

A Retrospective Analysis of Diabetic Ketoacidosis in Saudi Arabia: Incidence, Risk Factors, and Treatment Approaches

Nawal Alsubaie¹, Lama Hani Sayed¹, Fatimah Mohammed Khudair¹, Salem Alsuwaidan^{2,*}, Najat Alghamdi³, Faisal Almazroua⁴, Khalid Manea Alotaibi⁵, Amani Saleh Alrossies¹, Ammena Yahya Binsaleh¹, Badria Alotaibi⁶, Nora Almosa⁷, Ahmad Almalki⁷, Aymen Alqurain⁸, Prafulla Sabale^{9,*}

¹Department of Pharmacy Practice, College of Pharmacy, Princess Nourah bint Abdulrahman University, Riyadh, SAUDI ARABIA.

²Department of Research and Innovation Center, King Saud Medical City, Ministry of Health, Riyadh, SAUDI ARABIA.

³Department of Endocrine, King Saud Medical City, Ministry of Health, Riyadh, SAUDI ARABIA.

⁴Department of Emergency, King Saud Medical City, Ministry of Health, Riyadh, SAUDI ARABIA.

⁵Department of Pharmacy, Al-Dawaa Pharmacy, Riyadh, SAUDI ARABIA.

⁶Department of Pharmaceutical Science, College of Pharmacy, Princess Nourah bint Abdulrahman University, Riyadh, SAUDI ARABIA.

⁷Department of Family Medicine, Chronic Illness Clinic, Prince Sultan Military Medical City, SAUDI ARABIA.

⁸Department of Clinical Practice, Faculty of Pharmacy, Northern Border University, Rafha, SAUDI ARABIA.

⁹Department of Pharmaceutical Sciences, Rashtrasant Tukdoji Maharaj Nagpur University, Nagpur, Maharashtra, INDIA.

ABSTRACT

Aim/Background: Diabetic Ketoacidosis (DKA) is a life-threatening complication of diabetes mellitus that remains a major public health issue in Saudi Arabia, affecting patients with both type 1 and type 2 diabetes. This study aimed to investigate the incidence, risk factors, clinical characteristics, treatment outcomes, and recurrence patterns of DKA, with a particular focus on identifying key triggers and examining molecular indicators that may influence recurrence.

Materials and Methods: A retrospective observational study was conducted at King Saud Medical City (KSMC) over a two-year period from July 2022 to July 2024. A total of 355 patients diagnosed with DKA were included. Data were collected on demographics, comorbidities, clinical presentations, biochemical parameters, treatment protocols, and hospitalization trends. Treatment interventions and recurrence rates were also analyzed. **Results:** Out of 355 patients, 94.6% (n=336) had type 1 diabetes with a mean age of 22.75 years. The leading precipitating factors for DKA were noncompliance with insulin therapy (36.3%) and missed insulin doses (32.4%). Common clinical manifestations included vomiting (69.3%), abdominal pain (62%), and nausea (36.6%). The majority of patients (84.5%) received fluid resuscitation with 0.9% normal saline, and 92.7% were treated with regular insulin infusion. The mean treatment duration was 4 days, often requiring ICU (33.9%) or PICU (27.9%) admission. Recurrence of DKA was observed in 23.9% of cases, predominantly among females aged 10-18 years. The overall mortality rate was 1.6%. **Conclusion:** Nonadherence to insulin therapy remains the primary contributor to DKA in Saudi Arabia. The findings emphasize the critical importance of early detection, patient education, and strict compliance with insulin therapy to minimize DKA incidence, severity, and recurrence. There is a pressing need for enhanced diabetes management protocols and public health strategies focused on prevention, especially in adolescent populations.

Keywords: Diabetic ketoacidosis (DKA), Ketones, Management, Recurrence, Risk Factors, Saudi Arabia, Type 1 Diabetes.

Correspondence:

Dr. Salem Alsuwaidan

Department of Research and Innovation Center, King Saud Medical City, Ministry of Health, Riyadh, SAUDI ARABIA.
Email: alraces@hotmail.com

Dr. Prafulla Sabale

Department of Pharmaceutical Sciences, Rashtrasant Tukdoji Maharaj Nagpur University, Nagpur-440033, Maharashtra, INDIA.
Email: prafullasable@yahoo.com

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INTRODUCTION

Retrospective observational studies use historical data to identify present patterns and connections between data points that prospective studies cannot determine.¹ These studies use historical records to generate statistical insights into illness

progression patterns, therapeutic efficacy rates, and treatment outcomes across various patient demographics.² The analytical system provides researchers with access to possible biomarkers, facilitating the assessment of risk factors and the validation of treatment targets for illnesses such as Diabetes Mellitus (DM) and Diabetic Ketoacidosis (DKA).³⁻⁵ The efficient examination of previous patient data, along with economical evaluation, renders retrospective investigations advantageous as they produce fresh research hypotheses for predicting future evaluations that enhance medical treatment strategies and clinical success criteria.

DKA is a serious acute complication of diabetes mellitus, most commonly affecting individuals with type 1 diabetes, though it



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can also occur in type 2 diabetes under certain conditions. It is primarily triggered by an absolute or relative deficiency of insulin, often compounded by elevated levels of counter-regulatory hormones such as glucagon, cortisol, catecholamines, and growth hormone. This hormonal imbalance impairs glucose uptake by peripheral tissues and promotes gluconeogenesis and glycogenolysis, leading to hyperglycemia (Figure 1). In the absence of adequate insulin, the body resorts to breaking down fat (lipolysis) for energy, resulting in the production of ketone bodies (acetoacetate, β -hydroxybutyrate, and acetone).⁶⁻⁸ The accumulation of these ketones leads to metabolic acidosis. Hyperglycemia-induced osmotic diuresis further exacerbates the condition by causing dehydration and electrolyte imbalances, particularly the loss of potassium and bicarbonate. Common precipitating factors for DKA include infections, physical or emotional stress, and insufficient insulin therapy.⁹

