

Awareness of Diabetic Ketoacidosis among senior year medical students in Al-Qassim Universities KSA: A cross-sectional study

To Cite:

Elghamrawy TA, Alhumaidan RI, Alassaf FA, Alfouzan AA, Alanazi HN, Alotaibi EF, Almohaimeed IA. Awareness of Diabetic Ketoacidosis among senior year medical students in Al-Qassim Universities KSA: A cross-sectional study. *Medical Science* 2023; 27: e291ms3057. doi: <https://doi.org/10.54905/disssi/v27i137/e291ms3057>

Authors' Affiliation:

¹Associate Professor of Anatomy & Physiology, Riyadh Elm University, Saudi Arabia/Specialty: Human Anatomy, Saudi Arabia
²MBBS Student at Al-Qassim University, Saudi Arabia
³MBBS Student at Northern border University, Saudi Arabia
⁴MBBS Student at Taif University, Saudi Arabia

Contact List

Tarek A Elghamrawy	Tarekabdalmoneim@riyadh.edu.sa
Raghad Ibrahim Alhumaidan	raghadalhomidan@outlook.sa
Farah Abdullah Alassaf	Fara7alassaf@hotmail.com
Abdulmajeed Abdulaziz Alfouzan	abdulmajeedfozan@gmail.com
Hind Naif Alanazi	hnr8978@gmail.com
Ebtisam Fahad Alotaibi	Ebtisam.fahad16@gmail.com
Ibrahim Ahmad Almohaimeed	Ibrahimmohaimeed@gmail.com

Peer-Review History

Received: 16 May 2023
 Reviewed & Revised: 20/May/2023 to 03/July/2023
 Accepted: 07 July 2023
 Published: 12 July 2023

Peer-review Method

External peer-review was done through double-blind method.

Medical Science
 pISSN 2321-7359; eISSN 2321-7367

This open access article is distributed under [Creative Commons Attribution License 4.0 \(CC BY\)](https://creativecommons.org/licenses/by/4.0/).

Tarek A Elghamrawy¹, Raghad Ibrahim Alhumaidan², Farah Abdullah Alassaf², Abdulmajeed Abdulaziz Alfouzan², Hind Naif Alanazi³, Ebtisam Fahad Alotaibi⁴, Ibrahim Ahmad Almohaimeed²

ABSTRACT

Background: The management of Diabetes Mellitus and its important complication Diabetic Ketoacidosis is very important for students soon to be physicians. We in this study will investigate their awareness and knowledge through a cross-sectional pre-validated Questionnaire in senior students at Qassim Universities. **Methods:** This study is cross-sectional; online questionnaire-based observational study conducted at Qassim Universities to measure their knowledge regarding diabetic ketoacidosis. The respondents were senior final-year MBBS students at that college, and the data were collected and analyzed statistically. **Results:** Among the 292 senior medical students from Al-Qassim Universities, who participated in the study, 45.2% were male and majority of participants were in their fifth year (50.7%). Moreover, 81.5% of the 292 senior medical students from Al-Qassim Universities who participated in the study had sufficient knowledge of diabetic ketoacidosis. There is a weak association between gender and inadequate knowledge (OR=1.59, 95% CI (0.89, 2.83), P=0.137). Unaizah College of Medicine had the highest proportion of students with enough knowledge (86.4%), whereas Sulaiman Al-Rajhi University had the lowest proportion of students with inadequate knowledge (35.6 percent). There were no gender or academic year variations in knowledge (p=0.091 and p=0.055, respectively). **Conclusion:** It could be concluded from the current study that most of the students had basic knowledge regarding the definition and diagnosis of diabetes mellitus, DKA, and their management. In addition, our study recommends preparing of some interventions to increase the level of awareness among senior medical students as preparing workshops.

Keywords: Diabetes mellitus, Diabetic Ketoacidosis, Awareness, Knowledge.

