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Diabetic ketoacidosis: Knowledge and awareness assessment among parents and caregivers of children and adolescents diagnosed by Type l DM in Saudi Arabia

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ABSTRACT

Background: Diabetes mellitus type 1 is characterized by the absence of insulin. One of the most common complications of DM is Diabetic Ketoacidosis, which is caused by a prolonged decrease of insulin due to loss of pancreatic β- cells by the immune response developing many symptoms such as high glucose levels, ketonuria, irregular electrolytes and dehydration. DKA episodes in children with T1DM are considered an issue worldwide. DKA often occurs at the beginning of diagnosis of diabetes mellitus type 1. This study aims to determine knowledge and awareness of diabetes ketoacidosis among parents and caregivers who have children or adolescents diagnosed with T1DM. *Methodology:* The study was conducted in Saudi Arabia from August 2022 to November 2022 as a descriptive cross-sectional with a minimum sample size of 666. The data was collected using a questionnaire translated into Arabic language. The data was analyzed by using statistical package for the social sciences (SPSS, version 28). *Results:* In our research, there were 1055 respondents. Mothers of diabetic children made up 42.7% of research respondents, followed by sisters (21.9%), fathers (20.1%) and brothers (15.3%). Of the study's respondents, 53.1% had strong knowledge of diabetic ketoacidosis, 34.8% had lack of knowledge, 8.6% had low knowledge and 3.5% had no knowledge at all. Age, diabetes, occupation, working status and the age of a diabetic child were all substantially correlated with knowledge score. *Conclusion:* The majority of caregivers in this study demonstrate poor knowledge and awareness of the signs and symptoms of DKA, However, they still require extra education because the majority of them are uninformed of the significance of DKA management.

Keywords: Diabetic ketoacidosis, Diabetes mellitus, Children, Adolescent, Caregivers, Parents

1. INTRODUCTION

Diabetes Mellitus (DM) is a condition of insufficient insulin that prevents energy produced by glucose (Elhassan et al., 2022). There are two forms of DM, type 1 diabetes mellitus, which is the absence of insulin due to loss of pancreatic β- cells by the immune process and (Diabetes-Mellitus) Type 2, characterized by insulin resistance (Caetano et al., 2022; Elhassan et al., 2022). Saudi Arabia ranks among higher countries with an incidence of DM (Alotaibi et al., 2022). A common complication in a patient with DM is DKA, which frequently occurs at the beginning of T1DM diagnosis due to inadequate adherence to insulin treatment (Rakshit, 2021). DKA is a severe complication of DM, mostly in T1DM (Garg et al., 2018). Diabetes ketoacidosis is characterized by three main symptoms hyperglycemia, acidosis and ketosis (Aljuhani et al., 2021). Frequently, DKA episodes are known to be persistent issues worldwide in children with known diabetes mellitus (Gebeyehu et al., 2022).

In MENA region, a report by International Diabetes Federation (IDF) in 2019 estimated that 149400 children and adolescents were diagnosed with T1DM. And this number was increasing by 20800 yearly according to the same report (Arafa et al., 2020). In developing countries, the incidence of mortality in hyperglycemic emergencies such as diabetic ketoacidosis (DKA) varies from 4-40% (Shahid et al., 2020). Many patients diagnosed with T1DM develop ketoacidosis with an incidence of thirteen to eighty percent (Evans et al., 2021). An estimate 7 million people have diabetes, while an additional 3 million have prediabetes. Perhaps even more significant concern is the recently worrisome rise of diabetic in Saudi-Arabia. In Saudi Arabia, the prevalence of diabetes has actually multiplied during the last 30 years (Robert et al., 2016).

A study done in Aseer region in 2018 about mothers' awareness and understanding of diabetic-ketoacidosis, 67 percent of parents are familiar with DKA. We comprehend that 48.6 percent of people with diabetes received information from health educators, 41 percent from doctors and 15 percent from the internet or the media (Othman et al., 2018). In another study in the north of Saudi Arabia in 2018. Their findings reveal the parent's ignorance of the illness and lack of awareness. As a result, 65 percent of children have encountered issues including acidity brought on by high sugar levels or a sudden drop in sugar levels (Alruwaili et al., 2018). Moreover, in 2020, a paper was finished in Abha, aimed to determine how much parents of children with type 1 diabetes mellitus (T1DM) understand diabetic ketoacidosis (DKA). 37.9% of parents had a poor understanding of DKA, which is more than one-third of all parents (Alhomood et al., 2020).