The incidence of diabetes is escalating internationally and is regarded as among of the most swiftly proliferating medical issues of the modern era. In 2021, around 537 million individuals globally were diagnosed with diabetes; projections indicate that this figure will increase to 643 million by 2030 and to 783 million by 2045. The IDF Diabetes Atlas reports that annually, about 96,000 kids and teens under 15 years of age are diagnosed with T1DM worldwide, with 13% to 80% of these cases exhibiting DKA upon identification.^{10,11} In the context of Saudi Arabia, the highest frequencies were observed between 12.8% and 80% of cases had DKA at diagnosis. Romania, and the UAE, whereas the lowest frequencies were identified in Sweden, the Slovak Republic, and Canada. When countries were ranked by DKA frequency, Sweden (14%), Canada (18.6%), Finland (22%), and Hungary (23%), as well as the United Arab Emirates (80%), Romania (67%), Taiwan (65%), and Saudi Arabia (59%) had the highest frequencies.¹² Moreover, it is estimated that DKA accounts for 30% of hospital admissions for diabetes-related complications in some regions.¹³ DKA is associated with significant healthcare costs and serious complications, including cerebral edema, renal failure, and death.¹⁴

Patients frequently experience symptoms such as nausea, vomiting, and a distinct fruity smell in their breath. Some people may experience classic symptoms of DM, such as thirst and frequent urination. The results showed that sex, age, BMI, HbA_{1c} levels, diabetes duration, and clinic attendance were strongly associated with DKA.^{15,16} Regarding pediatric patients, among the patients, most were aged 5-10 years, with associated complications, including hypokalemia, hypoglycemia, and hyperchloremic metabolic acidosis.¹⁷

Over 70% of patients recovered within 24-72 hr, with a mortality rate of 1.83%.¹⁸ Only a minority required ICU admission, and most patients stayed one to five days in the hospital.¹⁹ DKA during pregnancy warrants special attention which can poses a considerable danger to both the mother and child, highlighting

the need for enhanced prenatal education on DKA prevention and heightened awareness of DKA symptoms among pregnant women.²⁰

The management of DKA involves fluid resuscitation, since the majority of patients have a water deficit of approximately 100 mL per kilogram of body weight. The primary therapy often involves the injection of intravenous fluids to replenish intravascular volume and enhance renal perfusion.^{7,21} The selection of liquids (e.g., normal saline vs Lactated Ringer's solution) might affect the results.²² The use of insulin is fundamental in the management of DKA as it diminishes plasma glucose concentrations and mitigates the progression of ketoacidosis by reducing hepatic glucose production, enhancing peripheral glucose usage, and suppressing lipolysis, ketogenesis, and glucagon secretion.²³ Understanding the mechanisms leading to DKA, its clinical manifestations, and effective management strategies are crucial for reducing the morbidity and mortality associated with DKA. Despite the high burden of DKA in Saudi Arabia, limited data exist on its recurrence patterns, risk factors, and treatment outcomes, particularly in younger populations.

The present study aimed to comprehensively investigate DKA among Saudi patients by exploring its incidence, primary triggers, risk factors, and clinical outcomes across different age groups and genders. It further evaluated current management practices, hospitalization patterns, and biochemical predictors of recurrent DKA episodes. The ultimate goal was to inform strategies that enhance early detection, improve treatment approaches, and reduce the overall incidence and complications of DKA in diabetic patients in Saudi Arabia. Moreover, it can fill existing knowledge gaps and contributes to the development of better management strategies in clinical practice. This study was conducted to address the rising concern of DKA among Saudi patients by identifying its key triggers, risk factors, and management practices. By evaluating incidence patterns, treatment outcomes, and healthcare utilization, the study aims to support early detection and reduce DKA-related complications, thereby improving clinical strategies and patient outcomes in Saudi Arabia.

MATERIALS AND METHODS

Ethical Considerations

All investigators handled all data collection and access of the patient's information and ensured that all information was secured and the data needed were accessed with restrictions for objectives and research purposes only, and the study was conducted with respect to patients' information and confidentiality. Investigators informed the IRP committee of their participation in this research effort. Data were collected from medical records at King Saud Medical City (KSMC) Hospital. Ethical approval to conduct this study was granted under Reference No.: H1RI-28-Apr24-01 from the IRP of KSMC Hospital.

Observational Retrospective Study

This observational retrospective study reviewed patients' medical records at the emergency department of KSMC between July 2022 and July 2024. Estimating the 355 participants in this research using a 95% confidence interval, a 5% margin of error, and a population size of 66,000 patients with DKA in Saudi Arabia.²⁴ The diagnosis of DKA was confirmed according to the Guidelines and Protocols of Diabetes Emergencies at Saudi Ministry of Health (MOH) biochemical criteria for adult and pediatric populations, defined as hyperglycemia (blood glucose >11 mmol/L ≈ 200 mg/dL), ventricular pH <7.3, bicarbonate <15 mEq/L, and positive serum ketones or significant ketonuria (≥+2 urine ketones).⁷

This research included male and female patients with type 1 and type 2 diabetes, including all age ranges and both genders.^{17,25} Additionally, we recruited patients with comorbidities other than diabetes, such as hypertension, dyslipidemia, renal failure, and hyperthyroidism. For the disease-related data, the study included the duration of diabetes, age at the first attack of DKA, triggering factors, associated symptoms, and laboratory values including electrolyte, blood glucose, venous blood gas, and HbA_{1c}.^{16,26} In addition, this study analyzed management, including insulin type and fluid replacement therapy, length of hospital stay, ICU admission, treatment outcome (whether the DKA was resolved or the patient experienced any complications), and recurrence rate. Table 1, depicts an overview of the method used in the present study.

Statistical analysis

The clinical and demographic details of the research participants are presented as mean ± standard deviation for constant parameters and as percentages for qualitative variables. A Chi-square test was used to analyze the disparities in category variables. Each of the statistical analyses were conducted using the statistical program

SPSS (version 25.0; SPSS Inc., Chicago, IL, USA). The threshold for statistical significance was established at $p < 0.05$.

RESULTS

A total of 355 patients diagnosed with DKA were included in the study, with a slight 188 female majority (53.1%) compared with 166 males (46.9%). The average age was 22.75 years (SD ± 15.55), with a notable prevalence of younger patients under 30 yrs of age. The average age at the first DKA attack was 10.61 years (+11.54). The majority of patients 94.6 % were diagnosed with type 1 DM, compared to 5.4% type 2 DM. Most, if not all, patients were admitted to the emergency room with an average glucose level of 27.84 mmol/l (+11.1), and the average HbA_{1c} level was 12.71 (+2.64); the average and standard deviation are shown in Table 2. The most common comorbidity was hypothyroidism (4.2%), followed by end-stage renal disease (3.7%), then celiac disease with (0.8%), cancer with (0.6%), and other comorbidities, such as sleep apnea and asthma with (3.9%).