1. INTRODUCTION

DKA, or diabetic ketoacidosis, is a potentially fatal metabolic consequence of both types of diabetes. When insulin levels are too low, cells are unable to use glucose from the blood for energy, leading to diabetic ketoacidosis (DKA). Instead, ketone acids are produced when fat is broken down by the liver. Without prompt medical attention, a patient whose body produces an excessive amount of ketones may not survive. Hyperglycemia, metabolic acidosis, and ketosis are the trinity of symptoms that define diabetic ketoacidosis (DKA) (Wolfsdorf et al., 2018).

With a prevalence rate of 17.7 percent, Saudi Arabia has the highest DM incidence in the Middle East and North Africa (MENA) region (Habeab et al., 2011) and the fourth highest incidence of Type 1 Diabetes Mellitus (T1DM) globally (Alanazi et al., 2018). Since DKA is considered a potentially fatal metabolic condition that may be treated with relative ease if caught early, we think it's crucial to raise awareness and educate future doctors about the condition. Polyuria and polydipsia, muscle fatigue, weight loss, dyspnea, vomiting, and the having a history of the conditions were among the most common clinical symptoms that are reported by patients diagnosed with DKA (Farran et al., 2020; Alshareef et al., 2023; Al-Ahmadi et al., 2023).

Coma and death may ensue from difficulties in the respiratory and gastrointestinal systems brought on by these symptoms, such as respiratory failure and severe stomach pain. The prevalence of DKA in newly diagnosed diabetic youngsters varies from 16% to 80% among regions. Diabetic ketoacidosis (DKA) is often treated with intravenous fluid resuscitation and electrolyte supplementation. The most severe effects of DKA are cerebral edema, cardiac arrhythmias, heart failure, respiratory failure, hypoglycemia, and hypokalemia (Karslioglu-French et al., 2019).

Diabetic ketoacidosis was fatal before insulin was discovered in 1921. Diabetic ketoacidosis-related adult mortality has consistently dropped to less than 1 percent in the nearly 100 years since the introduction of insulin. Up to 5% mortality is seen in specific patient populations, most notably those who are severely ill or elderly (Habeab et al., 2011). Diabetes education, knowledge, and awareness among medical students are crucial since they will one day confront this huge public health issue (Vanelli et al., 1999).

Additionally, research indicates that medical students' expertise of DKA is poor. Increasing the awareness of diabetes and its complications as DKA among medical and public population has been shown to reduce the incidence of DKA at the time of initial T1DM diagnosis. Thus, the purpose of this study was to evaluate the awareness and understanding of senior medical students at Qassim Universities on DKA. Our overall purpose is to assess and refresh the knowledge and understanding of medical students on diabetes mellitus and diabetic ketoacidosis. This is due to the fact that medical students are a crucial foundation of the healthcare system and the future healthcare practitioners.

2. MATERIAL AND METHODS

Research design

A cross-sectional descriptive study was used to measure the awareness of senior medical students of DKA and its complications and management during the period from 20th June to 20th July 2022.

Questionnaire

This is an observational cross-sectional study performed using a pre-validated online questionnaire. It was done to assess senior medical students' knowledge and understanding of diabetic ketoacidosis (DKA) at universities in Al-Qassim (Qassim College of medicine, Unaizah college of medicine, Sulaiman Al-Rajhi University). We have sent an online survey to a total number of 443 senior-years medical students, over the month of July 2022. The study targeted all males and females who are in 4th and 5th years of college of medicine hence we excluded students of other years or other medical colleges outside Qassim region.

The survey has three main sections containing socio-demographic details: participants' basic knowledge about diabetes, essential information about DKA (signs, symptoms, and management). The questionnaire covered the principal aspects of DM regarding its clinical manifestations, the best indicators for glycemic control, and the cut off values of both fasting and postprandial blood sugar necessary for diagnosing DM. In the questionnaire we will also focus on the most important aspects of DKA regarding its early clinical picture, pathophysiology, and management. We used a previously developed questionnaire with similar objectives (Singh et al., 2014; Madkhly et al., 2020).

In order to maintain accuracy and confidentiality the survey was restricted to one response only by using personal emails of the participants, the personal information was kept undeclared. All participants have been served a written consent form in which they all agree to participate. Ethical clearance was obtained from the Institutional Review Board of Riyadh Elm University, with IRB

approval number "SRP/2022/123/763/734", before commencement of the study. Only those from whom voluntary informed consent obtained were enrolled for the study.

