

Knowledge and Practice Regarding the Assessment and Management of Diabetic Ketoacidosis Among Critical Care and Emergency Nurses in the Northwestern Region of Saudi Arabia: A Cross-Sectional Study

Ghaida Shujayyi Alsulami, PhD, RN ^{1,*}; Khaled M. Al-Sayaghi, PhD, RN ^{2,3}; Rami A. Elshatarat, PhD, RN ³; Ali Alharbi, PhD, RN ⁴; Fatimah Mohamed Moqbel, MSc, RN ⁵; Hassan N. Moafa, PhD ^{6,7}; Khadega A. Alhefnawy, PhD, RN ^{3,8}; Abdullah R. Allugmani, MSc, RN ³; Hala Zaiton, PhD, RN ³; Doaa El Sayed Fadila, PhD, RN ^{9,10}

¹Department of Clinical Nursing Practices, Faculty of Nursing, Umm Al-Qura University, Makkah, Saudi Arabia

²Nursing Division, Faculty of Medicine and Health Sciences, Sana'a University, Sana'a, Yemen

³Department of Medical and Surgical Nursing, College of Nursing, Taibah University, Madinah, Saudi Arabia

⁴Medical Surgical Department, College of Nursing, King Saud University, Riyadh, Saudi Arabia

⁵Faculty of Nursing, Applied Science Private University, Amman, Jordan

⁶Department of Public Health, College of Nursing and Health Sciences, Jazan University, Jazan, Saudi Arabia

⁷University Hospital, Medical City, Jazan University, Jazan, Saudi Arabia

⁸Medical-Surgical Nursing Department, Menoufia University, Menoufia, Egypt

⁹Department of community health nursing, College of Nursing, Taibah University, Madinah, Saudi Arabia

¹⁰Department of Gerontological Nursing, Faculty of Nursing, Mansoura University, Mansoura, Egypt

*Corresponding author: Gssulami@uqu.edu.sa

ABSTRACT

Background: Diabetic ketoacidosis (DKA) is a life-threatening acute complication of diabetes requiring timely assessment, continuous monitoring, and coordinated evidence-based management. Critical care and emergency nurses play an essential role in early recognition, treatment, prevention of complications, and patient education. However, variation in nurses' knowledge and clinical practice may affect the quality and safety of DKA care. **Aim:** To assess knowledge and practice regarding the assessment and management of DKA among critical care and emergency nurses in the Northwestern Region of Saudi Arabia and to identify factors associated with knowledge and practice. **Methods:** A quantitative cross-sectional descriptive correlational study was conducted among 477 registered critical care and emergency nurses working in selected hospitals in Makkah, Madinah, Jeddah, Yanbu, and Taif. Participants were recruited using convenience sampling. Data were collected electronically using a researcher-developed 42-item questionnaire comprising demographic and work-related characteristics, DKA-related educational exposure, 15 knowledge items, and 12 scenario-based practice items. Descriptive statistics, independent-samples t-tests, one-way ANOVA, Pearson correlation, and multiple linear regression were used for analysis. **Results:** The mean knowledge score was 10.57 ± 2.61 out of 15, with most nurses demonstrating a moderate level of knowledge. The mean practice score was 9.10 ± 2.03 out of 12, with most participants demonstrating a moderate level of practice. Knowledge and practice differed significantly according to gender, educational qualification, clinical work area, previous DKA care experience, and previous DKA-related educational exposure. Knowledge was positively correlated with practice ($r = 0.428$, $p = 0.003$). Previous DKA-related education, higher educational qualification, previous DKA care experience, and availability of a standardized DKA protocol were independent predictors of knowledge. Higher educational qualification, greater nursing experience, previous DKA care experience, DKA-related education, and higher knowledge were independent predictors of practice. Knowledge was the strongest predictor of practice. **Conclusion:** Critical care and emergency nurses demonstrated moderate levels of knowledge and practice regarding DKA assessment and management, indicating opportunities for competency improvement. Structured DKA education, regular clinical training, standardized protocols, and practice-based competency assessment may strengthen nurses' ability to provide timely and evidence-based DKA care.

Keywords: diabetic ketoacidosis, nurses, critical care, emergency nursing, knowledge, clinical practice, diabetes mellitus, Saudi Arabia

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INTRODUCTION

DKA is a serious and potentially life-threatening acute complication of diabetes mellitus, characterized by hyperglycemia, metabolic acidosis, and increased ketone production resulting from inadequate insulin activity. Although DKA is most commonly associated with type 1 diabetes mellitus, it may also occur in individuals with type 2 diabetes, particularly in the presence of acute illness, infection, physiological stress, or

inadequate glycemic control (Eledrisi, Beshyah, & Malik, 2021; Elendu et al., 2023; Gosmanov, Gosmanova, & Dillard-Cannon, 2014). If not recognized and treated promptly, DKA can progress to severe dehydration, electrolyte abnormalities, cerebral complications, cardiovascular instability, and organ dysfunction, resulting in substantial morbidity and mortality (Barski, Golbets, Jotkowitz, & Schwarzfuchs, 2023; Gosmanov et al., 2014; Westerberg, 2013).

DKA remains an important clinical challenge in emergency and critical care settings, where patients often present with varying degrees of metabolic and physiological instability (Tran et al., 2017; Umpierrez & Kitabchi, 2003; Westerberg, 2013). Clinical manifestations range from nausea, vomiting, thirst, dehydration, and fatigue to Kussmaul respirations, altered mental status, hemodynamic instability, and organ dysfunction. Consequently, early recognition of clinical manifestations, accurate interpretation of laboratory findings, and timely initiation of appropriate treatment are essential for preventing deterioration and improving outcomes (Dhatariya & Care, 2022; Eledrisi et al., 2021; Elendu et al., 2023; Gosmanov et al., 2014).

Effective DKA management requires coordinated interventions, including fluid resuscitation, continuous intravenous insulin therapy, careful electrolyte monitoring and replacement, frequent assessment of metabolic status, and prevention of treatment-related complications. Nurses play a central role throughout this process, particularly in emergency departments and critical care units. Their responsibilities include initial patient assessment, recognition of clinical deterioration, monitoring of vital signs and neurological status, administration and monitoring of intravenous therapies, identification of electrolyte abnormalities, evaluation of treatment response, and provision of patient and family education (Savage et al., 2011; Shaker, Faltas, & Abdelhady, 2025; Tran et al., 2017). Appropriate nursing assessment and timely clinical decision-making are therefore essential components of safe and effective DKA management (Savage et al., 2011; Shaaban Ibrahim Ali, Salah Hassan, & Said Ali, 2017; Shaker et al., 2025).

Despite the availability of evidence-based guidelines and standardized approaches to DKA management, healthcare professionals may demonstrate variations in knowledge and clinical practice. Deficiencies in understanding insulin therapy, potassium management, fluid replacement, monitoring requirements, recognition of treatment endpoints, and transition from intravenous to subcutaneous insulin therapy may compromise the safety and effectiveness of care (Savage et al., 2011; Umpierrez & Kitabchi, 2003; Westerberg, 2013). Previous research has identified variability in healthcare professionals' knowledge of DKA, particularly regarding electrolyte abnormalities, insulin administration, fluid management, and criteria for resolution. These findings emphasize the importance of continuing education, competency-based training, and adherence to evidence-based protocols (Barski et al., 2023; Elendu et al., 2023; Kajembula, Matheo, Simchimba, Masasi, & Chikwala, 2024).