Among recent studies, some regions in Saudi Arabia are not covered yet. Therefore, it is crucial to cover other areas. Moreover, there are a few sample sizes in previous researches. As mentioned earlier, the incidence rate of diabetes mellitus (DM) is increasing. Accordingly, it is vital to assess the knowledge and awareness regarding DKA since DM is rising and DKA is one of its dangerous complications among caregivers of children and adolescents having type 1 DM.

2. MATERIALS AND METHODS

Study design and Study setting

This study, which applied a descriptive cross-sectional questionnaire-based methodology, was undertaken in Saudi Arabia between July 2022 to November 2022.

Sample size, inclusion, and exclusion criteria

According to the general authority for statistics in the kingdom of Saudi Arabia, there were 10,962,983 children and adolescents between zero to nineteen living in Saudi Arabia in 2020. Based on a 5% margin error with a confidence level of 99%, a minimum sample size of 666 is required.

The Sample size was estimated using the formula: $n= P (1-P) * Z\alpha^2 / d^2$ with a confidence level of 95%;

n: Calculated sample size

Z: The z-value for the selected level of confidence (1- a) = 1.96.

P: An estimated prevalence of knowledge

Q: (1 – 0.50) = 50%, i.e., 0.50

D: The maximum acceptable error = 0.01.

So, the calculated minimum sample size was:

$n = (1.96)^2 X 0.50 X 0.50/ (0.01)^2 = 666$.

Parents who have children or adolescents with diabetes mellitus type 1 within the age of 0-19 years and any other direct caregivers for children diagnosed with DM-1 other than parents were included. Otherwise, parents and caregivers who have patients older than 19 years and medical personnel and diabetes mellitus type 2 were excluded.

Data collection Technique and tools

The questionnaire was obtained with the permission of Dr. Ossama A. Mostafa and we will use it as our tool (Alhomood et al., 2020). The modified questionnaire includes two parts: Demographic data of parents and caregiver's age, gender, education, nationality, being diabetic, employment and kindship of the child or adolescents. And the child's data such as gender, age and duration since diagnosis with T1DM. The second part consists of 40 items regarding knowledge and awareness of DKA among parents and caregivers. We have considered the scoring system as the correct answers get 3 points while incorrect answers get one point. And the response 'Not Sure' gets 2 points finally, zero for 'I don't know' answers. So, the total possible score is 120. Wherefore, we consider having from zero to thirty points (i.e., ≤ 25%) is 'lack of knowledge,' while a score of 31-60 is 'low knowledge' and fair knowledge for getting a score of 61-90. And those who get more than 90 points (i.e., >75%) are considered to have 'good knowledge'.

Pilot test

The questionnaire was distributed on 20 individuals and asked to fill it. This was done to test the simplicity of the questionnaire and the feasibility of the study. Data of the pilot study was excluded from the final data of the study.

Analyzes and entry method

Data was entered in the Microsoft Excel Software. Then, the SPSS program (version 28) was used to analyze the collected data). The Chi-square test was used to calculate the significant association and finally, tables and figures were used to display the results.

3. RESULTS

The study included 1055 participants, 29.8% of them aged between 31- 40 years old, 28.6% aged between 21- 30 years old and 20.3% aged between 41- 50 years old. 24.6% of children relatives had diabetes. 93.5% were Saudi. 42.7% of study participants were diabetic children' mothers, 21.9% were sisters, 20.1% were fathers and 15.3% were brothers.

The gender of the child or adolescent with diabetes was half males and half females. Child or teenage age was reported as 31.1% were 11- 15 years old, 30.8% were 6- 10 years old and 27.7% were 16- 20 years old. 22.7% of participants were from eastern province, 10.9% were from Riyadh and 10.4% were from Makkah.