Statistical analysis

All the responses obtained from the study participants were coded and analyzed using a statistical program. Descriptive statistics of frequency distribution and percentages were calculated for the categorical variables. Finally, Chi-square and Fisher's exact tests were applied to find out the relationship between characteristics of the study participants and their knowledge toward DKA. A p-value of <0.05 was considered significant for all the statistical tests. All the data were analyzed using Statistical Package for Social Sciences (IBM-SPSS version 25, Armonk, NY, USA)

3. RESULTS

Among the 292 senior medical students from Al-Qassim Universities who participated in the study, 45.2% were male and 54.8% were female, according to the study's findings. Qassim College of Medicine had the most participants (44.9%), followed by Sulaiman Al-Rajhi University (25.0%) and Unaizah College of Medicine (30.1%). The majority of participants were in their fifth year (50.7%), whilst 49.3% were in their fourth (Table 1).

Table 1 Characteristics of the participants (N=292)

		Count	Column N %
Gender	Male	132	45.2%
	Female	160	54.8%
College	Unaizah College of Medicine	88	30.1%
	Sulaiman Al-Rajhi University	73	25.0%
	Qassim College of Medicine	131	44.9%
Academic year	4th Year	144	49.3%
	5th year	148	50.7%

The majority of senior medical students at Qassim Universities (94.9%) correctly identified the endocrine pancreas as the organ associated with diabetes. The majority of individuals (65.4%) correctly identified stomach pain, confusion, nausea, and vomiting as the characteristic symptoms of DKA. In terms of HbA1c as the best indicator of glycemic management, 87.7% of participants provided the right response. 84.6 percent of participants correctly selected 126 mg/dL as the FBS diagnostic threshold value for diagnosing diabetic mellitus. The majority of participants (71.2%) correctly recognized two hours after eating as the ideal period to assess postprandial blood sugar. The majority of participants correctly identified diabetic ketoacidosis (DKA) as an acute consequence of type 1 diabetes (74%) (Table 2).

Potassium was accurately identified by 66.8 percent of participants as the electrolyte deficient in DKA. Moreover, 68.2% of participants correctly selected normal saline and dextrose normal saline as the replacement fluids. The majority of participants correctly identified insulin and IV fluids as the first-line treatment for DKA (85.3%), with IV as the method of insulin delivery (78.8%), and that DKA is managed in the intensive care unit (ICU) (60.3%) (Figure 1).

Table 2 The knowledge of the participants toward specific facts of the diabetes and DKA

		Count	Column N %
Diabetes is related to endocrine pancreas	No	9	3.1%
	Yes (Correct answer)	277	94.9%
	I do not know	6	2.1%
Classical symptoms of DKA	Abdominal pain, confusion, nausea, vomiting (Correct answer)	191	65.4%
	Abdominal pain, alertness, nausea, vomiting	51	17.5%
	Chest pain, confusion, nausea, vomiting	45	15.4%
	Chest pain, alertness, nausea, vomiting	5	1.7%
HbA1c is the best indicator of glycemic	No	22	7.5%
	Yes (Correct answer)	256	87.7%

control	I do not know	14	4.8%
A cut-off value of FBS for diagnosing diabetes mellitus	≥126 mg/dL (Correct answer)	247	84.6%
	115 mg/Dl	21	7.2%
	90 mg/Dl	15	5.1%
	<70 mg/Dl	9	3.1%
The best time to measure postprandial blood sugar is after eating	2 hours (Correct answer)	208	71.2%
	1 hours	46	15.8%
	3 hours	15	5.1%
	4 hours	23	7.9%
DKA is complication of DM	Acute (Correct answer)	216	74.0%
	Chronic	63	21.6%
	Not complication	13	4.5%
DKA is seen in diabetes	Type 1 (Correct answer)	164	56.2%
	Type 2	41	14.0%
	Both	87	29.8%
DKA is related to	Hyperglycemia (Correct answer)	246	84.2%
	Hypoglycemia	46	15.8%