The leading triggering factors revealed for initiating DKA were that non-compliance with insulin therapy (36.3%), and missed doses (32.4%) were the most cited reasons for exacerbation, then urinary tract infection with (17.2%), chemotherapy with (0.4%), and (13.7%) for other triggering factors. The clinical symptoms presenting with DKA were varied, with vomiting (69.3%) and abdominal pain (62.0%) reported most frequently, then nausea (36.6%), flu-like symptoms (30.4%), and urinary tract symptoms with (22.5%), (more detail as shown in Figure 2).

Patients with DKA used to stay in hospital mostly 2-3 days (27.6%-20.6 consequently); however, length of stay may reach up to 2-3 months depending on the comorbidity associated with DKA; specifically, they occupy GW with 37.5%, ICU with 33.2%, and PICU with 27.3%. The treatment outcome data showed that a significant majority (98.3%) of participants had a positive

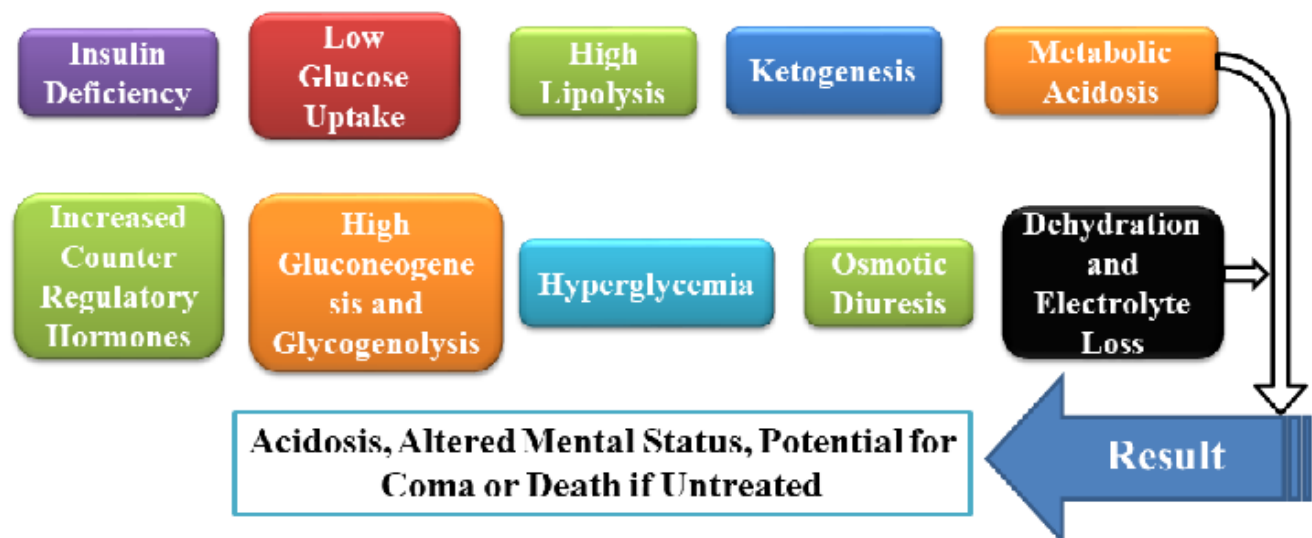


Figure 1: Pathophysiology of DKA.

Table 1: An overview of the method used in the present study.

Parameters	Observational Retrospective Study
Study Design	- Observational retrospective study - Review of medical records at KSMC emergency department - Time period: July 2022 to July 2024
Study Sample Size and Selection	- 345 participants - Confidence interval: 95% - Margin of error: 5% - Population size: 66,000 DKA patients in Saudi Arabia
Diagnosis Criteria (Saudi MOH Guidelines)	- Hyperglycemia: blood glucose >11 mmol/L ($\approx$ 200 mg/dL) - Ventricular pH <7.3 - Bicarbonate <15 mEq/L - Positive serum ketones or significant ketonuria ($\geq$ +2 urine ketones)
Inclusion Criteria	- Male and female patients - Type 1 and Type 2 diabetes - All age groups - Patients with comorbidities (e.g., hypertension, dyslipidemia, renal failure, hyperthyroidism)
Data Collection	- Patient Demographics - Disease-related Data (Duration of diabetes, Age at first DKA attack, Triggering factors, Associated symptoms) - Laboratory Values (Electrolytes, Blood glucose, Venous blood gas, HbA_{1c})
Management Analysis	- Insulin type - Fluid replacement therapy - Length of hospital stay - ICU admission
Treatment Outcomes	- DKA resolution - Complications (if any)

treatment outcome, with only 1.7% reporting a negative outcome (death). Recurrence of DKA was observed in 85 patients (23.9%), whereas 264 patients (74.4%) did not experience recurrence. The treatment protocol included basal and infusion of insulin with a bolus dose of insulin of almost 58% as initial treatment. Normal saline and potassium chloride, and sometimes ringer lactate and sodium bicarbonate.

This investigation elucidates the demographic attributes, comorbidities, and clinical manifestations of individuals experiencing diabetes complications. This underscores the importance of adherence to treatment protocols and monitoring triggering factors to reduce the incidence of diabetic emergencies. Based on the data illustrated in Table 3, age was categorized into different age groups, namely (0-10 yrs; 10.1-18 yrs; 18.1-25 yrs;

25.1-40 yrs; and 40.1 yrs and over). The comparison in relation to the mean duration of DM showed a progressive increase with age, and this was expected according to age group. The average age at the first DKA attack also increases with age; the corresponding standard deviation indicates greater variability among younger patients compared to older individuals, suggesting that younger patients experience a wider range of ages at which DKA occurs. The average glucose levels did not significantly differ across the age categories. Overall, the mean glucose level was 27.84 ± 11.14 , indicating a greater variability from its standard deviation. The HbA_{1c} showed a similar trend, with an overall mean of 12.71 with standards deviations of 2.64 to show minimal variation across age groups.

Mean sodium levels were consistent across age groups with low variability, and mean potassium levels showed slight variations, with a standard deviation indicating consistency within age groups. Although both bicarbonate and chloride levels exhibited variability, bicarbonate levels generally increased in the older age groups. There is a slightly higher mean age in males with 25.14 ± 16.66 years, compared with the mean age of females with 20.64 ± 14.21 years, suggesting that male participants tend to be older than females with no significant difference ($p=0.680$). In terms of sex differences (Table 4), the mean duration of DM was significantly different. Males showed a mean duration of 13.75 ± 14.17 years, while females 10.72 ± 10.49 years. This difference is considered lesser with respect to sex when assessing the duration of the disease. Regarding the age of the first DKA attack, males had a mean age of 11.39 ± 11.89 , and females had a mean of 9.91 ± 11.22 years. Despite the small difference in means, the much larger standard deviation indicates that participants presented at a much wider age range at which they first experienced DKA.