Table 1 Sociodemographic characteristics of participants (n=1055).

Parameter		No.	%
Age	18-20	141	13.4
	21-30	302	28.6
	31-40	314	29.8
	41-50	214	20.3
	51-60	59	5.6
	More than 60	25	2.4
Diabetes	Yes	260	24.6
	No	795	75.4
If yes, since when	15^{th}	88	33.8
	10 – 6	78	30.0
	more than 10	94	36.2
Occupation	Illiterate	21	2.0
	primary	40	3.8
	Intermediate stage	37	3.5
	secondary	281	26.6
	university	481	45.6
	Postgraduate	195	18.5

Employment	unemployed	567	53.7
	Not related to health	488	46.3
Nationality	Saudi	986	93.5
	Non-Saudi	69	6.5
Monthly family income (in riyals)	less than 5000	203	19.2
	From 5000 to 10000	333	31.6
	From 10000 to 15000	251	23.8
	more than 15,000	251	23.8
Relationship type of child or adolescent	Father	212	20.1
	Brother	161	15.3
	Sister	231	21.9
	Mother	451	42.7
Child or teenage age	15th	110	10.4
	10 - 6	325	30.8
	15 - 11	328	31.1
	20 - 16	292	27.7
The gender of the child or adolescent	Male	527	50.0
	female	528	50.0
Time since diabetes diagnosis (in years)	15th	772	73.2
	10 - 6	198	18.8
	more than 10	85	8.1
Region	Eastern Province	239	22.7
	Al Baha area	41	3.9
	Al-Jawf region	22	2.1
	Northern Border	41	3.9
	Riyadh region	115	10.9
	Qassim region	77	7.3
	Medina area	66	6.3
	Tabuk region	66	6.3
	Jazan region	65	6.2
	Hail region	68	6.4
	Asir region	50	4.7
	Mecca area	110	10.4
	Najran Province	52	4.9
	Other	43	4.1

As illustrated in table (2), 61.8% of participants know diabetic ketoacidosis. 54.1% reported that child was admitted to the hospital to receive treatment for complications of diabetes before. 22.3% of diabetic children had sibling with diabetes. Only 38.5% knew minimum blood sugar level correctly while 25.5% knew highest blood sugar level after eating. Figure 1 shows that 53.1% of study participants had good knowledge of diabetic ketoacidosis, 34.8% had fair knowledge, 8.6% had low knowledge and 3.5% had lack of knowledge.

Table 2 Knowledge of participants of ketoacidosis (n=1055).

Parameter		No.	%
Know diabetic ketoacidosis	Yes	652	61.8
	No	403	38.2
The child was admitted to the hospital to receive treatment for complications of diabetes before	Yes	571	54.1
	No	484	45.9
Patient have siblings with diabetes	Yes	235	22.3
	No	820	77.7
Minimum (fasting) blood sugar level	80-100	406	38.5
	100-120	308	29.2
	120-140	213	20.2
	more than 140	128	12.1
Max (after eating) blood sugar level	120-140	168	15.9
	140-160	173	16.4
	160-180	209	19.8
	180-200	269	25.5
	more than 200	236	22.4
Normal level of cumulative sugar for child	6-7	245	23.2
	7-8	261	24.7
	8-9	144	13.6
	9-10	134	12.7
	10-11	68	6.4
	11-12	42	4.0
	More than 12	26	2.5
	Don't know	135	12.8