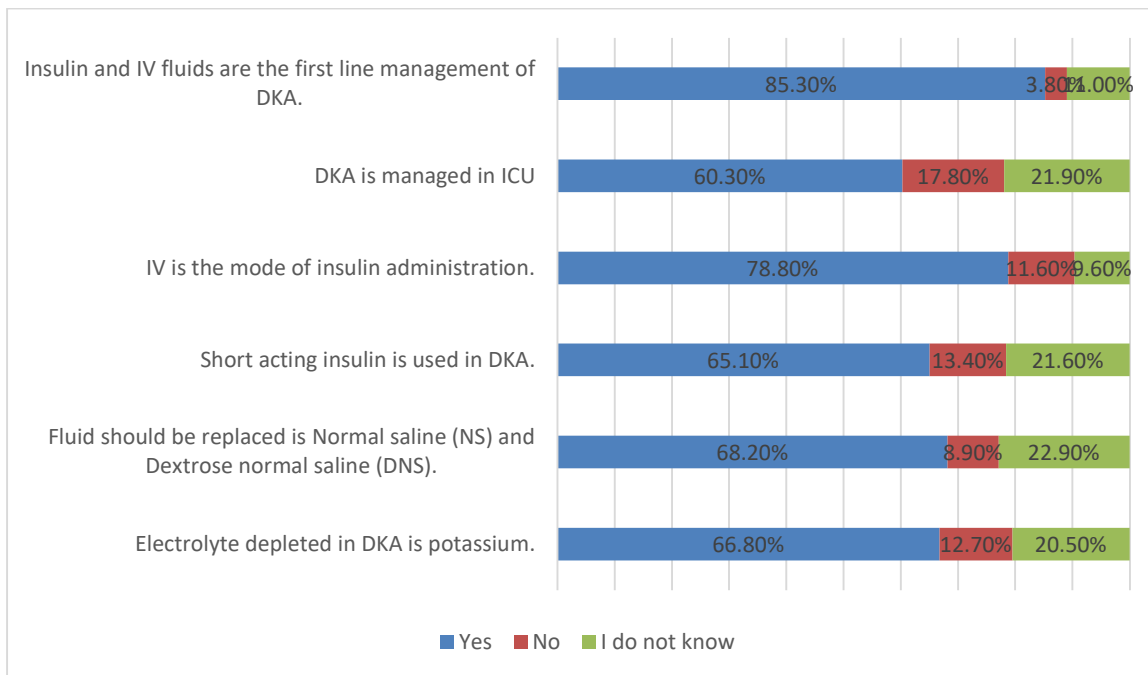


Figure 1 The knowledge of the participants considering management of DKA

In general, 81.5% of the 292 senior medical students from Al-Qassim Universities who participated in the study had adequate understanding of diabetic ketoacidosis, whereas 18.5% had inadequate knowledge (Figure 2).

The results indicate that there is a statistically significant variation in the knowledge of senior medical students regarding diabetic ketoacidosis based on their college of study ($p=0.000$). Unaizah College of Medicine had the largest percentage of students with appropriate knowledge (86.4%), whereas Sulaiman Al-Rajhi University had the worst percentage of students with poor knowledge (35.6%). There was no statistically significant difference in knowledge depending on gender or academic year ($p=0.091$ and $p=0.055$, respectively) (Table 3).

On the basis of the odds ratios, 95% confidence intervals, and p -values, the following conclusions can be drawn: This link is not statistically significant, but there is a weak association between gender and inadequate knowledge, with males having slightly higher odds of inadequate knowledge than females. There is a statistically significant relationship between college and ignorance.