In Saudi Arabia, diabetes mellitus represents a major public health concern, with a considerable burden of diabetes-related complications requiring emergency and critical care services. Healthcare facilities in the Northwestern Region manage patients with acute diabetic complications, including DKA; however, evidence regarding the DKA-related knowledge and clinical practices of critical care and emergency nurses in this region remains limited (Albagawi, Alkubati, & Abdul-Ghani, 2023; Almutairi et al., 2024; Alotaibi, 2019). Differences in nurses' educational backgrounds, clinical experience, previous exposure to DKA education, and availability of institutional protocols may further contribute to variations in competency.

Assessing nurses' knowledge and practice is therefore important for identifying specific competency gaps and determining factors associated with DKA management performance. Such information can guide the development of targeted educational interventions, simulation-based training, standardized clinical protocols, and continuing professional development activities (Kajembula et al., 2024; Lehtamo & Virtanen, 2026; Savage et al., 2011; Shaaban Ibrahim Ali et al., 2017). Accordingly, the present study assessed knowledge and practice regarding the assessment and management of DKA among critical care and emergency nurses in the Northwestern Region of Saudi Arabia.

Problem Statement

DKA requires rapid recognition and coordinated evidence-based management to prevent severe complications and adverse

outcomes. Safe management depends on accurate assessment, appropriate fluid resuscitation, continuous insulin administration, electrolyte monitoring and correction, frequent evaluation of treatment response, and effective patient education. Critical care and emergency nurses are directly involved in many of these processes and therefore have an important role in ensuring timely and safe DKA care (Albagawi et al., 2023; Almutairi et al., 2024; Barski et al., 2023).

Although established international guidelines provide clear recommendations for DKA management, variations in healthcare professionals' knowledge and clinical practices have been reported. Deficiencies in recognizing diagnostic criteria, administering insulin safely, managing potassium abnormalities, selecting appropriate fluid therapy, monitoring patients, and determining resolution of DKA may increase the risk of treatment-related complications. In addition, professional experience, educational exposure, and the availability of standardized institutional protocols may influence nurses' preparedness to manage DKA (Abd Elkhalek Mekky et al., 2023; Alskafi et al., 2025; Kajembula et al., 2024).

In Saudi Arabia, there is limited evidence specifically examining DKA-related knowledge and clinical practice among critical care and emergency nurses in the Northwestern Region. This evidence gap makes it difficult to determine the extent of existing competency gaps and the factors associated with nurses' performance. Assessing these competencies is important for informing continuing professional development, strengthening institutional DKA protocols, and supporting improvements in patient safety and quality of care (Kajembula et al., 2024; Shaker et al., 2025; Yousef, 2026).

Significance of the Study

DKA is a medical emergency requiring timely and coordinated clinical management. Nurses are frontline healthcare professionals who continuously assess patients, recognize deterioration, administer prescribed therapies, monitor treatment responses, identify complications, and provide education to patients and families. Consequently, nurses' knowledge and clinical practice are important determinants of the safety and quality of DKA care (Alskafi et al., 2025; Elendu et al., 2023).

The present study provides evidence regarding DKA-related knowledge and practice among critical care and emergency nurses in the Northwestern Region of Saudi Arabia. Identifying areas of competency and deficiency can assist nursing educators, clinical leaders, and healthcare administrators in designing targeted educational programs and competency-based training (Almutairi et al., 2024; Alotaibi, 2019).

The findings may also inform the development or strengthening of standardized DKA management protocols, simulation-based educational activities, and continuing professional development programs. Enhancing nurses' competency may contribute to earlier recognition of DKA, safer administration of insulin and electrolyte therapy, improved monitoring, prevention of treatment-related complications, and more effective patient education (Kajembula et al., 2024; Lehtamo & Virtanen, 2026; Savage et al., 2011).

Furthermore, the study contributes to the limited evidence concerning DKA management competency among nurses in Saudi Arabia and provides a basis for future research evaluating educational interventions, simulation-based training, clinical protocols, and other strategies designed to improve DKA management.

Study Aim and Specific Objectives

The aim of this study was to assess knowledge and practice regarding the assessment and management of DKA among critical care and emergency nurses in the Northwestern Region of Saudi Arabia, and to identify factors associated with nurses' knowledge and practice.

The study sought to: 1) Assess the levels of knowledge and clinical practice regarding the assessment and management of DKA among critical care and emergency nurses; 2) Examine differences

in knowledge and practice scores according to selected demographic, professional, and clinical characteristics, including educational qualification, clinical work area, previous DKA care experience, and previous DKA-related educational exposure; 3) Determine the relationship between nurses' knowledge and practice regarding DKA assessment and management; and 4) Identify independent predictors of nurses' knowledge and practice, including demographic and professional characteristics, previous DKA care experience, DKA-related educational exposure, availability of standardized DKA protocols, and knowledge level.

Conceptual Framework

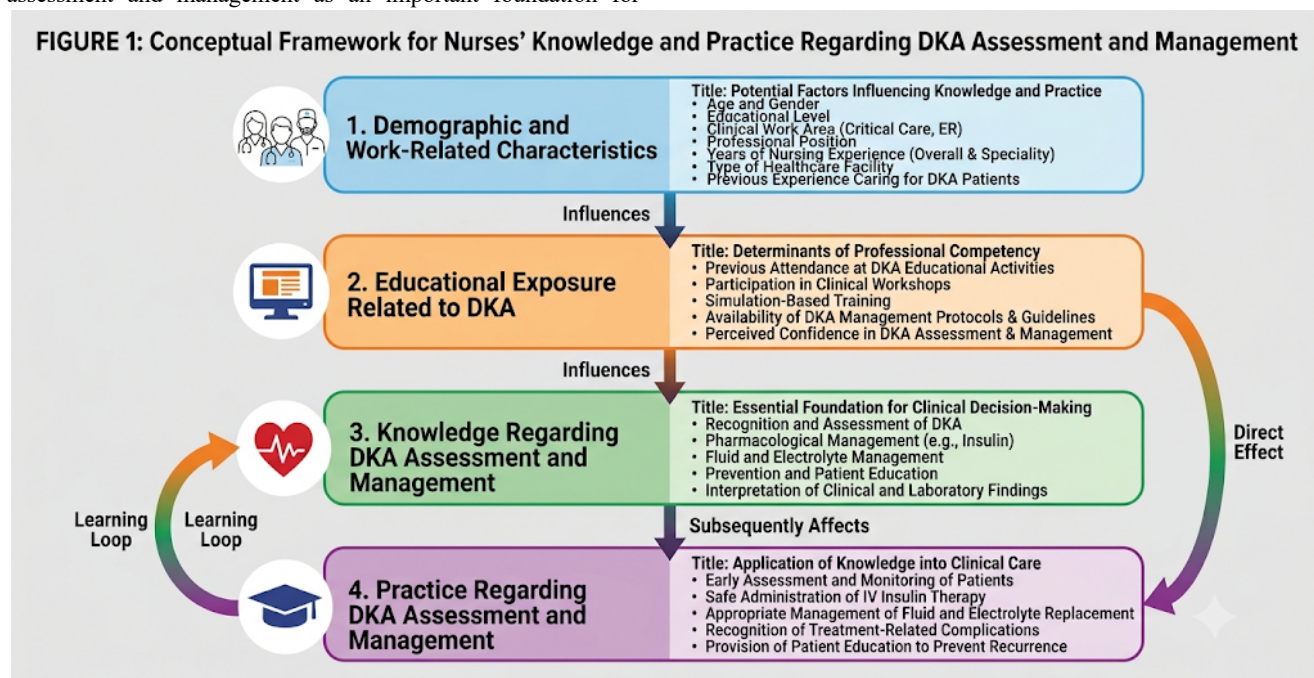
This study was guided by a knowledge–practice framework, which proposes that nurses' clinical performance is influenced by individual characteristics, professional experience, clinical exposure, educational preparation, and access to evidence-based resources. As illustrated in Figure 1, demographic and work-related characteristics—including age, gender, educational qualification, clinical work area, professional experience, and previous DKA care experience—along with DKA-related educational exposure and availability of standardized protocols, were considered potential factors influencing nurses' knowledge and practice (Savage et al., 2011; Shafiee, Kamel, & Halperin, 2002; Westerberg, 2013).