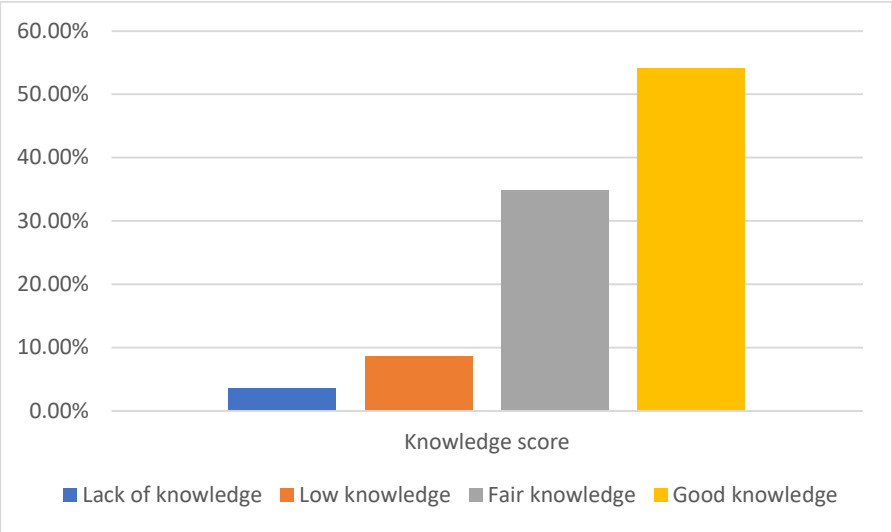

Figure 1 knowledge scores of participants of ketoacidosis (n= 1055)

In table (3): 30.9% of participants reported that ketoacidosis is caused by high insulin levels, while 45.9% reported that ketoacidosis is caused by insulin deficiency. 73.2% of participants knew that frequent urination is a sign of ketoacidosis 71% extreme thirst, 62.8% pain in the abdomen (colic), 56% weight loss, 60.2% vomit, 64.5% distinctive breath smell, 39.8% cold skin cold, 50.2% impaired consciousness, 61.3% body weakness and 51.1% arrhythmia (Figure 2).

Table 3 Knowledge of participants ketoacidosis (n=1055)

Parameter	Yes	No	Don't know	Not sure
Ketoacidosis is caused by high insulin levels	326 30.9%	392 37.2%	181 17.2%	156 14.8%
Ketoacidosis is caused by insulin deficiency	484 45.9%	195 18.5%	155 14.7%	221 20.9%
ketoacidosis low blood sugar	220 20.9%	473 44.8%	167 15.8%	195 18.5%
Ketoacidosis is caused by undereating	288 27.3%	285 27.0%	225 21.3%	257 24.4%
Frequent urination is a sign of ketoacidosis	772 73.2%	65 6.2%	109 10.3%	109 10.3%
Extreme thirst is a sign of ketoacidosis	749 71.0%	60 5.7%	122 11.6%	124 11.8%
Pain in the abdomen (colic) is a sign of ketoacidosis	663 62.8%	70 6.6%	139 13.2%	183 17.3%
Weight loss is a sign of ketoacidosis	591 56.0%	89 8.4%	168 15.9%	207 19.6%
Vomit is a sign of ketoacidosis	635 60.2%	101 9.6%	152 14.4%	167 15.8%
Distinctive breath smell is a sign of ketoacidosis	680 64.5%	88 8.3%	142 13.5%	145 13.7%
Skin cold is a sign of ketoacidosis	420 39.8%	124 11.8%	211 20.0%	300 28.4%
Impaired consciousness is a sign of ketoacidosis	530 50.2%	106 10.0%	171 16.2%	248 23.5%
Body weakness is a sign of ketoacidosis	647 61.3%	68 6.4%	157 14.9%	183 17.3%
Arrhythmia is a sign of ketoacidosis	539 51.1%	62 5.9%	198 18.8%	256 24.3%

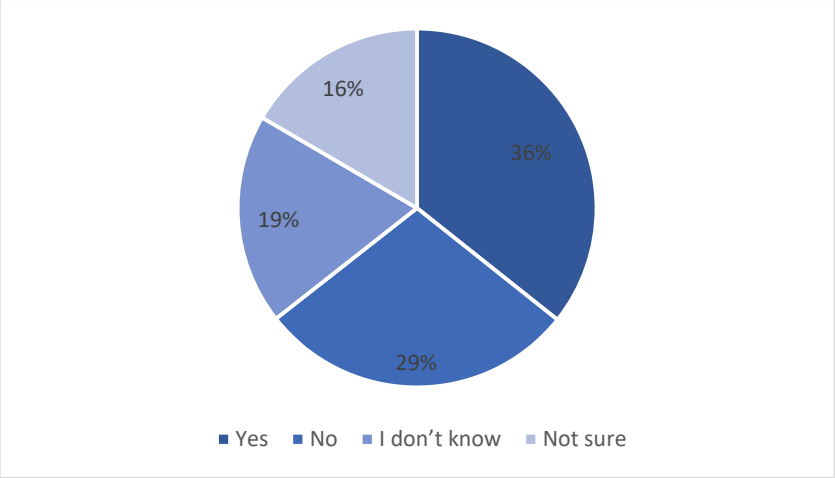

Figure 2 knowledge scores of participants about ketoacidosis as a result of severe infection (n= 1055)