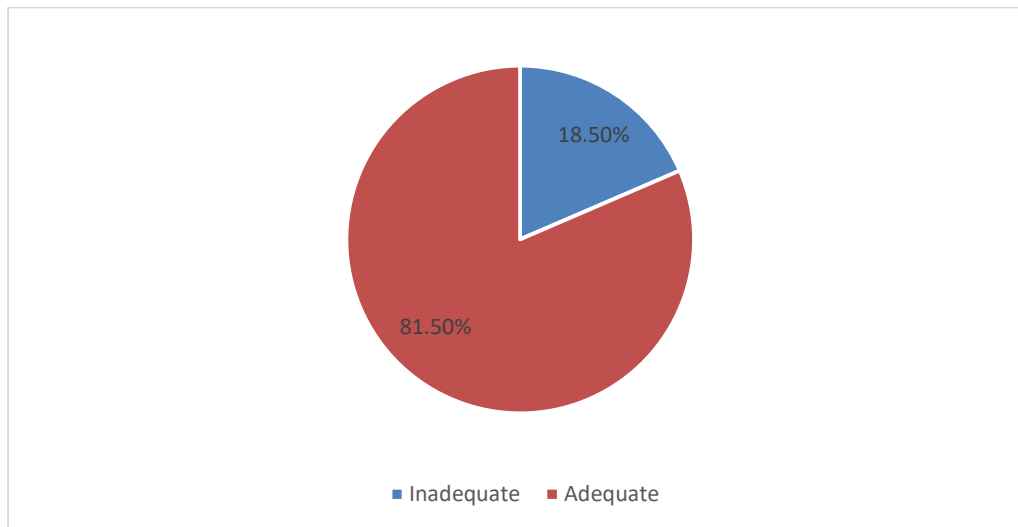


Figure 2 Distribution of the participants depending on their knowledge toward DKA

Table 3 The relation between demographic factors and level of knowledge

		Knowledge				P-value
		Inadequate		Adequate		
		Count	Row N %	Count	Row N %	
Gender	Male	30	22.7%	102	77.3%	0.091
	Female	24	15.0%	136	85.0%	
College	Unaizah College of Medicine	12	13.6%	76	86.4%	0.000*
	Sulaiman Al-Rajhi University	26	35.6%	47	64.4%	
	Qassim College of Medicine	16	12.2%	115	87.8%	
Academic year	4th Year	33	22.9%	111	77.1%	0.055
	5th year	21	14.2%	127	85.8%	

Specifically, Sulaiman Al-Rajhi University students had significantly greater probabilities of inadequate knowledge than Unaizah College of Medicine students, while Qassim College of Medicine students have significantly lower odds of inadequate knowledge than the reference group. There is no statistically significant relationship between academic year and poor knowledge; although the odds ratio implies that fourth-year students have somewhat higher odds of having inadequate knowledge than fifth-year students (Table 4).

Table 4 Regression analysis of the effect of the demographic factors of the participants on level of knowledge

Variable	Odds Ratio	95% CI	p-value
Gender (Male vs Female)	1.59	(0.89, 2.83)	0.137
College			
Sulaiman Al-Rajhi University	3.49	(1.74, 7.00)	0.0007
Qassim College of Medicine	0.43	(0.21, 0.87)	0.019
Academic year (Fifth year vs fourth year)	1.63	(0.88, 3.03)	0.118

4. DISCUSSION

A dangerous and potentially fatal diabetes consequence is diabetic ketoacidosis (DKA). People who have type 1 diabetes have the highest risk of developing DKA. It is also possible for those who have type 2 diabetes to have this condition (Wolfsdorf et al., 2018). It is essential for medical students, particularly senior students, to have this understanding. Because of this, our study focused on senior medical students at Qassim Universities to investigate the prevalence of diabetes mellitus and diabetic ketoacidosis.

According to the findings of the study, the vast majority of senior medical students studying at Qassim Universities had sufficient knowledge of diabetic ketoacidosis. In example, the majority of participants were able to properly identify the endocrine

pancreas as the organ that is connected with diabetes, recognize the typical symptoms of diabetic ketoacidosis (DKA), and select the appropriate therapeutic options for effectively managing DKA. Despite this, there were still some gaps in knowledge, as a sizeable portion of the participants were unable to accurately identify several of the essential characteristics of DKA.