The framework further conceptualized knowledge regarding DKA assessment and management as an important foundation for

clinical practice. Knowledge encompassed recognition and assessment of DKA, pharmacological management, fluid and electrolyte management, and prevention and patient education. Previous DKA-related education, clinical exposure, professional experience, and access to standardized guidelines may contribute to nurses' knowledge and competency (Eledrisi et al., 2021; Elendu et al., 2023; Gosmanov et al., 2014). Clinical practice represented the application of this knowledge through appropriate assessment and monitoring, insulin and fluid therapy, electrolyte management, recognition of complications, and patient education (Alotaibi, 2019; Elendu et al., 2023; Shafiee et al., 2002).

Accordingly, Figure 1 presents the hypothesized relationships among nurses' demographic and professional characteristics, educational exposure, knowledge, and clinical practice regarding DKA management. The framework assumes that these characteristics and educational factors may contribute to differences in knowledge, while greater knowledge is expected to be associated with better clinical practice.

This conceptualization provided the basis for examining group differences, the relationship between knowledge and practice, and the independent predictors of knowledge and practice in the present study (Gosmanov et al., 2014; Shafiee et al., 2002; Westerberg, 2013).



METHODS

Study Design

A quantitative, cross-sectional descriptive correlational study design was employed to assess knowledge and practice regarding the assessment and management of DKA among critical care and emergency nurses in the Northwestern Region of Saudi Arabia. The cross-sectional design enabled assessment of nurses' knowledge and clinical practice at a specific point in time and examination of relationships between demographic and work-related characteristics, educational exposure, knowledge, and practice outcomes.

This design facilitated identification of potential competency gaps in DKA management and factors associated with variations in knowledge and clinical practice. Although cross-sectional studies cannot establish causal relationships, this approach was appropriate for describing current nursing competencies and identifying areas requiring targeted educational and quality-improvement interventions.

Study Setting

The study was conducted among critical care and emergency nurses working in selected hospitals in the Northwestern Region of Saudi Arabia. The participating healthcare facilities provided emergency and critical care services and managed patients with acute diabetes-related complications, including DKA.

The selected hospitals included governmental, university, military, and private healthcare facilities located in major cities of the region, including Makkah, Madinah, Jeddah, Yanbu, and Taif. These settings were selected because they provide emergency and intensive care services in which nurses are directly involved in the assessment, stabilization, monitoring, treatment, and education of patients with DKA.

Including nurses from multiple hospitals and geographical areas enhanced the diversity of the study sample and provided a broader assessment of DKA management competency among nurses working in acute care settings.

Study Population

The target population consisted of registered nurses working in critical care and emergency care settings in hospitals located in the

Northwestern Region of Saudi Arabia. The accessible population included nurses working in clinical areas where patients with DKA were commonly assessed and managed, including adult intensive care units (ICUs), pediatric intensive care units (PICUs), emergency departments (EDs), and cardiac intensive care units (CCUs), where applicable.

These nurses were considered an appropriate population because their clinical responsibilities included early recognition of DKA, assessment of clinical deterioration, administration and monitoring of prescribed treatments, prevention of complications, and provision of patient and family education.

Sample Size and Sampling Technique

The required sample size was determined using G*Power software to ensure adequate statistical power for the planned analyses. Based on the specified statistical parameters, the minimum required sample size was 384 nurses. To enhance the adequacy and representativeness of the sample, the researchers targeted recruitment of approximately 450 nurses.

Ultimately, 477 eligible critical care and emergency nurses participated in the study. A convenience sampling technique was used to recruit participants. Eligible nurses were invited to complete the electronic questionnaire through professional communication channels, including nurses' professional email addresses and social media platforms.

The questionnaire was distributed among nurses working in different critical care and emergency settings across multiple hospitals and cities, including Makkah, Madinah, Jeddah, Yanbu, and Taif. This approach facilitated recruitment of nurses with diverse educational backgrounds, professional positions, clinical experiences, and previous exposure to DKA care.

Inclusion and Exclusion Criteria

Inclusion Criteria

Participants were eligible if they were registered nurses currently working in critical care units or emergency departments in selected hospitals in the Northwestern Region of Saudi Arabia, had at least six months of experience in their current critical care or emergency nursing role, provided direct patient care, and were available during the data collection period. Participants were also required to voluntarily agree to participate and provide informed consent.

Exclusion Criteria

Nursing students, interns, and trainees were excluded. Nurses working exclusively in administrative, educational, or other non-clinical positions were also excluded. Nurses with less than six months of critical care or emergency nursing experience, those on extended leave during the data collection period, and nurses who had participated in the development, review, or validation of the questionnaire were excluded.

Study Instrument

Data were collected using a structured, self-administered questionnaire developed by the researchers based on current evidence-based recommendations for the assessment and management of DKA, including international diabetes management guidelines, critical care recommendations, and relevant nursing literature (Albagawi et al., 2023; Eledrisi et al., 2021; Gosmanov et al., 2014; Shafiee et al., 2002; Westerberg, 2013). The questionnaire was administered electronically using Google Forms to facilitate accessibility, standardized data collection, and efficient organization of responses. The instrument consisted of 42 items organized into four sections.

Section I: Demographic and Work-Related Characteristics

The first section comprised 10 items assessing participants' demographic and professional characteristics, including age, gender, nationality, highest nursing qualification, current clinical work area, professional position, total nursing experience, critical

care/emergency nursing experience, type of healthcare facility, and previous experience caring for patients with DKA.

Section II: Educational Exposure Related to DKA

The second section comprised five items assessing participants' previous exposure to DKA-related education and clinical resources. The items addressed attendance at DKA educational programs during the previous two years, type and duration of the most recent educational activity, availability of a standardized DKA management protocol in the clinical unit, and participants' confidence in assessing and managing patients with DKA.

Section III: Knowledge Regarding DKA Assessment and Management

The third section assessed participants' knowledge using 15 multiple-choice questions (MCQs) covering four domains: (1) recognition, assessment, and diagnosis of DKA; (2) pharmacological management; (3) fluid, electrolyte, and supportive management; and (4) prevention and patient education. The knowledge items addressed key principles of DKA recognition and diagnosis, insulin therapy, potassium assessment and replacement, fluid management, monitoring of metabolic resolution, and patient education, consistent with established recommendations for DKA management (Eledrisi et al., 2021; Gosmanov et al., 2014; Shafiee et al., 2002; Westerberg, 2013). Each correct response was assigned one point, whereas an incorrect response was assigned zero points. The total knowledge score therefore ranged from 0 to 15, with higher scores indicating greater knowledge regarding DKA assessment and management.

Section IV: Practice Regarding DKA Assessment and Management

The fourth section assessed nurses' practice using 12 scenario-based MCQs designed to evaluate the application of evidence-based principles in the assessment and management of patients with DKA. The practice items covered four domains: (1) initial assessment and monitoring; (2) pharmacological management; (3) fluid and electrolyte management; and (4) non-pharmacological management and patient education. The items assessed practical decision-making related to patient assessment, monitoring of vital signs and glucose levels, insulin administration, potassium management, fluid resuscitation, assessment of DKA resolution, and patient education (Alotaibi, 2019; Elendu et al., 2023; Gosmanov et al., 2014; Shafiee et al., 2002). Each correct response received one point and each incorrect response received zero points. The total practice score ranged from 0 to 12, with higher scores indicating better practice regarding DKA assessment and management.