Table (4) illustrate that, 67.2% of participants knew that ketoacidosis is a dangerous situation to the life of the child. 85.5% reported that ketoacidosis is when blood sugar level above normal and not responding to home treatment, 68.5% reported that ketoacidosis is when the urine ketone level is medium or high. 16.5% reported that ketoacidosis can be managed at home while 85.9% that it must be managed in the hospital. 66.3% reported that checking blood sugar level is necessary in ketoacidosis and 38.7% reported that checking the potassium level in the blood is necessary in ketoacidosis and 75.5% reported that urine ketone test is necessary in ketoacidosis.

Table 4 Knowledge of participants ketoacidosis (n=1055)

Parameter	Yes	No	Don't know	Not sure
Ketoacidosis is a dangerous situation to the life of the child	709 67.2%	74 7.0%	83 7.9%	189 17.9%
Ketoacidosis is a simple case	116 11.0%	634 60.1%	97 9.2%	208 19.7%
Ketoacidosis is when you have persistent vomiting	867 82.2%	48 4.5%	51 4.8%	89 8.4%
Ketoacidosis is when blood sugar level above normal and not responding to home treatment	902 85.5%	40 3.8%	51 4.8%	62 5.9
Ketoacidosis is when the urine ketone level is medium or high	723 68.5%	54 5.1%	102 9.7%	176 16.7%
Ketoacidosis can be managed at home	174 16.5%	622 59.0%	99 9.4%	160 15.2%
Ketoacidosis must be managed in the hospital	906 85.9%	26 2.5%	60 5.7%	63 6.0%
Check blood sugar level is necessary in ketoacidosis	699 66.3%	175 16.6%	75 7.1%	106 10.0%
Checking the potassium level in the blood is necessary in ketoacidosis	408 38.7%	201 19.1%	186 17.6%	260 24.6%
Urine ketone test is necessary in ketoacidosis	796 75.5%	31 2.9%	118 11.2%	110 10.4%

As shown in table (5): 70.7% of participants reported injecting an appropriate dose of insulin for management of ketoacidosis. 71.2% reported giving fluids or solutions. 85.5% reported taking insulin directly and 86.4% reported continuous monitoring of blood sugar level.

Table 5 Knowledge of participants of management of ketoacidosis (n=1055)

Parameter	Yes	No	Don't know	Not sure
Inject an appropriate dose of insulin	746 70.7%	77 7.3%	82 7.8%	150 14.2%
Giving fluids and solutions	751 71.2%	30 2.8%	100 9.5%	174 16.5%
Take insulin as directed	902 85.5%	17 1.6%	65 6.2%	71 6.7%
Continuous monitoring of blood sugar level	912 86.4%	15 1.4%	65 6.2%	63 6.0%

Table (6) reported that: 8.7% defined overeating as a complication of ketoacidosis, 71.6% severe dehydration, 59.8% coma and 22.7% brain swelling. Eat healthy food, exercise and take medication were defined by 88.6% for prevention of ketoacidosis, as well as monitoring blood sugar level daily regularly by 88.6%, adjusting insulin dose as needed 84.1%, go to the emergency department when the blood sugar level is high 75.6% and go to the emergency department when the urine ketone level is high 82.4%.

Knowledge score was significantly associated with age, having diabetes, occupation, working status and diabetic child age (P< 0.05) as illustrated in table (7).