Similarly, another study by Madkhly et al., (2020) designed to evaluate the awareness and understanding of DKA among final-year Saudi medical students, finding that the majority of students had basic knowledge about diabetes, including its clinical aspects and therapy. On the other hand, there were certain knowledge gaps about DKA, in particular with electrolyte abnormalities and fluid replenishment (Madkhly et al., 2020). These findings are congruent with those of a previous study that looked at the same topic and was conducted at Southern Indian University. That study indicated that medical students had inadequate knowledge regarding DKA (Singh et al., 2014).

Lack of awareness about diabetic ketoacidosis (DKA) among medical students and workers in the healthcare industry can have substantial repercussions for the care that patients get and their outcomes (Singh et al., 2014; Alreshidi et al., 2022). Diabetic ketoacidosis is considered one of the life-threatening complications of diabetes that needs to be diagnosed and treated as soon as possible (Wersäll et al., 2021). Failure to detect and manage DKA effectively can lead to serious complications, including cerebral edema, hypotension, and death (Cangelosi et al., 2017).

Inadequate information regarding diabetic ketoacidosis (DKA) can lead to a delayed diagnosis as well as improper management, both of which can result in unfavorable results for patients (Al-Aboudi et al., 2016). Medical students and healthcare staff are responsible for providing care to patients who have diabetes. In addition, diabetic patients depend on healthcare personnel to educate them and offer support in order to properly manage their illness; yet inadequate awareness regarding DKA might result in ineffective patient education and assistance.

According to the findings of the study, there was also a statistically significant difference in the amount of information possessed by senior medical students from different colleges of medical education. The percentage of students who graduated with acceptable knowledge was highest at Unaizah College of Medicine, whereas the percentage of students who graduated with insufficient information was highest at Sulaiman Al-Rajhi University. This underscores the significance of focused educational interventions among medical students in order to increase their knowledge and understanding of DKA, particularly among medical students attending universities with lower levels of expertise.

Additionally, the study found no statistically significant variation in knowledge based on gender or academic year. On the other hand, the odds ratio revealed that fourth-year students had somewhat higher odds of inadequate knowledge than fifth-year students, which highlights the significance of continuing education and training for medical students throughout their academic careers. The study of Madkhly et al., (2020) demonstrated that final-year students in this study were knowledgeable in general information about diabetes as they have concluded their basic learning in the physiology, pathology, and pharmacology of diabetes, and the basics of DKA.

A systematic study by Alanazi et al., (2018) indicated a large gap in awareness and understanding regarding diabetes in the entire Saudi community, including medical students and healthcare personnel. Several research conducted in a variety of nations came to the conclusion that health education is a potent instrument that may be used to control diabetes and other chronic diseases. Therefore, raising the awareness toward diabetes and education in the general population may result in improved outcomes for public health (Alsous et al., 2019). For medical students and health care personnel, higher levels of knowledge about diabetes and associated consequences, such as DKA, are required because they are the major source of information for patients (Christie et al., 2009; Ahmed et al., 2016).

Medical students need to be trained in diabetes, since they will eventually be dealing with this significant public health issue. We are optimistic that the frequency of DKA will decrease as a result of increased medical and public awareness of diabetes and DKA. Recollection bias and selection bias may have affected our inquiry, both of which are inherent limits of cross-sectional research and were present in our investigation. These biases constituted one of the limitations of our study. Because the majority of the responses on the questionnaire came from the students' recollections, there is a possibility that our study's findings were influenced by recall bias. However, our study had a greater sample size than the prior studies, which may have overcome the influence of the bias. It is advised that future research uses larger sample sizes from diverse Saudi universities.

5. CONCLUSION

It is possible to draw the following conclusion based on the findings of this study: The vast majority of the students possessed fundamental information regarding the concept of diabetes mellitus and the diagnostic process. Moreover, regarding the management of DKA, more than half of the participants, 60 percent, know that DKA considered one of acute conditions, and it is

managed in the ICU, but some participants do not, 22 percent and about 86 percent agreed that insulin and IV fluids are the first lines of management of DKA. In order to improve senior medical students' knowledge of diabetic ketoacidosis (DKA), it is necessary to use interventions such as study seminars and workshops. For this reason, greater emphasis on this subject is recommended in their educational program to raise their degree of awareness.