Validity and Reliability Testing

Content validity was established through review of the questionnaire by an expert panel comprising specialists in diabetes care, critical care nursing, emergency nursing, and nursing education. The experts assessed each item for relevance to DKA assessment and management, clarity, appropriateness for the target population, and alignment with current evidence-based recommendations.

The Content Validity Index (CVI) was calculated based on the experts' evaluations, and items that did not meet acceptable validity criteria were revised or modified before final data collection.

A pilot study was conducted among nurses with characteristics similar to those of the target population. Pilot participants were not included in the final study sample. The pilot assessment examined item clarity, comprehensibility, estimated completion time, functionality of the electronic questionnaire, and feasibility of the data collection procedures.

Because the knowledge and practice sections consisted of dichotomously scored multiple-choice items, internal consistency reliability was assessed using the Kuder–Richardson Formula 20 (KR-20).

Data Collection Procedure

Ethical approval was obtained from the Ethical Committee of the College of Nursing at Umm Al-Qura University, and the necessary permissions were obtained from the nursing administrations of the selected healthcare facilities.

Following ethical approval, the final questionnaire was generated using Google Forms. The electronic questionnaire link was distributed to eligible nurses using professional communication channels, including professional email addresses and social media platforms such as LinkedIn, Facebook, and X (formerly Twitter).

The professional email addresses and social media accounts used for recruitment were obtained through the nursing administration departments of the selected healthcare facilities. The nursing administrations facilitated access to eligible nurses while maintaining the confidentiality of participants' personal information.

Before accessing the questionnaire, participants were presented with an electronic informed-consent statement describing the study purpose, procedures, voluntary nature of participation, confidentiality, and their right to decline participation. Only participants who provided informed consent proceeded to the questionnaire.

All questionnaire items were programmed as mandatory fields in Google Forms, and participants could not submit the questionnaire until all required items had been completed. Consequently, no missing data were present in the final dataset. No personally identifying information was collected through the questionnaire. A total of 477 completed questionnaires were obtained and included in the final analysis.

Ethical Considerations

Ethical approval was obtained from the Ethical Committee of the College of Nursing at Umm Al-Qura University before commencement of data collection. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki and applicable principles concerning privacy, confidentiality, and protection of research participants, including relevant principles consistent with the Health Insurance Portability and Accountability Act (HIPAA).

Participation was voluntary, and electronic informed consent was obtained before questionnaire completion. Participants were informed about the purpose and procedures of the study, their right to decline participation or withdraw without penalty, and the confidentiality and anonymity of their responses.

No names, employee identification numbers, personal contact information, patient information, or other personally identifiable information were collected. Although professional communication channels were used for recruitment, participants' social media usernames and email addresses were not requested as part of the questionnaire. The collected data were used exclusively for research purposes and were securely maintained with access restricted to the research team.

Data Analysis

Data collected through Google Forms were exported and analyzed using IBM SPSS Statistics. Descriptive statistics were used to summarize participants' demographic, professional, educational, knowledge, and practice characteristics. Categorical variables were presented as frequencies and percentages, whereas continuous variables were summarized using means and standard deviations.

Knowledge and practice scores were calculated by summing the number of correct responses. Knowledge scores ranged from 0 to 15, and practice scores ranged from 0 to 12. Participants were categorized into poor, moderate, and good levels according to the predefined percentage-based classification.

Independent-samples *t*-tests were used to compare mean knowledge and practice scores between two-group categorical variables, whereas one-way analysis of variance (ANOVA) was used for comparisons involving more than two groups. Pearson correlation analysis was used to examine the relationship between knowledge and practice scores. Multiple linear regression analyses were performed to identify demographic, professional, and educational factors independently associated with knowledge and practice scores.

Statistical significance was established at $p < 0.05$. As all questionnaire items were mandatory and incomplete questionnaires could not be submitted, there were no missing data requiring imputation or missing-data analysis.

RESULTS

Demographic and Work-Related Characteristics

A total of 477 critical care and emergency nurses participated in the study. As shown in Table 1, the largest proportion of participants were aged 25–34 years (190, 39.8%), followed by those aged 35–44 years (155, 32.5%). Female nurses constituted 61.6% ($n = 294$) of the sample, while 38.4% ($n = 183$) were male. Slightly more than half of the participants were Saudi nationals ($n = 248$, 52.0%), whereas 48.0% ($n = 229$) were non-Saudi.

Regarding educational qualifications, most participants held a bachelor's degree in nursing ($n = 343$, 71.9%), followed by a master's degree ($n = 96$, 20.1%) and a diploma ($n = 38$, 7.9%). No participants with doctoral qualifications were reported. In terms of clinical work area, the largest proportion worked in emergency departments ($n = 171$, 35.8%), followed by adult ICUs ($n = 151$, 31.7%) and PICUs ($n = 91$, 19.1%). Most participants were staff nurses ($n = 365$, 76.5%).

Regarding total nursing experience, 29.8% ($n = 142$) had 2–5 years of experience, 29.1% ($n = 139$) had 6–10 years, and 28.9% ($n = 138$) had more than 10 years. Similarly, 31.7% ($n = 151$) had 2–5 years of critical care or emergency nursing experience. More than half of the participants worked in government hospitals ($n = 251$, 52.6%). Importantly, the majority of nurses reported previous experience caring for patients diagnosed with DKA ($n = 399$, 83.6%), while 16.4% ($n = 78$) had no previous DKA care experience (Table 1).

Table 1. Demographic and Work-Related Characteristics of Participants (N = 477)		
Variable	n	%
Age (years)		
<25	45	9.4
25–34	190	39.8
35–44	155	32.5
≥45	87	18.2
Gender		
Male	183	38.4
Female	294	61.6
Nationality		
Saudi	248	52.0
Non-Saudi	229	48.0
Highest nursing qualification		
Diploma in Nursing	38	7.9
Bachelor's degree in Nursing	343	71.9
Master's degree in Nursing	96	20.1
Current clinical work area		
Adult ICU	151	31.7
PICU	91	19.1
Emergency Department	171	35.8
CCU	48	10.1
Other	16	3.4
Current professional position		
Staff Nurse	365	76.5
Charge Nurse	46	9.6
Nurse Specialist	39	8.2
Nurse Educator	17	3.6
Nurse Manager	10	2.1
Total nursing experience		
<2 years	58	12.2
2–5 years	142	29.8
6–10 years	139	29.1
>10 years	138	28.9
Critical care/emergency nursing experience		
<2 years	74	15.5
2–5 years	151	31.7
6–10 years	132	27.7
>10 years	120	25.2
Type of healthcare facility		
Government hospital	251	52.6
Private hospital	103	21.6
Military hospital	57	11.9
University hospital	66	13.8
Previous care of patients with DKA		
Yes	399	83.6
No	78	16.4

Educational Exposure Related to DKA

As presented in Table 2, 60.0% (n = 286) of participants reported attending an educational program, workshop, or training related to DKA management during the previous two years, whereas 40.0% (n = 191) had not attended any DKA-related educational activity. Hospital-based in-service education was the most commonly reported educational activity (n = 151, 31.7%), followed by workshops or conferences (n = 72, 15.1%), online courses (n = 35, 7.3%), and self-directed learning (n = 28, 5.9%).