Mean glucose levels are another critical parameter to analyze; for males, the mean glucose level was 27.89 ± 9.95 compared to females, with a mean of 27.80 ± 12.12 . This finding suggests that males may have higher average glucose levels, with no significant difference. This result reflecting also the mean of HbA_{1c} level in females, with a slightly higher value of $13.08 \pm 2.76\%$, compared with the HbA_{1c} levels for males, which have a mean of $12.30 \pm 2.44\%$.²⁶ The slightly higher mean HbA_{1c} in females indicates poorer glycemic control on average, with no significant difference. Sodium, potassium, bicarbonate, and chloride levels provide valuable insights into the metabolic status of individuals suffering from DKA. The mean sodium level in males is 133.73 ± 7.29 , while the mean sodium in females was 132.62 ± 6.81 . The mean potassium levels were 5 ± 1.02 for the male gender and 4.76 ± 0.83 for the female gender. Bicarbonate levels for males exhibited a mean of 8.47 ± 4.52 , whereas females had a mean of 8.08 ± 4.42 . The mean chloride level for males was 97.49 ± 9.01 compared to females at 98.92 ± 8.83 for females. The comparable means and standard deviations indicate similar electrolyte regulations across sexes.

DISCUSSION

DKA is an immediate, serious, and occasionally fatal consequence of diabetes. It is often observed in individuals with type 1 diabetes. Occasionally, individuals with type 2 DM may encounter this problem. It is defined by increased body ketone concentrations, metabolic acidosis, and uncontrolled hyperglycemia.¹⁹ Despite the severity of DKA, there is currently little evidence to address its incidence, initiation, risk factors, and proper therapeutic management. A thorough identification of these characteristics will raise public awareness and help healthcare professionals to better understand this significant issue.

This research revealed that among 355 patients, 188 females constituted the majority (53.1%) compared to 166 men (46.9%) diagnosed with DKA, while the difference was not statistically significant ($p>0.05$). A research done in Riyadh similarly indicated that women had a greater incidence.¹⁴ The majority of individuals were diagnosed with type 1 diabetes (94.6%), whereas 5.4% had type 2 diabetes. Likewise, one research determined that type 1 diabetes constituted the majority of the group (89.2%), whereas 10.8% had type 2 diabetes.¹³ Unlike other study found that most of the patients had type 2 diabetes (62.7%).²⁷

This study found that most patients diagnosed with DKA were between the ages of 10 and 18 years, indicating that younger people are more likely to develop DKA. While previous studies found that the majority of the patients were between the ages of 14 and 30 years, another found that the majority of the patients were between the ages of 15 and 24 years, and the third found that the majority of them were between 21 and 30 years of age.²⁸⁻³⁰ The long-term care of patients with DKA depends on determining triggering events. This study found that non-adherence to insulin treatment (36.3%), missed insulin doses (32.4%), and infection, particularly Urinary Tract Infection (UTI), accounted for (17.2%) of the most significant factors associated with the development of DKA. These results align with the findings of other studies, in which non-adherence to diabetes therapy followed by infection was the most common precipitating cause of hospitalization for DKA.²⁷⁻³¹ However, stressful situations, high blood glucose levels when taking medication, and newly diagnosed type 1 diabetes have also been reported as factors that trigger DKA development.²⁹

The results of this study indicated that the clinical symptoms associated with DKA are diverse, with vomiting (69.3%) and abdominal pain (62.0%) being the most commonly reported. Nausea was observed in (36.6%) of cases, flu-like symptoms in (30.4%), and urinary tract symptoms in (22.5%). These results were consistent with data obtained in relevant studies that found that the clinical presentation was mostly characterized by gastrointestinal symptoms such as nausea, vomiting, and abdominal pain, as well as osmotic symptoms such as polyuria and polydipsia. There have also been reports of neurological

symptoms, such as disorientation, altered mental status, and loss of consciousness.²⁷

Research revealed that the predominant symptoms were polyuria and polydipsia (97.9%), followed by easy fatigability (82.9%) and abdominal pain (47.0%).²⁹ Effective therapy of DKA necessitates initiating fluid replacement based on the severity of the condition. Mild DKA is characterized by a venous pH of less than 7.3 or bicarbonate levels below 15 mmol/L. Moderate DKA is defined by a pH of less than 7.2 or bicarbonate levels below 10 mmol/L, and severe DKA is indicated by a pH of less than 7.1 or bicarbonate levels below 5 mmol/L. In the juvenile demographic, those with mild or moderate DKA should start treatment with 5 mL/kg/hr of 0.9% saline intravenously, whereas those with severe DKA should commence at a rate of 7 mL/kg/hr. Insulin infusion should commence 1-2 hr after fluid beginning, at a dosage of 0.05-0.1 units/kg/hr. For adults, the preferred initial fluid was 0.9% saline given at a rate of 15-20 mL/kg/hr. Insulin treatment should be started when the serum potassium level surpasses 3.3 mEq/L. The first insulin dosage was 0.1 unit per kilogram per hour.²³ Similar to the management guidelines from the US and the UK, both agreed that fluid replacement should be the main treatment, and that 0.9% sodium chloride solution is the optimal choice for initial fluid replacement. The US guidelines recommend 15-20 mL/kg/h (1-1.5 L) in the first hour (regardless of severity), whereas the UK document recommended 1 L in each of the first 2 hr. Fluid replacement rates were comparable. Both guidelines recommended the same insulin infusion rate of 0.1 units/kg/h.³² Based on our findings, the majority of the patients started fluid replacement with 0.9% saline (84.5%) with or without the following fluids: 15% potassium chloride (74.4%), Ringer lactate (38.3%), and 8.4% sodium bicarbonate for the severe cases with pH level<6.9 and did not respond to the initial management (13.2%). According to the protocol, (92.7%) of the patients started regular insulin infusions at a dose of 0.1 units/

Table 2: Mean and standard deviation for description of patients diagnosed with DKA.