Acknowledgement

The authors would like to thank the senior-year medical students from Al-Qassim Universities in Saudi Arabia who participated in this study on diabetic ketoacidosis awareness. Their insightful contributions and contributions were crucial to the accomplishment of this research. The authors would also like to thank the teachers and staff of Al-Qassim Universities in Saudi Arabia for their cooperation and support in facilitating access to participants and resources. In addition, the contributions of the research assistants who assisted with data collection, entry, and analysis are thanked. The manuscript's reviewers and editors who provided constructive criticism are also acknowledged for their contributions. Appreciation is extended to the Department of Family and Community Medicine at Qassim University for their assistance and encouragement. Finally, the authors would like to thank everyone who assisted and supported them throughout the study and manuscript preparation. Without their assistance, this investigation would not have been feasible.

Author Contributions

TE: Conceptualization, Methodology, Writing - Review & Editing, Supervision

AA, IA and EA: Methodology, Data Curation, Writing - Review & Editing, Formal Analysis

RA and FA: Methodology, Data Curation, Writing - Review & Editing, Visualization

HA: Conceptualization, Methodology, Writing - Original Draft Preparation, Investigation, Supervision

Ethical approval

The study was approved by the Medical Ethics Committee of Riyadh Elm University, Qassim University, Taif University, and Northern Border University.

Informed consent

Written & Oral informed consent was obtained from all individual participants included in the study. Additional informed consent was obtained from all individual participants for whom identifying information is included in this manuscript.

Funding

This study has not received any external funding.

Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

REFERENCES AND NOTES

- Ahmed MA, Al-Maghamsi M, Al-Harbi AM, Eid IM, Baghdadi HH, Habeb AM. Reduced Frequency and Severity of Ketoacidosis at Diagnosis of Childhood Type 1 Diabetes in Northwest Saudi Arabia. *J Pediatr Endocrinol Metab* 2016; 29(3):259-64. doi: 10.1515/jpem-2015-0077
- Al-Aboudi IS, Hassali MA, Shafie AA. Knowledge, attitudes, and quality of life of type 2 diabetes patients in Riyadh, Saudi Arabia. *J Pharm Bioallied Sci* 2016; 8(3):195-202. doi: 10.4103/0975-7406.171683
- Al-Ahmadi AF, Almohmmadi GT, Alhejaili AF, Boudal EK, Atallah HA, Boudal EA, Alrashidi YJ, Bamagos MJ, Almurashi AM, Al-Johani BM, Alrajabi TI, Al-Harbi A, Alhajjam IS, Al-Dubai S. Socio-demographic and clinical characteristics of patients with diabetic ketoacidosis at King Salman bin Abdulaziz medical city in Al-Madinah, Saudi Arabia. *Medical Science* 2023; 27: e58ms2679. doi: 10.54905/disssi/v27i131/e58ms2679
- Alanazi FK, Alotaibi JS, Paliadelis P, Alqarawi N, Alsharari A, Albagawi B. Knowledge and awareness of diabetes