Regarding the duration of the most recent educational activity, 22.0% (n = 105) reported participating in activities lasting 2–4 hours, while 16.6% (n = 79) reported activities lasting less than 2 hours. A one-day educational activity was reported by 13.2% (n = 63), and 8.2% (n = 39) reported participating in an activity lasting more than one day.

Approximately two-thirds of participants reported that a standardized DKA management protocol was available in their clinical unit (n = 302, 63.3%). However, 17.2% (n = 82) reported that no protocol was available, while 19.5% (n = 93) were unsure about the availability of a standardized protocol.

In terms of confidence, the largest proportion of nurses reported being moderately confident in assessing and managing DKA (n = 196, 41.1%), followed by those who were very confident (n = 132,

27.7%). Only 6.5% (n = 31) reported that they were not confident, whereas 7.1% (n = 34) reported being extremely confident (Table 2).

Table 2. Educational Exposure Related to DKA Among Participants.

Variable	n	%
Attended DKA educational program during the past two years		
Yes	286	60.0
No	191	40.0
Type of DKA-related educational activity		
Hospital-based in-service education	151	31.7
Workshop or conference	72	15.1
Online course	35	7.3
Self-directed learning	28	5.9
None	191	40.0
Duration of most recent DKA educational activity		
<2 hours	79	16.6
2–4 hours	105	22.0
One day	63	13.2
More than one day	39	8.2
Not applicable	191	40.0
Standardized DKA protocol available in clinical unit		
Yes	302	63.3
No	82	17.2
I do not know	93	19.5
Confidence in assessing and managing DKA		
Not confident	31	6.5
Slightly confident	84	17.6
Moderately confident	196	41.1
Very confident	132	27.7
Extremely confident	34	7.1

Knowledge Regarding the Assessment and Management of DKA

The participants' responses to the 15 knowledge questions are presented in Table 3. Overall, the proportion of correct responses ranged from 57.2% to 80.7%, indicating variation in knowledge across the different domains.

Within the recognition, assessment, and diagnosis domain, the highest proportion of correct responses was observed for identifying the combination of hyperglycemia, metabolic acidosis, and ketone production as characteristic of DKA (n = 377, 79.0%). This was followed by recognition of Kussmaul respirations (n = 362, 75.9%) and identification of positive ketones with metabolic acidosis (n = 353, 74.0%). Knowledge regarding missed insulin doses or infection as common precipitating factors was demonstrated by 71.5% (n = 341) of participants.

In the pharmacological management domain, 77.8% (n = 371) correctly identified continuous intravenous regular insulin infusion as the recommended insulin therapy for acute DKA. However, only 61.6% (n = 294) correctly identified that insulin administration should be delayed when serum potassium is below 3.3 mmol/L. Knowledge regarding the use of dextrose-containing fluids while continuing insulin therapy when blood glucose decreases was demonstrated by 66.2% (n = 316). The lowest proportion of correct responses in

this domain was observed for the indication for sodium bicarbonate therapy, with only 57.2% (n = 273) correctly identifying its use in severe metabolic acidosis.

Within the fluid, electrolyte, and supportive management domain, the highest proportion of correct responses across all knowledge items was observed for identifying 0.9% normal saline as the initial intravenous fluid (n = 385, 80.7%). Furthermore, 77.4% (n = 369) correctly identified restoration of circulating volume and tissue perfusion as the primary purpose of fluid replacement. Approximately two-thirds correctly recognized the effect of insulin on intracellular potassium shifting (n = 328, 68.8%) and the criteria indicating resolution of DKA (n = 302, 63.3%).

Regarding prevention and patient education, 75.3% (n = 359) correctly identified insulin adherence and sick-day management education as important strategies for preventing recurrent DKA. Similarly, 72.7% (n = 347) correctly recognized the importance of continuing insulin therapy and monitoring glucose and ketones during illness.

The overall mean knowledge score was 10.57 ± 2.61 out of 15, indicating a moderate level of knowledge. Based on the predefined categories, 56.8% (n = 271) of participants had moderate knowledge, 23.5% (n = 112) had good knowledge, and 19.7% (n = 94) had poor knowledge (Table 3).

Table 3. Participants' Knowledge Regarding the Assessment and Management of DKA (N = 477)		
Knowledge Domain/Item	Correct answer n	Correct answer %
Domain 1. Recognition, Assessment, and Diagnosis		
1. Combination of hyperglycemia, metabolic acidosis, and ketone production	377	79.0
2. Positive ketones with metabolic acidosis	353	74.0
3. Deep rapid breathing (Kussmaul respirations)	362	75.9
4. Missed insulin doses or infection	341	71.5
Domain 2. Pharmacological Management		
5. Continuous intravenous regular insulin infusion	371	77.8
6. Serum potassium level before insulin initiation	334	70.0
7. Delay insulin when potassium is <3.3 mmol/L	294	61.6
8. Add dextrose while continuing insulin infusion	316	66.2
9. Sodium bicarbonate for severe metabolic acidosis	273	57.2
Domain 3. Fluid, Electrolyte, and Supportive Management		
10. Administer 0.9% normal saline as initial fluid	385	80.7
11. Restore circulating volume and tissue perfusion	369	77.4
12. Insulin shifts potassium into cells	328	68.8
13. Resolution of acidosis, anion gap, and ketones	302	63.3
Domain 4. Prevention and Patient Education		
14. Insulin adherence and sick-day management education	359	75.3
15. Continue insulin and monitor glucose and ketones during illness	347	72.7
Level of Participants' Knowledge Regarding the Assessment and Management of DKA	n	%
Poor (<60%)	94	19.7
Moderate (60–79%)	271	56.8
Good (≥80%)	112	23.5
Total score of Participants' Knowledge Regarding the Assessment and Management of DKA (Range = 0–15)	Mean	SD
	10.57	2.61

Practice Regarding the Assessment and Management of DKA

The findings regarding nurses' practices are presented in Table 4. The percentage of correct responses across the 12 practice items ranged from 65.8% to 84.3%.

Within the initial assessment and monitoring domain, most participants correctly identified assessment of airway, breathing, circulation, vital signs, and neurological status as the priority action for a patient suspected of having DKA (n = 402, 84.3%). Similarly, 81.6% (n = 389) correctly identified new confusion or reduced consciousness as an urgent finding requiring immediate attention. Approximately three-quarters of participants (n = 365, 76.5%) correctly identified hourly blood glucose monitoring during intravenous insulin therapy according to the DKA management protocol.

In the pharmacological management domain, 73.0% (n = 348) correctly indicated that insulin should be continued until ketoacidosis resolves. However, only 67.3% (n = 321) correctly selected withholding insulin and administering potassium replacement when the serum potassium level was 2.9 mmol/L. Similarly, 65.8% (n = 314) correctly identified the need to confirm DKA resolution before transitioning from intravenous to

subcutaneous insulin. A total of 70.6% (n = 337) correctly recognized the need to continue insulin and administer dextrose-containing fluids when blood glucose decreases while ketones remain elevated.

For fluid and electrolyte management, 84.1% (n = 401) correctly identified monitoring intake and urine output as an important method of assessing fluid balance. Additionally, 79.9% (n = 381) correctly identified 0.9% normal saline as the initial fluid for resuscitation, while 78.4% (n = 374) correctly identified serum potassium as the laboratory parameter requiring assessment in a patient developing cardiac arrhythmias.

Regarding non-pharmacological management and patient education, 77.8% (n = 371) correctly identified individualized diabetes education as an important intervention for preventing recurrent DKA. Furthermore, 72.1% (n = 344) correctly identified education regarding insulin adherence, glucose monitoring, ketone testing, and sick-day management as an important component of discharge preparation.