Characteristics of DKA Patients	Mean±SD
Age (in year)	22.75±15.55
Duration of DM (in yr)	12.15±12.43
Age at first DKA attack	10.61±11.55
Glucose Level (mmol/l)	27.84±11.14
HbA _{1c} (%)	12.71±2.64
pH Level (7.35-7.45)	7.09±0.20
Sodium Level (136-145 mmol/l)	133.14±7.05
Potassium Level (3.4-4.5 mmol/l)	4.87±0.93
Bicarbonate Level (22-26 mmol/l)	8.26±4.46
Chloride Level (98-107 mmol/l)	98.25±8.93

The values are expressed as Mean±SD (n=no. of patients in each characteristics).

Table 3: Mean and standard deviation for the descriptive parameter according to age categories, for patients diagnosed with DKA.

Mean	All (n=355)	(0-10 yrs) (n=61)	(10.1-18 yrs) (n=119)	(18.1-25 yrs) (n=65)	(25.1-40 yrs) (n=58)	(40.1 and > yrs) (n=52)
Age	22.75±15.55	5.98±3.22	14.02±1.84	21.95±2.03	31.79±5.10	53.35±7.88
Duration of DM (in yr)	12.15±12.43	2.41±2.45	7.45±3.49	12.05±5.16	18.31±9.95	27.58±21.03
Age at first DKA attack	10.61±11.55	3.57±2.41	6.57±3.14	9.91±4.97	13.48±9.19	25.77±20.72
Glucose Level	27.84±11.14	26.29±9.88	28.18±10.71	28.24±10.55	28.71±13.81	27.42±11.10
HbA _{1c}	12.71±2.64	12.61±2.62	13.51±2.20	12.46±3.08	12.13±2.41	12.00±2.94
pH Level	7.09±0.20	7.04±0.14	7.09±0.25	7.12±0.13	7.12±0.20	7.05±0.22
Sodium	133.14±7.05	133.66±6.20	134.06±4.90	131.81±5.51	131.84±10.66	133.51±8.59
Potassium	4.87±0.93	4.69±0.86	4.89±0.85	5.02±1.05	4.95±1.01	4.77±0.92
Bicarbonate	8.26±4.46	6.26±3.23	7.92±4.40	8.65±4.62	9.94±4.33	9.05±4.95
Chloride	98.25±8.93	102.10±8.33	98.73±7.43	96.98±7.26	95.62±11.45	97.10±10.05

The values are expressed as mean±SD (n=no. of patients in each characteristics).

Table 4: Comparative data for the mean and standard deviation for the descriptive parameter according to sex (male and female), for patients diagnosed with DKA.

Mean	All (n=355)	Female (n=188)	Male (n=167)	p-value
Age	22.75±15.55	20.64±14.21	25.14±16.66	0.680
Duration of DM (in yr)	12.15±12.43	10.72±10.49	13.75±14.17	0.804
Age at first DKA attack	10.61±11.55	9.91±11.22	11.39±11.89	0.001
Glucose Level	27.84±11.14	27.80±12.12	27.89±9.95	0.599
HbA _{1c}	12.71±2.64	13.08±2.76	12.30±2.44	0.709
pH Level	7.09±0.20	7.08±0.23	7.09±0.16	0.507
Sodium	133.14±7.05	132.62±6.81	133.73±7.29	0.634
Potassium	4.87±0.93	4.76±0.83	5.00±1.02	0.724
Bicarbonate	8.26±4.46	8.08±4.42	8.47±4.52	0.675
Chloride	98.25±8.93	98.92±8.83	97.49±9.01	0.276

The values are expressed as mean±SD (n=no. of patients in each characteristics).

kg/hr. Basal and bolus insulin were started 2 hr after DKA was resolved in 80% and 57.7%, respectively.

The results of this study indicated that (68.7%) of the patient's experienced hyponatremia, while (5%) experienced hypernatremia, (3.67%) had hypokalemia, (62%) had hyperkalemia, (49%) had hypochloremia, and (13.20%) had hyperchloremia. In contrast, one a study found that the most common electrolyte imbalance reported was hypokalemia (40.9%).²⁷ According to these study findings, 96.1% of patients spent at least one day in the hospital, with an average of four days, and depending on the triggering events (such as infection), this might have been longer. In contrast to previous findings, the average length of hospital stay was found to be two days in one publication and six days in another.

This study identified the ward in which the patients were admitted to determine the severity of DKA and the need for frequent

monitoring. Most of the patients in this study were admitted to the ICU and PICU (33.9%, 27.9%, respectively). Similar to the relevant findings, most patients were admitted to the ICU and PICU.²⁷⁻³³ This study found that recurrence of DKA was observed in 85 patients (23.9%) with T1DM, 52 were female and 33 were male, and most of them were in the age group of 10.1-18 years old. Similarly, a study showed that recurrence at 6 and 12 months was higher in T1DM than in T2DM, Younger age, female sex, lower weight, and non-adherence to insulin.³⁴ In addition, a study showed that female had more recurrence with a female-to-male ratio of 6:2; most of the patients had type 1 DM and were between 11 and 26 years old.³⁵ In addition to a studies done in Riyadh and Jeddah showed similar results.

Two different investigations reported the mortality rate from DKA, which was 3.5% in 1993 and was further reduced to 2.9% in 2002.³⁶⁻³⁸ This study revealed a 1.6% death rate among patients enrolled between 2022 and 2024, and it was noticed that most

of the deaths were related to comorbidities. Similarly, one study reported a 1.83% mortality rate⁹. The reduction in mortality rates reflected an increased understanding of DKA and adherence to the guidelines. In contrast to local research, the authors reported no deaths due to DKA.⁸ The limitations of this study include its retrospective observational design, which increases the possibility of reducing data quality and completeness, and being a single-center study, which limits generalizability. Future studies should look at further multicenter studies to improve the generalizability of the findings, as well as the role and impact of patient education about their disease and medication management in preventing DKA onset and/or recurrence. A summary of this study's findings has been compared with those of previous studies, and is presented in Table 5.

FUTURE DIRECTION

The research indicates that electrolyte abnormalities are commonly observed in both genders with DKA, with only slight variations. These data suggest that effective electrolyte monitoring and control during DKA therapy is important for both girls and

boys. Additional research may be required to investigate the underlying factors associated with the minor discrepancies seen between male and female patient groups, such as illness duration and age at initial DKA onset. This electrolyte management strategy may enhance outcomes and reduce complications in people with DKA. Consequently, further research should clarify the processes that contribute to the gender-specific inequalities in the start and course of illness. Furthermore, investigating the hormonal role in electrolyte equilibrium during DKA episodes may enhance our comprehension of therapeutic optimization.

