the general acceptability of this intervention. Physicians were most often reported as the primary source of information, followed by pharmacists. Thus, the level of counseling could be enhanced by having coordinated messages sent from diabetes clinics and community pharmacies. Education should be expanded to include short scenarios and rehearsing behavior and should be used in situations beyond recognition questions, such as when patients explain what they would do if they developed vomiting or fever, were unable to keep fluids down, became dehydrated, or were preparing for surgery.

Attention should be paid to older adults because the inverse association between age band and knowledge persisted under both scoring rules. For older patients, counseling should include simple language, large print, repetition, and a scenario-based teaching-back approach. Relatives or caregivers who help with medication management should be given the same written action plan and be involved in rehearsal of the steps to be taken during acute illnesses or before surgery, with the patient's permission. This reinforcement should be complementary to systematic education, not a replacement.

5.4 Strengths and limitations

This study has several strengths, including targeting an under-investigated medication-safety problem, consecutive enrollment in routine clinical care, item-level reporting that included explicit denominators, adjustment for prespecified demographic and clinical variables, and sensitivity analysis with a stricter scoring rule. Separate reporting of the knowledge items also facilitated the detection of clinically specific deficits that would not have been apparent from the overall score alone.

Several limitations should be taken into account. Firstly, the cross-sectional design does not allow conclusions to be drawn about temporal sequence or causality. Participants who remembered education may have had different levels of health literacy, motivation, healthcare contact, cognition, disease complexity, or other unmeasured characteristics. Second, self-reported measures of education, intended action, and previous behavior are susceptible to recall and social-desirability bias, which is likely to be significant in an interviewer-administered survey. The hypothesized outcome of intended action was not observed because the illness episode had occurred in the past, and the survey did not determine if the episode of illness was preceded by education. No clinical outcomes, including ketoacidosis, dehydration, hospitalization, or perioperative complications, were measured.

Third, the questionnaire developed by the investigator was not fully validated. The knowledge scale had only preliminary internal consistency (Kuder–Richardson coefficient 0.69), and there was no criterion validity, construct validity, or test–retest reliability. The most important criterion for the two multiple-response items, which were awarded partial credit, was that no more than one undesirable response could be selected at the same time. Some of the conclusions are sensitive to this choice, including the lower score under strict scoring, as well as the decline in the educational-attainment coefficient. The three attitude items should also be kept separate due to low internal consistency between items, which did not allow the creation of a single composite construct.

Fourth, the five items were bounded and coarse, and age, education, and diabetes duration were ordinal scores with a fixed relationship between adjacent scores. Standard errors were large; however, other models or category-specific estimates may be informative in larger samples. Lastly, the study has limited generalizability to other Palestinian regions, primary care, and those without easy access to care. Assessment of selection bias is further constrained by the inability to measure the number approached, as well as the nonresponse profile.

In summary, the findings highlight a meaningful and potentially targetable gap in the safety of SGLT2 inhibitors in the context of sick days. They assist with the implementation of a standardized Arabic counseling intervention with written instructions and teach-back. Future studies should use a more fully validated instrument, document the timing and content of education, assess retention, and measure observed medication management and clinical outcomes rather than relying solely on recalled education and stated intentions.

6. Conclusions and Recommendations

Among adults with type 2 diabetes receiving SGLT2 inhibitors in Jenin, sick-day knowledge was incomplete, and fewer than half recalled receiving specific sick-day education. Important gaps concerned recognition of ketoacidosis without marked hyperglycemia and preoperative withholding. Recalled education remained associated with appropriate intended action after adjustment, although causality cannot be established. Older age was consistently associated with lower knowledge, whereas the association with educational attainment was

sensitive to the scoring method. These findings highlight the need for systematic SGLT2 inhibitor safety education, with particular attention to older adults and those involved in supporting their medication use.

A standardized Arabic-language sick-day education protocol should be provided when an SGLT2 inhibitor is initiated and reinforced during follow-up visits, medication refills, acute illness contacts, and preoperative assessment. Older adults should receive additional support using plain language, large-print written instructions, repetition, and scenario-based teach-back. With the patient's consent, relatives or caregivers should be included in counseling so that they can recognize warning symptoms and assist with appropriate medication management during illness.

Counseling should explain when temporary withholding is indicated, the possibility of ketoacidosis without marked hyperglycemia, relevant warning symptoms, when urgent medical advice is required, preoperative withholding, and when treatment may be safely restarted. Physicians and pharmacists should provide consistent messages and document education of both the patient and, when applicable, the caregiver. The effectiveness of this approach should be evaluated prospectively using validated measures and observed medication-management behavior.

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8. Declarations

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Conflict of interest/Competing interests

The authors declare that they have no financial or non-financial interests related to this work.

Ethics approval and consent to participate

Participation was voluntary, and participants received information about the study before providing informed consent. Consent was documented through an affirmative response to the first questionnaire item before the interview proceeded. No directly identifying personal information was collected.

Consent for publication

Not applicable. This manuscript contains no identifiable personal information, images, or individual-level case details.

Data availability

The de-identified data supporting the findings of this study are available from the corresponding author upon reasonable request and subject to applicable ethical and institutional requirements.

Materials availability

The Arabic-language questionnaire administered in the study is provided in Supplementary File 1. Additional study materials are available from the corresponding author upon reasonable request.

Code availability

The Python code used for data management and statistical analysis is available from the corresponding author upon reasonable request.

Authors' Contributions

Ikhlas Jarrar, Huda Masri, and Suhad Al-Ahmad contributed to the study conceptualization and design, questionnaire development, methodology, statistical analysis, project supervision, and preparation, critical revision, and editing of the manuscript. 5th-year students Dina Khalaf and Nagham Zakarneh contributed to participant recruitment and data collection as part of their graduation project. All authors reviewed and approved the final manuscript and agreed to be accountable for the work.

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