The overall mean practice score was 9.10 ± 2.03 out of 12. More than half of participants demonstrated a moderate level of practice (n = 259, 54.3%), while 33.8% (n = 161) demonstrated good practice and 11.9% (n = 57) demonstrated poor practice (Table 4).

Table 4. Participants' Practice Regarding the Assessment and Management of DKA (N = 477)		
Practice Domain/ Item	Correct answer n	Correct answer %
Domain 1. Initial Assessment and Monitoring		
1. Assess ABCs, vital signs, and neurological status	402	84.3
2. Monitor blood glucose hourly according to protocol	365	76.5
3. Recognize new confusion or reduced consciousness as an urgent finding	389	81.6
Domain 2. Pharmacological Management		
4. Hold insulin and replace potassium when potassium is 2.9 mmol/L	321	67.3
5. Continue insulin until ketoacidosis resolves	348	73.0
6. Continue insulin and add dextrose when glucose falls but ketones remain elevated	337	70.6
7. Confirm DKA resolution before transition to subcutaneous insulin	314	65.8
Domain 3. Fluid and Electrolyte Management		
8. Initiate 0.9% normal saline for fluid resuscitation	381	79.9
9. Monitor intake and urine output to assess fluid balance	401	84.1
10. Assess serum potassium when cardiac arrhythmias occur	374	78.4
Domain 4. Non-Pharmacological Management and Education		
11. Provide insulin, glucose, ketone, and sick-day management education	344	72.1
12. Provide individualized education to prevent recurrent DKA	371	77.8
Level of Participants' Practice Regarding the Assessment and Management of DKA	n	%
Poor (<60%)	57	11.9
Moderate (60–79%)	259	54.3
Good (≥80%)	161	33.8
Participants' Practice Regarding the Assessment and Management of DKA (Range = 0–12)	Mean	SD
	9.10	2.03

Differences in Knowledge and Practice According to Participant Characteristics

As shown in Table 5, statistically significant differences in knowledge and practice scores were observed according to gender, educational qualification, clinical work area, previous DKA care experience, and previous DKA educational exposure ($p < 0.05$).

Female nurses had significantly higher knowledge scores than male nurses (10.78 ± 2.55 vs. 10.24 ± 2.68 , $p = 0.031$) and higher practice scores (9.27 ± 1.96 vs. 8.82 ± 2.12 , $p = 0.014$).

Educational qualification was significantly associated with both knowledge and practice scores ($p < 0.001$ for both). Knowledge scores increased from 9.42 ± 2.51 among nurses with a diploma to 11.24 ± 2.43 among those with a master's degree. Similarly, practice scores increased from 8.18 ± 2.01 among diploma-prepared nurses to 9.82 ± 1.74 among nurses with a master's degree.

Significant differences were also observed across clinical work areas for both knowledge ($p = 0.018$) and practice ($p = 0.022$). Nurses working in the ED demonstrated the highest mean knowledge score (10.81 ± 2.47), whereas nurses working in the CCU had a lower mean knowledge score (9.88 ± 2.73). ED nurses also demonstrated the highest practice score (9.32 ± 1.91).

Previous experience caring for patients with DKA was significantly associated with both knowledge and practice. Nurses with previous DKA care experience had higher knowledge scores than those without such experience (10.76 ± 2.52 vs. 9.58 ± 2.86 , $p < 0.001$) and higher practice scores (9.28 ± 1.93 vs. 8.18 ± 2.28 , $p < 0.001$).

Similarly, nurses who had received DKA-related educational exposure demonstrated significantly higher knowledge scores than those without previous educational exposure (11.18 ± 2.36 vs. 9.65 ± 2.68 , $p < 0.001$). Their practice scores were also significantly higher (9.61 ± 1.82 vs. 8.34 ± 2.19 , $p < 0.001$) (Table 5).

Table 5. Knowledge and Practice Scores by Selected Demographic and Work-Related Characteristics				
Variable	Knowledge Mean (SD)	p-value*	Practice Mean (SD)	p-value*
Gender				
Male	10.24 (2.68)	0.031	8.82 (2.12)	0.014
Female	10.78 (2.55)		9.27 (1.96)	
Educational qualification				
Diploma	9.42 (2.51)	<0.001	8.18 (2.01)	<0.001
Bachelor's	10.39 (2.57)		8.91 (2.04)	
Master's	11.24 (2.43)		9.82 (1.74)	
Clinical work area				
Adult ICU	10.72 (2.49)	0.018	9.25 (1.89)	0.022
PICU	10.48 (2.65)		9.08 (2.03)	
ED	10.81 (2.47)		9.32 (1.91)	

Table 5. Knowledge and Practice Scores by Selected Demographic and Work-Related Characteristics

CCU	9.88 (2.73)		8.63 (2.19)	
Other	9.69 (2.84)		8.44 (2.26)	
Previous DKA care experience				
Yes	10.76 (2.52)	<0.001	9.28 (1.93)	<0.001
No	9.58 (2.86)		8.18 (2.28)	
Previous DKA education				
Yes	11.18 (2.36)	<0.001	9.61 (1.82)	<0.001
No	9.65 (2.68)		8.34 (2.19)	

* A statistically significant p-value (< 0.05) is indicated in bold.

Correlation Between Knowledge and Practice

A statistically significant positive correlation was observed between nurses' knowledge and practice scores regarding DKA assessment and management ($r = 0.428$, $p = 0.003$), as shown in

Table 6. This finding indicates that nurses with higher knowledge scores tended to demonstrate better practice scores. The magnitude of the correlation suggests a moderate positive association between knowledge and practice.

Table 6. Correlation Between Knowledge and Practice Regarding DKA Management

Variables	1. Knowledge score r (p value) *	2. Practice score r (p value) *
1. Knowledge score	1.00	
2. Practice score	0.428 (0.003)	1.00

* A statistically significant p-value (< 0.05) is indicated in bold.

Predictors of Knowledge Regarding DKA Management

Multiple linear regression analysis was conducted to identify factors independently associated with knowledge regarding DKA assessment and management. The overall regression model was statistically significant ($R^2 = 0.21$, adjusted $R^2 = 0.20$, $p < 0.001$), indicating that the variables included in the model explained approximately 21% of the variance in knowledge scores (Table 7).

A bachelor's degree or higher was significantly associated with higher knowledge scores ($B = 0.91$, $SE = 0.31$, $\beta = 0.13$, $p = 0.004$). Previous experience caring for patients with DKA was also a

significant positive predictor of knowledge ($B = 0.76$, $SE = 0.29$, $\beta = 0.12$, $p = 0.009$).

The strongest predictor in the model was previous DKA-related educational exposure ($B = 1.38$, $SE = 0.25$, $\beta = 0.24$, $p < 0.001$). The availability of a DKA management protocol was also significantly associated with higher knowledge scores ($B = 0.61$, $SE = 0.26$, $\beta = 0.10$, $p = 0.020$).

In contrast, age ($p = 0.168$), female gender ($p = 0.105$), and more than five years of nursing experience ($p = 0.061$) were not statistically significant independent predictors of knowledge (Table 7).

Table 7. Multiple Linear Regression Predicting Knowledge Regarding DKA Management

Predictor	B	SE	β	p-value*
Age	0.04	0.03	0.07	0.168
Female gender	0.39	0.24	0.07	0.105
Bachelor's degree or higher	0.91	0.31	0.13	0.004
>5 years nursing experience	0.47	0.25	0.08	0.061
Previous DKA care experience	0.76	0.29	0.12	0.009
Previous DKA educational exposure	1.38	0.25	0.24	<0.001
DKA protocol available	0.61	0.26	0.10	0.020
Multiple Linear Regression Model		$R^2 = 0.21$	Adjusted $R^2 = 0.20$	$p < 0.001$

* A statistically significant p-value (< 0.05) is indicated in bold.