Table 6 Knowledge of participants of complications and prevention of ketoacidosis (n=1055)

	Yes	No	Don't know	Not sure
Overeating	92 8.7%	770 73.0%	78 7.4%	115 10.9%
Severe dehydration	755 71.6%	33 3.1%	90 8.5%	177 16.8%
Coma	631 59.8%	109 10.3%	115 10.9%	200 19.0%
Swelling of the brain	239 22.7%	210 19.9%	250 23.7%	356 33.7%
Eat healthy food, exercise, and take medication	935 88.6%	24 2.3%	57 5.4%	39 3.7%
Monitor blood sugar level daily regularly	935 88.6%	27 2.6%	52 4.9%	41 3.9%
Adjusting insulin dose as needed	887 84.1%	47 4.5%	58 5.5%	63 6.0%
Go to the emergency department when the blood sugar level is high	798 75.6%	120 11.4%	56 5.3%	81 7.7%
Go to the emergency department when the urine ketone level is high	869 82.4%	29 2.7%	64 6.1%	93 8.8%

Table 7 Knowledge scores of participants in association with their sociodemographic characters (n=1055)

		Knowledge Score				Total (N=1055)	P value
		Good knowledge	Fair knowledge	Low knowledge	Lack of knowledge		
Age	18 - 20	61	56	17	7	141	0.027
		10.9%	15.3%	18.7%	18.9%	13.4%	
	21 - 30	149	124	20	9	302	
		26.6%	33.8%	22.0%	24.3%	28.6%	
	31 - 40	188	90	27	9	314	
		33.6%	24.5%	29.7%	24.3%	29.8%	
	41 - 50	108	78	19	9	214	
		19.3%	21.3%	20.9%	24.3%	20.3%	
	51 - 60	35	16	6	2	59	
		6.3%	4.4%	6.6%	5.4%	5.6%	
	More than 60	19	3	2	1	25	
		3.4%	0.8%	2.2%	2.7%	2.4%	
Have diabetes	yes	155	81	14	10	260	0.038
		27.7%	22.1%	15.4%	27.0%	24.6%	
	no	405	286	77	27	795	
		72.3%	77.9%	84.6%	73.0%	75.4%	
Working status	unemployed	314	198	41	14	567	0.051
		56.1%	54.0%	45.1%	37.8%	53.7%	
	Not related to health	246	169	50	23	488	
		43.9%	46.0%	54.9%	62.2%	46.3%	

Occupation	Illiterate	18	2	1	0	21	0.004
		3.2%	0.5%	1.1%	0.0%	2.0%	
	primary	20	15	2	3	40	
		3.6%	4.1%	2.2%	8.1%	3.8%	
	Average	14	13	8	2	37	
		2.5%	3.5%	8.8%	5.4%	3.5%	
	secondary	151	97	26	7	281	
		27.0%	26.4%	28.6%	18.9%	26.6%	
	university	241	189	34	17	481	
		43.0%	51.5%	37.4%	45.9%	45.6%	
	Postgraduate	116	51	20	8	195	
		20.7%	13.9%	22.0%	21.6%	18.5%	
Nationality	Saudi	516	350	84	36	986	0.182
		92.1%	95.4%	92.3%	97.3%	93.5%	
	Non-Saudi	44	17	7	1	69	
		7.9%	4.6%	7.7%	2.7%	6.5%	
	less than 5000	94	76	23	10	203	
		16.8%	20.7%	25.3%	27.0%	19.2%	
	From 5000 to 10000	146	126	38	17	327	
		26.1%	34.3%	41.8%	45.9%	31.0%	
	10000-15000	160	91	17	6	274	
		28.5%	24.8%	18.7%	16.2%	26.0%	
	more than 15,000	160	74	13	4	251	
		28.6%	20.2%	14.3%	10.8%	23.8%	
Child or teenage age	1 - 5	62	39	4	5	110	0.006
		11.1%	10.6%	4.4%	13.5%	10.4%	
	6 - 10	200	93	23	9	325	
		35.7%	25.3%	25.3%	24.3%	30.8%	
	11 - 15	163	126	30	9	328	
		29.1%	34.3%	33.0%	24.3%	31.1%	
	16 - 20	135	109	34	14	292	
		24.1%	29.7%	37.4%	37.8%	27.7%	
The gender of the child or adolescent	Male	291	167	48	21	527	0.189
		52.0%	45.5%	52.7%	56.8%	50.0%	
	female	269	200	43	16	528	
		48.0%	54.5%	47.3%	43.2%	50.0%	
Time since diabetes diagnosis (in years)	1 - 5	408	267	69	28	772	0.839
		72.9%	72.8%	75.8%	75.7%	73.2%	
	6 - 10	101	75	16	6	198	
		18.0%	20.4%	17.6%	16.2%	18.8%	
	more than 10	51	25	6	3	85	
		9.1%	6.8%	6.6%	8.1%	8.1%	