The management of DKA involves a multifaceted strategy and should not be equated with the acute phase of therapy. Long-term care strategies are essential for preventing recurrence and enhancing overall patient outcomes. This process is facilitated by patient education on the need of adhering to drug regimens, regular blood glucose testing, and identifying early indicators of DKA. Healthcare practitioners must emphasize the importance of adhering to prescribed insulin regimens and adjusting dosages as instructed. Moreover, it is essential to address psychosocial variables that may contribute to non-adherence, such as limited

Table 5: Comparison of study results on DKA: Current Findings and previous studies.

Parameter	Study findings	Similar findings	Contradictory findings	References
Gender Distribution	Females (53.1%), Males (46.9%) (not statistically significant).	Females had a higher incidence.	N/A	7
Type of Diabetes	T1DM: (94.6%), T2DM: (5.4%).	T1DM: (89.2%), T2DM (10.8%).	T2DM: (62.7%).	6,16
Age Distribution	Majority: 10-18 years.	Majority: 14-30 years; Majority 15-24 years.	Majority: 21-30 years.	17-20
Precipitating Factors	Non-adherence: (36.3%), Missed insulin dose: (32.4%), infections (17.2%).	Non-adherence and infections as common triggers.	Stressful situations, high glucose, new onset T1DM.	6,16-19,21
Clinical Symptoms	Vomiting (69.3%), Abdominal pain (62%), Nausea (36.6%), Flu-like symptoms (30.4%), UTI (22.5%).	GI and osmotic symptoms common.	Polyuria and polydipsia (97.9%), Fatigue (82.9%).	6,16-19,21
Management Protocol	Fluid replacement with 0.9% normal saline (84.5%), insulin infusion rate 0.1 units/kg/hr.	Similar guidelines in US/ UK protocols ²¹ .	N/A	22
Electrolyte Imbalances	Hyponatremia (68.7%), Hyperkalemia (62%), Hypochloremia (49%).	N/A	Hypokalemia (40.9%).	16
Length of Hospital Stay	Average: 4 days.	N/A	Average: 2 days. Average: 6 days.	6,8
Admission to ICU/PICU	ICU (33.9%), PICU (27.9%).	Similar rates of ICU/PICU admission.	N/A	6,16,23
Recurrence	Recurrence more in T1DM (23.9%), Females, and age group of 10-18 years.	Higher recurrence in T1DM, younger age and females.	N/A	6,24,24
Mortality Rate	(1.6%).	(1.83%) ⁹ .	(3.5%) ²⁵ ; (2.9%) ²⁶ ; no mortality reported. ⁸	26,27

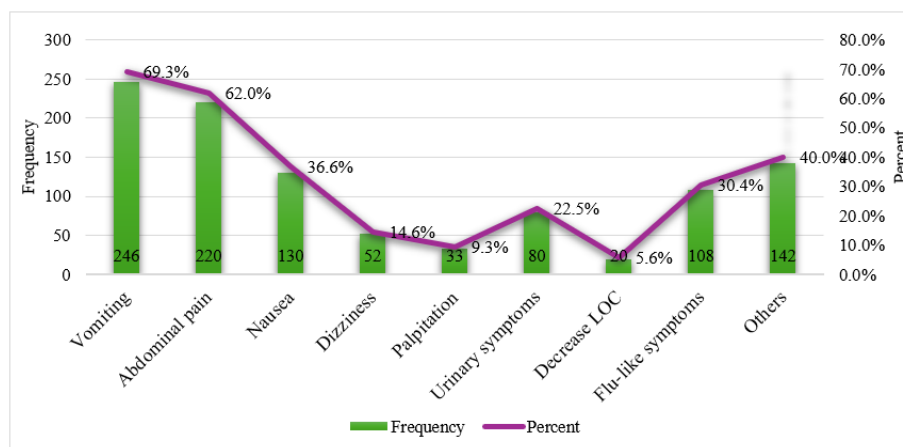


Figure 2: Frequency and percentages of clinical symptom presenting with DKA patients.

financial means or psychological issues. Through regular follow-up consultations and ongoing care from a multidisciplinary team, patients can more effectively control their diabetes and avoid future DKA episodes. Moreover, the implementation of technology solutions, like as continuous glucose monitoring devices and insulin pumps, may prove advantageous for certain patients in preventing the recurrence of DKA. Furthermore, the creation of tailored care plans that integrate individual risk factors and triggers enhances the optimization of long-term DKA management techniques. This study emphasizes the necessity of enhancing patient education to prevent the start or recurrence of DKA. Future research should focus on the creation of effective educational interventions tailored for various age demographics and distinct forms of diabetes. Additionally, the impact of technology (e.g., mobile applications, continuous glucose monitoring devices) on enhancing adherence to insulin therapy and facilitating early identification of DKA needs investigation to reduce the incidence of DKA.

CONCLUSION

Interestingly, this data demonstrates that, despite the minor differences that exist with regards to the gender of the DKA patients, electrolyte imbalances are consistent across both genders. Thus, gender need not preclude the necessity for careful electrolyte monitoring during DKA treatment. Further exploration is necessary to uncover small differences by gender regarding the duration of the disease and the age of the first DKA attack. Better care and fewer complications in pediatric DKA patients may be achieved with more complete electrolyte management. Mechanisms driving gender-specific differences in disease onset and progression and any influence the hormones may have on electrolyte balance during DKA episodes also warrant future studies. These results may be used to develop better-tailored treatment strategies and longer-term care approaches to prevent DKA recurrence and improve overall patient outcomes. Medication nonadherence is the most common cause of DKA development. The most prevalent symptoms are

nausea, vomiting, and abdominal pain. The majority of the patients were young and predominantly female. The typical length of stay was four days, with the majority of patients admitted to the ICU. Fluid replacement with 0.9% saline was necessary for proper DKA therapy, followed by regular insulin infusion. Identifying these critical aspects will improve patient health, quality of life, and disease management. Diabetes care relies heavily on patient education regarding their disease, effective drug use, and the prevention of complications.

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CONFLICT OF INTEREST

The authors declare that there is no conflict of interest.

ETHICAL APPROVAL

Ethical approval to conduct this study was granted under Reference No.: H1RI-28-Apr24-01 from the IRP of King Saud Medical City (KSMC) Hospital.