Predictors of Practice Regarding DKA Management

The multiple linear regression model predicting DKA-related practice was statistically significant ($R^2 = 0.29$, adjusted $R^2 = 0.28$, $p < 0.001$), with the included variables explaining approximately 29% of the variance in practice scores (Table 8).

Educational qualification was significantly associated with practice, with nurses holding a bachelor's degree or higher demonstrating higher practice scores ($B = 0.72$, $SE = 0.25$, $\beta = 0.12$, $p = 0.005$). More than five years of nursing experience was also a significant predictor of better practice ($B = 0.51$, $SE = 0.20$, $\beta = 0.11$, $p = 0.011$).

Previous DKA care experience significantly predicted higher practice scores ($B = 0.68$, $SE = 0.23$, $\beta = 0.13$, $p = 0.004$). Previous DKA-related educational exposure was also significantly associated with better practice ($B = 0.94$, $SE = 0.20$, $\beta = 0.18$, $p < 0.001$). Importantly, knowledge score was a significant independent predictor of practice ($B = 0.27$, $SE = 0.04$, $\beta = 0.35$, $p < 0.001$), representing the strongest standardized predictor in the model. This finding further supports the observed positive relationship between nurses' knowledge and their reported practice regarding DKA assessment and management. Age ($p = 0.207$) and female gender ($p = 0.104$) were not statistically significant independent predictors of practice (Table 8).

Table 8. Multiple Linear Regression Predicting Practice Regarding DKA Management

Predictor	B	SE	β	p-value*
Age	0.03	0.02	0.06	0.207

Table 8. Multiple Linear Regression Predicting Practice Regarding DKA Management				
Female gender	0.31	0.19	0.07	0.104
Bachelor's degree or higher	0.72	0.25	0.12	0.005
>5 years nursing experience	0.51	0.20	0.11	0.011
Previous DKA care experience	0.68	0.23	0.13	0.004
Previous DKA educational exposure	0.94	0.20	0.18	<0.001
Knowledge score	0.27	0.04	0.35	<0.001
Multiple Linear Regression Model		R ² = 0.29	Adjusted R ² = 0.28	p < 0.001
* significant p value (< 0.05) is indicated as bold text.				

DISCUSSION

This study examined nurses' knowledge and practice regarding the assessment and management of DKA among critical care and emergency nurses in the Northwestern Region of Saudi Arabia. Overall, the findings indicate that nurses demonstrated moderate levels of both knowledge and practice, suggesting that although many participants were familiar with fundamental principles of DKA care, important competency gaps remain. These findings are clinically relevant because DKA is a rapidly progressive metabolic emergency requiring timely recognition, appropriate fluid therapy, continuous insulin administration, careful electrolyte monitoring, and identification of treatment endpoints (Barski et al., 2023; Dhatariya & Care, 2022; Elendu et al., 2023). The pattern observed in the present study is consistent with recent evidence from Palestine, where critical care nurses demonstrated considerable deficiencies in DKA-related knowledge and where the authors emphasized the need for structured education and standardized clinical guidance (Alskafi et al., 2025). Similarly, qualitative evidence from emergency departments in Tanzania identified challenges related to nurses' preparedness, clinical exposure, training, and application of DKA management principles (Kajembula et al., 2024). These findings collectively suggest that working in high-acuity environments does not necessarily ensure comprehensive DKA competency.

The item-level findings indicate that nurses were generally more familiar with recognition, initial assessment, fluid resuscitation, and routine monitoring than with complex treatment decisions. Important gaps were evident in areas involving potassium management, continuation or modification of insulin therapy, administration of dextrose while ketosis persists, criteria for DKA resolution, and appropriate use of bicarbonate therapy. These aspects require nurses to interpret laboratory findings and dynamically adjust care rather than simply follow routine procedures. Such gaps are particularly important because inappropriate insulin administration in the presence of severe hypokalemia or premature discontinuation of insulin may increase the risk of serious complications. Current DKA guidelines emphasize careful potassium assessment before and during insulin therapy, continued insulin until ketoacidosis resolves, appropriate dextrose supplementation when indicated, and biochemical assessment of resolution rather than relying on glucose concentration alone (Dhatariya & Care, 2022; Gosmanov et al., 2014; Savage et al., 2011). Similar deficiencies in specific aspects of diabetes-related clinical knowledge have been reported among nurses in Saudi Arabia, where a discrepancy between perceived and objectively assessed knowledge was identified (Albagawi et al., 2023). Thus, the present findings support the need for education that emphasizes clinical reasoning and decision-making, rather than focusing primarily on factual information.

A major finding was the positive relationship between educational exposure, previous DKA-care experience, and nurses' knowledge and practice. Nurses who had previously participated in DKA-related education and those with previous experience caring for patients with DKA demonstrated better competency, and these factors remained significant predictors after adjustment for other characteristics. Higher nursing qualifications were also associated with better knowledge and practice. These findings suggest that both formal educational preparation and repeated clinical exposure contribute to DKA competency. However, clinical experience

alone may not be sufficient because opportunities to manage DKA may vary substantially among nurses and clinical settings. Recent evidence among critical care nurses similarly supports the importance of targeted DKA education and continuing professional development (Alskafi et al., 2025). Furthermore, the Saudi study by Albagawi et al. (2023) demonstrated that nurses' diabetes knowledge was influenced by educational and professional characteristics and emphasized the importance of access to guidelines and continuing education. Therefore, structured DKA education should complement clinical experience, particularly for nurses who have limited exposure to DKA.

The significant positive association between knowledge and practice further supports the conceptual framework of this study, suggesting that stronger knowledge is associated with better application of DKA management principles. Knowledge was also an important independent predictor of practice, indicating that improving nurses' understanding of DKA may contribute to improved clinical decision-making. Nevertheless, the relationship was not perfect, suggesting that knowledge alone does not fully determine clinical performance. Organizational factors, availability of protocols, clinical experience, workload, supervision, and opportunities for simulation and skills practice may also influence practice. The finding that availability of a standardized DKA protocol was associated with knowledge further emphasizes the importance of institutional support. Evidence-based DKA protocols can reduce variation in care and provide nurses with accessible guidance for fluid management, insulin administration, electrolyte replacement, monitoring, and transition of therapy (Dhatariya & Care, 2022; Tran et al., 2017). In addition, the finding that a considerable proportion of nurses were only moderately confident despite previous educational exposure reinforces the distinction between perceived confidence and objectively assessed competency, which has also been demonstrated in Saudi nursing research (Albagawi et al., 2023).

Taken together, the findings demonstrate that DKA management competency among critical care and emergency nurses is an important area for continuing professional development in Saudi Arabia. The observed pattern of moderate knowledge and practice, together with deficiencies in complex management decisions, indicates that educational interventions should be targeted, practical, recurrent, and competency-based. Simulation, case-based learning, clinical scenarios, and protocol-based exercises may be particularly useful because they allow nurses to integrate assessment findings, laboratory results, medication management, and ongoing reassessment. Previous research has similarly emphasized the importance of targeted education, standardized protocols, and institutional support in improving DKA nursing care (Alskafi et al., 2025; Kajembula et al., 2024). Although the cross-sectional design prevents causal conclusions, the findings provide useful evidence for strengthening DKA education and clinical governance in critical care and emergency settings across the Northwestern Region of Saudi Arabia.