4. DISCUSSION

Diabetes mellitus (DM) is a metabolic condition characterized by consistently high blood sugar levels. DM has a more significant impact on the metabolism of proteins, lipids and carbohydrates (Baynest, 2015). The three primary types of diabetes are type 1 diabetes (T1DM), type 2 diabetes (T2DM) and gestational diabetes. T1DM is regarded as one of the endocrine disorders that affect children and adolescents most often (Satti et al., 2013). Diabetic ketoacidosis (DKA) is generally caused by a lack of insulin. It is a

severe acute consequence of diabetes that accounts for most hospitalizations due to severe insulin insufficiency (Alanazi et al., 2018). It happens when the body is unable to utilize glucose as a source of energy due to a lack of insulin, which causes an increase in the amount of glucose and the tissue subsequently uses ketone or fatty acid for energy, resulting in diabetic ketoacidosis. DKA is usually linked with T1DM rather than T2DM; nevertheless, DKA can also be detected in T2DM patients (Alanazi et al., 2018). This is a descriptive cross-sectional questionnaire-based conducted among 666 participants, Saudi Arabia. The study aiming to assess the level of knowledge and awareness of DKA among caregivers of children and adolescents having type 1 DM.

In our study, 53.1% of survey participants had a strong understanding of diabetic ketoacidosis, 34.8% had a fair understanding, 8.6% had a low understanding and 3.5% had no understanding. This was higher than reported in a cross-sectional online survey was conducted among 348 people from Hail City, Saudi Arabia, found that 43.7% of the respondents were correct that DKA is an emergency complication of DM that required urgent intervention. Only 17.8% of the respondents were aware that DKA is not only for children and more than half (51.1%) believed that maintaining the normal level of A1c reduces the incidence of DKA (Alreshidi et al., 2022). Generally, the results show that more than two-thirds (67.8%) of the subjects were assumed to have poor awareness levels, 23.6% were moderate and only 8.6% were good (Alreshidi et al., 2022). In Abha City A cross-sectional study was conducted among 385 parents of T1DM children attending the Diabetes Center; more than one-third of parents (37.9%) had poor grade of knowledge regarding DKA, 32.5% had fair grade while 9.6% of parents had good knowledge regarding diabetic ketoacidosis (Alhomood et al., 2020). In Riyadh city, Saudi Arabia, another cross-sectional study design was conducted among 412 subjects reported; of the contributors, 64.7 percent said they were aware of DKA, yet it was still a concerning figure since 35.3% did not know about it (Kaabba et al., 2021). In Sudan, a cross-sectional institution-based study included 110 participants found that (56.9%) participants had poor knowledge scores and (21.8%) participants have never heard of DKA (Elhassan et al., 2022).

According to our study results, only 45.9% reported that ketoacidosis is caused by insulin deficiency. In Hail city, Saudi Arabia, another study reported that 28.7% of participants think that high blood sugar due to irregular eating and exercise can cause of DKA, One-fourth (25.3%) of the individuals were aware that a major contributor to DKA was low blood insulin levels which may be related to forgetting to take insulin injections and only 27% and 24.7% of the respondents knew that infection and physical exertion can cause DKA (Alreshidi et al., 2022). Another study conducted in Abha city found that regarding causes of ketoacidosis, (49.1%) of cases reported hypoglycemia while 46.2% correctly stated low insulin dose followed by 43.9% of parents correctly denied high insulin dose, low food intake (35.6%), or severe infections (34.8%) (Alhomood et al., 2020). Results from Another study conducted in Sudan showed that knowledge of the two most common causes of DKA, infections and omitted doses, was poor, 35.5% and 39.1%, respectively (Elhassan et al., 2022). While 42.7% reported poor diet as cause for DKA (Elhassan et al., 2022).