AUTHORS CONTRIBUTION

Conceptualization; Data curation; NHA, LHS, FMK, Nora A, AA; Formal analysis; Investigation; Methodology; SA, NA, FA, KMA, FMK, Aymen A, PS; Project administration; Resources; Software; ASA, AYB, BA, Nora A; Supervision; Validation; Visualization; NHA, LHS, ASA, AYB, BA; Writing - original draft; Writing - review and editing SA, NA, FA, KMA, AA, Aymen, PS.

ABBREVIATIONS

DKA: Diabetic Ketoacidosis; **DM:** Diabetes Mellitus; **ICUs:** Intensive Care Units; **KSMC:** King Saud Medical City; **UTI:** Urinary Tract Infection.

SUMMARY

This study on Diabetic Ketoacidosis (DKA) included 355 patients, with a slight female majority (53.1%). The average age was 22.75 years, with a prevalence of younger patients under 30 years. Type 1 DM was predominant (94.6%). Non-compliance with insulin therapy (36.3%) and missed doses (32.4%) were the leading triggers for DKA. Vomiting (69.3%) and abdominal pain (62.0%) were the most common clinical symptoms. Treatment outcomes were largely positive (98.3%), with a low mortality rate (1.7%). Recurrence was observed in 23.9% of patients. The study highlighted the importance of treatment adherence and monitoring of triggering factors to reduce DKA incidence. Limitations included the retrospective design and single-center nature of the study.