Study Implications and Recommendations

Nursing Education and Continuing Professional Development

Healthcare institutions should establish regular, structured DKA-focused continuing education programs for critical care and emergency nurses. Educational content should prioritize areas associated with greater clinical risk, including potassium assessment and replacement, insulin administration, management of glucose decline while ketosis persists, criteria for DKA resolution, fluid and electrolyte management, and transition from intravenous to subcutaneous insulin. Education should move beyond traditional lectures and incorporate case-based learning, simulation, clinical scenarios, and competency assessments. This approach is consistent with recent evidence emphasizing targeted training to improve nurses' DKA knowledge, preparedness, and clinical competence (Alskafi et al., 2025; Kajembula et al., 2024). Continuing professional development should also promote lifelong learning and self-efficacy, enabling nurses to maintain competence and adapt their knowledge to evolving clinical guidelines and complex critical care situations (Rababa et al., 2026). Emerging educational technologies, including AI-supported learning tools, may provide additional opportunities for flexible, interactive, and individualized professional development when appropriately integrated with evidence-based clinical education (Saleh et al., 2025).

Clinical Practice and Institutional Protocols

Hospitals should ensure that standardized, evidence-based DKA management protocols are available and easily accessible in emergency departments, ICUs, and other relevant clinical areas. Nurses should receive structured orientation and periodic updates regarding these protocols to ensure that their availability translates into consistent clinical application. Protocols should provide clear guidance regarding initial assessment, fluid therapy, insulin administration, potassium management, glucose and ketone monitoring, criteria for adding dextrose, recognition of complications, criteria for DKA resolution, and transition to subcutaneous insulin (Dhatariya, 2022; Tran et al., 2017). Institutions should also integrate DKA management into broader quality-improvement and professional-development initiatives, with protocols reviewed regularly to reflect current evidence and clinical practice recommendations. Similar structured approaches to clinical decision-making and emergency care may help strengthen nurses' ability to respond appropriately to complex and rapidly changing patient conditions (Alsharawneh et al., 2025).

Competency Assessment and Targeted Support

DKA competency should be incorporated into ongoing nursing competency assessment, particularly for newly employed nurses and nurses with limited previous DKA-care experience. Objective assessments should be combined with self-reported confidence because perceived competence may not accurately reflect actual knowledge or clinical decision-making (Albagawi et al., 2023). Simulation-based competency assessments can provide opportunities to evaluate nurses' responses to changing glucose, potassium, acid-base, and neurological status. Nurses identified as having competency gaps should receive targeted remediation and reassessment. Simulation, case-based learning, and structured clinical scenarios should be used not only to assess technical skills but also to strengthen clinical reasoning, communication, and timely decision-making.

Recommendations for Future Research

Future research should evaluate the effectiveness of structured DKA educational and simulation-based interventions using quasi-experimental or randomized controlled designs. Studies should examine whether improvements in nurses' knowledge and practice are sustained over time and whether they translate into better adherence to DKA protocols and improved patient outcomes. Multicenter studies involving hospitals from different regions and healthcare sectors in Saudi Arabia are also recommended to determine the generalizability of the present findings. Future research should additionally investigate organizational factors such as staffing, workload, accessibility of guidelines, frequency of DKA exposure, and institutional training practices that may influence nurses' competency (Alskafi et al., 2025; Kajembula et

al., 2024). Future studies should also examine the potential contribution of lifelong learning, professional self-efficacy, and technology-enhanced education to sustained clinical competence among critical care and emergency nurses (Rababa et al., 2026; Saleh et al., 2025).

Overall, healthcare organizations should adopt a multifaceted DKA competency strategy that combines evidence-based protocols, recurrent education, simulation-based training, clinical exposure, objective competency assessment, and regular practice audits. Such an integrated approach may strengthen nurses' ability to translate DKA knowledge into safe clinical practice, promote lifelong professional learning, and support more consistent, evidence-based management of patients with DKA.

Study Limitations

Several limitations should be considered when interpreting the findings. First, the cross-sectional design provides a snapshot of nurses' knowledge and practice at one point in time and therefore does not permit causal inferences. Although significant associations were identified between educational exposure, previous DKA care experience, knowledge, and practice, these relationships should not be interpreted as evidence of causality.

Second, convenience sampling was used to recruit participants. Although nurses were recruited from multiple hospitals and cities and from different critical care and emergency settings, the sample may not fully represent all critical care and emergency nurses in the Northwestern Region of Saudi Arabia or other regions of the country. Selection bias may have occurred because nurses who were more interested in DKA management or continuing education may have been more likely to participate.

Third, data were collected using a self-administered electronic questionnaire. Although electronic data collection facilitated access to nurses across multiple healthcare facilities, it may have introduced response and social desirability biases. In addition, the practice section assessed clinical decision-making using scenario-based questions rather than direct observation of nurses' actual bedside performance. Consequently, the reported practice scores may not completely reflect real-world clinical practice.

Fourth, the questionnaire was developed by the researchers based on evidence-based recommendations and underwent expert review and pilot testing; however, it was not a widely established standardized international instrument. Therefore, comparisons with studies using different DKA knowledge or practice measures should be made cautiously. Finally, the regression models explained only part of the variation in knowledge and practice, suggesting that other factors not assessed in this study, such as institutional training systems, workload, staffing, clinical supervision, availability and use of protocols, and organizational support, may also influence DKA management competency.

CONCLUSION

This study demonstrated that critical care and emergency nurses in the Northwestern Region of Saudi Arabia had moderate levels of knowledge and practice regarding the assessment and management of DKA. Although many nurses demonstrated appropriate understanding of key principles of DKA recognition, fluid management, insulin therapy, monitoring, and patient education, important competency gaps remained in areas such as potassium management, indications for specific therapies, recognition of treatment milestones, and decisions related to transition from intravenous to subcutaneous insulin.

Knowledge and practice were positively associated, indicating that stronger theoretical knowledge is accompanied by better clinical decision-making regarding DKA management. Previous DKA-related educational exposure, previous experience caring for patients with DKA, higher educational qualification, and availability of standardized DKA protocols were important factors associated with improved competency. Notably, knowledge was the strongest independent predictor of practice, emphasizing the importance of strengthening nurses' knowledge as part of efforts to improve DKA care.

These findings highlight the need for structured and continuing DKA education for critical care and emergency nurses, particularly through evidence-based workshops, simulation-based training, case-based learning, and regular competency assessments. Healthcare institutions should also ensure the availability, accessibility, and consistent implementation of standardized DKA management protocols. Integrating regular educational programs with clinical protocols and competency-based assessment may help reduce knowledge and practice gaps, promote timely and safe management, and improve the quality of nursing care for patients experiencing DKA. Future longitudinal and interventional studies are recommended to evaluate whether targeted educational and organizational interventions produce sustained improvements in nurses' DKA management competency and patient outcomes.

AUTHOR CONTRIBUTION

All authors contributed substantially to the conception and design of the study. **G.S.A., K.M.A.-S., R.A.E., and H.N.M.** contributed substantially to the conception and design of the study, data collection, data analysis, interpretation of findings, and manuscript development. **G.S.A. and R.A.E.** coordinated data collection and prepared the initial draft. **K.M.A.-S. and H.N.M.** contributed to data analysis, interpretation, and critical revision of the manuscript. **A.A., F.M.M., K.A.A., A.R.A., H.Z., and D.E.S.F.** contributed to data collection, study implementation, interpretation, and critical review of the manuscript. All authors reviewed and approved the final manuscript and agreed to be accountable for the work and its submission for publication.

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Data availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

Competing interests

The authors declare no competing interests

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