- mellitus and its risk factors in Saudi Arabia. *Saudi Med J* 2018; 39(10):981-989. doi: 10.15537/smj.2018.10.22938
5. Alreshidi NF, Altamimi SS, Alharbi AN, Al-Shamry FFE, Alsharari AR, Alkhateeb AA, Alharbi MF. Assessment of Awareness and Practice toward Diabetic Ketoacidosis among Diabetic Patients and Their Caregivers in Hail Region. *Biomed Res Int* 2022; 2022:2904910. doi: 10.1155/2022/2904910
 6. Alshareef F, Ojayban F, Alsallum M, Alkaki A, Shaikh S, Albaqami R, Alsaadi L, Aljaroudi R, Alzahrani K. Diabetic ketoacidosis: Knowledge and awareness assessment among parents and caregivers of children and adolescents diagnosed by Type 1 DM in Saudi Arabia. *Medical Science* 2023; 27: e8ms2696. doi: 10.54905/disssi/v27i131/e8ms2696
 7. Alsous M, Abdel Jalil M, Odeh M, Al-Kurdi R, Alnan M. Public knowledge, attitudes and practices toward diabetes mellitus: A cross-sectional study from Jordan. *PLoS One* 2019; 14(3):e0214479. doi: 10.1371/journal.pone.0214479
 8. Cangelosi AM, Bonacini I, Serra RP, Di-Mauro D, Iovane B, Fainardi V, Mastroilli C, Vanelli M. Spontaneous Dissemination in Neighboring Provinces of DKA Prevention Campaign Successfully Launched in Nineties in Parma's Province. *Acta Biomed* 2017; 88(2):151-155. doi: 10.23750/abm.v88i2.6553
 9. Christie D, Strange V, Allen E, Oliver S, Wong IC, Smith F, Cairns J, Thompson R, Hindmarsh P, O'Neill S, Bull C, Viner R, Elbourne D. Maximising engagement, motivation and long-term change in a Structured Intensive Education Programme in Diabetes for children, young people and their families: Child and Adolescent Structured Competencies Approach to Diabetes Education (CASCADE). *BMC Pediatr* 2009; 9:57. doi: 10.1186/1471-2431-9-57
 10. Farran BA, Bin-Elaiwah RI, Aldarsouny AT, Alshamrani AM, Almaslamani AM, Alsubie BF, Zainab MM, Alkulaib MO, Khalifah A. Level of awareness of diabetic ketoacidosis among diabetes mellitus patients in Riyadh. *J Family Med Prim Care* 2020; 9(6):2676-2679. doi: 10.4103/jfmpc.jfmpc_385_20
 11. Habeb AM, Al-Magamsi MS, Halabi S, Eid IM, Shalaby S, Bakoush O. High incidence of childhood type 1 diabetes in Al-Madinah, North West Saudi Arabia (2004-2009). *Pediatr Diabetes* 2011; 12(8):676-81. doi: 10.1111/j.1399-5448.2011.00765.x
 12. Karslioglu-French E, Donihi AC, Korytkowski MT. Diabetic ketoacidosis and hyperosmolar hyperglycemic syndrome: review of acute decompensated diabetes in adult patients. *BMJ* 2019; 365:l1114. doi: 10.1136/bmj.l1114
 13. Madkhly TM, Mohammed FA, Majrashi HH, Kamili FH, Tawhari RAM, Hudisy AA, AbuDyab OAM, Mohajab AHA, Tumayhi GM. Final-year medical students' awareness and knowledge about DKA: A cross-sectional study from a Saudi University. *J Family Med Prim Care* 2020; 9(2):1076-1079. doi: 10.4103/jfmpc.jfmpc_905_19
 14. Singh H, Thangaraju P, Kumar S, Aravindan U, Balasubramanian H, Selvan T. Knowledge and Awareness of Diabetes and Diabetic Ketoacidosis (DKA) Among Medical Students in a Tertiary Teaching Hospital: An Observational Study. *J Clin Diagn Res* 2014; 8(4):HC04-6. doi: 10.7860/JCDR/2014/7917.4249
 15. Vanelli M, Chiari G, Ghizzoni L, Costi G, Giacalone T, Chiarelli F. Effectiveness of a prevention program for diabetic ketoacidosis in children. An 8-year study in schools and private practices. *Diabetes Care* 1999; 22(1):7-9. doi: 10.2337/diacare.22.1.7
 16. Wersäll JH, Adolfsson P, Forsander G, Ricksten SE, Hanas R. Delayed referral is common even when new-onset diabetes is suspected in children. A Swedish prospective observational study of diabetic ketoacidosis at onset of Type 1 diabetes. *Pediatr Diabetes* 2021; 22(6):900-908. doi: 10.1111/pedi.13229
 17. Wolfsdorf JL, Glaser N, Agus M, Fritsch M, Hanas R, Rewers A, Sperling MA, Codner E. ISPAD Clinical Practice Consensus Guidelines 2018: Diabetic ketoacidosis and the hyperglycemic hyperosmolar state. *Pediatr Diabetes* 2018; 19 Suppl 27:155-177. doi: 10.1111/pedi.12701