REFERENCES

- Putra DA, Wibowo MD, Susilo DH, Fandinata SS. The impact of concurrent diabetes mellitus and hypertension on hospital length of stay in patients with phlegmon: a cross-sectional study at RSUD Dr. Soetomo Surabaya. *J Med Pharm Chem Res.* 2025;7(2):150-60. doi: 10.48309/jmpcr.2025.457670.1246.
- Yamana H, Imai S, Yamasaki K, Horiguchi H, Ario K, Komatsu T, et al. Prognosis of patients with liver cirrhosis: a multi-center Retrospective observational study. *Hepatol Res.* 2021;51(12):1196-206. doi: 10.1111/hepr.13711, PMID 34492143.
- Vakharia JD, Agrawal S, Molino J, Topor LS. Family history of diabetes is associated with increased risk of recurrent diabetic ketoacidosis in pediatric patients. *Endocr Pract.* 2020;26(3):305-11. doi: 10.4158/ep-2019-0351, PMID 31859553.
- Sehgal V, Ulmer B. Clinical conundrums in the management of diabetic ketoacidosis in the elderly. *J Transl Int Med.* 2019;7(1):10-4. doi: 10.2478/jtim-2019-0003, PMID 30997351.
- Rochmah N, Perwitasari RK, Hisbiyah Y, Rosyidah LN, Ni'mah NL, Kusumastuti NP, et al. Factors affecting insulin-like growth Factor-1 Type 1 Diabetes Mellitus in Children. *J. Med. Pharm. Chem Res.* 2025;7(1):120-8. doi: 10.48309/jmpcr.2025.451173.1185.
- Calimag AP, Chlebek S, Lerma EV, Chaiban JT. Diabetic ketoacidosis. *Disease-A-Month.* 2023;69(3):101418. doi: 10.1016/j.disamonth.2022.101418, PMID 35577617.
- Dhatariya KK, Glaser NS, Codner E, Umpierrez GE. Diabetic ketoacidosis. *Nat Rev Dis Primers.* 2020;6(1):40. doi: 10.1038/s41572-020-0165-1, PMID 32409703.
- Fazeli Farsani S, Brodovicz K, Soleymannlou N, Marquard J, Wissinger E, Maiese BA. Incidence and prevalence of diabetic ketoacidosis (DKA) among adults with type 1 diabetes mellitus (T1D): a systematic literature review. *BMJ Open.* 2017;7(7):e016587. doi: 10.1136/bmjopen-2017-016587, PMID 28765134.
- Elliott TL, Pfothhauer KM. Classification and diagnosis of diabetes. *Prim Care.* 2022;49(2):191-200. doi: 10.1016/j.pop.2021.11.011, PMID 35595476.
- IDF diabetes atlas. In: IDF diabetes atlas 2021. IDF Diabetes Atlas; 2021.
- Abed MS, Rasool MI. Effect of genetic Glut4 polymorphism on insulin therapy response in patients with type 1 diabetes. *J Med Pharm Chem Res.* 2025;7(6):1048-58. doi: 10.48309/jmpcr.2025.474507.1399.
- Usher-Smith JA, Thompson M, Ercole A, Walter FM. Variation between countries in the frequency of diabetic ketoacidosis at first presentation of type 1 diabetes in the frequency: a systematic review. *Diabetologia.* 2012;55(11):2878-94. doi: 10.1007/s00125-012-2690-2, PMID 22933123.
- Elendu C, David JA, Udoyen AO, Egbunu EO, Ogbuiyi-Chima IC, Unakalamba LO, et al. Comprehensive review of diabetic ketoacidosis: an update. *Ann Med Surg (Lond).* 2023;85(6):2802-7. doi: 10.1097/ms9.0000000000000894, PMID 37363479.
- Alotaibi R, Alsulami M, Hijji S, Alghamdi S, Alnahdi Y, Alnahdi H, et al. Diabetic ketoacidosis in Saudi Arabia: factors precipitating initial admission and readmission. *Ann Saudi Med.* 2022;42(2):119-26. doi: 10.5144/0256-4947.2022.119, PMID 35380064.
- Al Hayek AA, Robert AA, Al-Shaikh R, Alhojele M, Aloufi S, Sabri D, et al. Factors associated with the presence of diabetic ketoacidosis: a retrospective analysis of patients with type 1 diabetes in Saudi Arabia. *Diabetes Metab Syndr.* 2020;14(6):2117-22. doi: 10.1016/j.dsx.2020.11.002, PMID 33395771.
- Anna N, Sadyah C, Putra A. Investigating the therapeutic potential of human umbilical cord- derived mesenchymal stem cell for diabetic foot ulcer: a systematic review and meta-analysis. *J Med Chem Sci.* 2025;8:201-11. doi: 10.26655/JMCHEMS CI.2025.2.7.
- Batwa M, Alharthi L, Ghazal R, Alsulami M, Slaghour R, Aljuhani R, et al. Diabetic ketoacidosis at the onset of type 1 diabetes mellitus among children and adolescents in Jeddah, Saudi Arabia: a study from the emergency department. *Cureus.* 2022;14(4):e24456. doi: 10.7759/cureus.24456, PMID 35651441.
- Temesgen D, Miskir Y, Dessie G, Nuru A, Tesema BB, Azmeraw M, et al. Time to recovery from diabetic ketoacidosis and its predictors among adult diabetic ketoacidosis patients in DEBRE MARKOS referral hospital, North West Ethiopia; 2021: Retrospective Cohort Study. *medRxiv.* p. 2022, 2022.04.12.22273779.
- Alotaibi A, Aldoukhi A, Albdah B, Alonazi JA, Alseraya AS, Alrasheed N. Diabetic ketoacidosis treatment outcome and associated factors among adult patients admitted to the emergency department and medical wards at King Abdulaziz Medical City, Riyadh, Saudi Arabia. *Cureus.* 2020;12(8):e10067. doi: 10.7759/cureus.10067, PMID 32999787.
- Dhanasekaran M, Mohan S, Erickson D, Shah P, Szymanski L, Adrian V, et al. Diabetic ketoacidosis in pregnancy: clinical risk factors [presentation]. *J Clin Endocrinol Metab.* 2022;107(11):3137-43. doi: 10.1210/clinem/dgac464, PMID 35917830.
- Evans K. Diabetic ketoacidosis: update on management. *Clin Med (Lond).* 2019;19(5):396-8. doi: 10.7861/clinmed.2019-0284, PMID 31530688.
- Jayashree M, Williams V, Iyer R. Fluid therapy for pediatric patients with diabetic ketoacidosis: current perspectives. *Diabetes Metab Syndr Obes.* 2019;12:2355-61. doi: 10.2147/DMSO.S194944, PMID 31814748.
- Eledrisi MS, Elzouki AN. Management of diabetic ketoacidosis in adults: a narrative review. *Saudi J Med Med Sci.* 2020;8(3):165-73. doi: 10.4103/sjms.sjms_478_19, PMID 32952507.
- Alenzi KA, Alanazi NS, Almalki M, Alomrani H, Alatawi FO. The evaluation of adverse drug reactions in Saudi Arabia: a retrospective observational study. *Saudi Pharm J.* 2022;30(6):735-41. doi: 10.1016/j.jsps.2022.03.018, PMID 35812140.
- Rochmah N, Soetjipto S, Faizi M, Hisbiyah Y, Perwitasari RK, Aina Q, et al. The determinant factor and quality of life in adolescent with type 1 diabetes mellitus: a study in limited resource setting. *J Med Pharm Chem Res.* 2025;7(4):725-32. doi: 10.48309/jmpcr.2025.461182.1284.
- Deshmukh AD, Shinde S, Tilak MA, Dhat VV. HbA1C for the diagnosis of pre-diabetes: it is time for mid- course correction. *J Med Chem Sci.* 2024;7:1075-81. doi: 10.26655/JMCHEMSCI.2024.8.8.
- Eledrisi MS, Alkabbani H, Aboawon M, Ali A, Alabdulrazzak I, Elhaj M, et al. Clinical characteristics and outcomes of care in patients hospitalized with diabetic ketoacidosis. *Diabetes Res Clin Pract.* 2022;192:110041. doi: 10.1016/j.diabres.2022.110041, PMID 35985426.
- Mandeel FH, Radhi HT, Sarwani AA, Alsadah AH. Precipitating factors for the development of diabetic ketoacidosis in a Tertiary Care Hospital in Bahrain. *Egypt J Hosp Med.* 2021;82(1):123-8. doi: 10.21608/ehjhm.2021.138134.
- Mekonnen GA, Gelaye KA, Gebreyohannes EA, Abegaz TM. Treatment outcomes of diabetic ketoacidosis among diabetes patients in Ethiopia. Hospital-based study. *PLOS One.* 2022;17(4):e0264626. doi: 10.1371/journal.pone.0264626, PMID 35381004.
- Ndebele NF, Naidoo M. The management of diabetic ketoacidosis at a Rural Regional Hospital in KwaZulu-Natal. *Afr J Prim Health Care Fam Med.* 2018;10(1):e1-6. doi: 10.4102/phcfm.v10i1.1612, PMID 29781681.
- Seth P, Kaur H, Kaur M. Clinical profile of diabetic ketoacidosis: a prospective study in a tertiary Care Hospital. *J Clin Diagn Res.* 2015;9(6):OC01-4. doi: 10.7860/JCDR/2015/8586.5995, PMID 26266145.
- Dhatariya KK, Vellanki P. Treatment of diabetic ketoacidosis (DKA)/hyperglycemic Hyperosmolar State (HHS): novel advances in the management of hyperglycemic crises (UK versus USA). *Curr Diabetes Rep.* 2017;17(5):33. doi: 10.1007/s11892-017-0857-4, PMID 28364357.
- Samargandy S, Alotaibi R, Alghamdi M, Alotaibi R, Hijji S, Alsulami M, et al. Rate of admission to the Intensive Care Unit in patients with diabetic ketoacidosis and its associated risk factors: a single-center experience. *Endocrinol Res Pract.* 2023;27(4):213-20. doi: 10.5152/erp.2023.23265.
- Ata F, Khan AA, Khamees I, Iqbal P, Yousaf Z, Mohammed BZ, et al. Clinical and biochemical determinants of length of stay, readmission and recurrence in patients admitted with diabetic ketoacidosis. *Ann Med.* 2023;55(1):533-42. doi: 10.1080/07853890.2023.2175031, PMID 36745515.
- Alourfi Z, Homsy H. Precipitating factors, outcomes, and recurrence of diabetic ketoacidosis at a university hospital in Damascus. *Avicenna J Med.* 2015;5(1):11-5. doi: 10.4103/2231-0770.148503, PMID 25625084.
- Rana SA, Malik WA, Babar MA. To evaluate various precipitating factors for diabetic ketoacidosis. *Pak J Med Heal Sci.* 2016;10(2):482-5.
- da Rosa Carlos Monteiro LE, Garcia SP, Bottino LG, Custodio JL, Telo GH, Schaan BD. Precipitating factors of diabetic ketoacidosis in type 1 diabetes patients at a tertiary hospital: a cross-sectional study with a two-time-period comparison. *Arch Endocrinol Metab.* 2022;66(3):355-61. doi: 10.20945/2359-399700000480, PMID 35657124.
- Naem MA, Al-Alem HA, Al-Dubayee MS, Al-Juraibah FN, Omair A, Al-Ruwaili AS, et al. Characteristics of pediatric diabetic ketoacidosis patients in Saudi Arabia. *Saudi Med J.* 2015;36(1):20-5. doi: 10.15537/smj.2015.1.9763, PMID 25630000.

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