Symptoms of ketoacidosis, 73.2% of our participants knew that frequent urination is a sign of ketoacidosis 71% extreme thirst, 62.8% pain in the abdomen (colic), 56% weight loss, 60.2% vomit, 64.5% distinctive breath smell, 39.8% cold skin cold, 50.2% impaired consciousness, 61.3% body weakness and 51.1% arrhythmia. Results from another study conducted in hail city, Saudi Arabia, showed that the most common symptoms of DKA were feeling exhausted/fatigued (64.9%), followed by nausea (48.9%) and unconsciousness (45.4%) (Alreshidi et al., 2022). Other symptoms were identified by participants stomachache (36.8%), difficulty breathing or rapid breathing (36.2%), distinctive breath smell (32.2%) and blurred vision (27%) (Alreshidi et al., 2022). Another study reported that as regards symptoms and signs of ketoacidosis, participants correctly stated polyuria (78.4%), severe thirst (77.7%), abdominal colic (65.2%), repeated vomiting (64.2%), loss of weight (55.6%), acetone odor of breath (52.7%), cold skin (43.4%), disturbed consciousness (40.3%) and muscle weakness (61.8%) (Alhomood et al., 2020). In Riyadh, another study reported that the most known symptom of DKA was identified by participants was the characteristic smell of breathing (70%), 66% agreed that sign of DKA is vomiting while the least known was the skin coldness (29.5%) (Kaabba et al., 2021). In Sudan, another study reported that he most frequently recognized symptoms of DKA were polydipsia and polyuria, 52% and 49%, respectively, while the knowledge of other symptoms was low (Elhassan et al., 2022).

As for knowledge about management of DKA, 70.7% of participants reported injecting an appropriate dose of insulin for management of ketoacidosis. 71.2% reported giving fluids or solutions. 85.5% reported taking insulin directly. In Hail city, another study reported; 40.8% of cases indicated that for in the management of DKA, the most typical step was to summon an ambulance and transport the pt to the hospital as quickly as possible. Only 12.6% said that they should give the patient oral sugar and wait until they get better (Alreshidi et al., 2022). Also, results from another study showed that 86.8% of participants correctly stated hospitalization, 55.1% stated insulin administration, while 53% stated intravenous fluids administration (Alhomood et al., 2020).

Results from another study observed that nearly half of cases (53.5%) correctly stated that he/she should go to the doctor when having high uncontrolled blood sugar, 37.4% correctly stated that diabetic children should go to the doctor when having repeated vomiting, while only 9.1% correctly stated that diabetic children should go to the doctor when having ketonuria (Alhomood et al., 2020). In Abha city, another study found that, 70.6% of cases correctly stated assessment of blood glucose level, 60.3% stated

assessment of ketonuria while 28.8% stated assessment of serum potassium level for diagnosis of ketoacidosis (Alhomood et al., 2020).

Eat healthy food, exercise and take medication were defined by 88.6% for prevention of ketoacidosis, as well as monitoring blood sugar level daily regularly by 88.6%, adjusting insulin dose as needed 84.1%, go to the emergency department when the blood sugar level is high 75.6% and go to the emergency department when the urine ketone level is high 82.4%. Another study found that concerning prevention of ketoacidosis, 83.9% of subjects correctly stated administration of the proper dose of insulin, and 82.3% stated blood sugar monitoring (Alhomood et al., 2020). Similarly, another study reported that (88.9%) of the participants know DKA can be avoided by taking insulin as prescribed, whereas 88.4 precent suggested (continuous-blood-glucose-monitoring) (Kaabba et al., 2021).

In our study, 8.7% defined overeating as a complication of ketoacidosis, 71.6% severe dehydration, 59.8% coma and 22.7% brain swelling. In Abha city another study reported; 68.1% correctly stated severe dehydration, 63.6% stated coma, while 22.6% stated brain edema (Alhomood et al., 2020). In Riyadh, another study found that (63.3%) of participants know about complications of DKA. 68.8 precent reported knowing it might cause coma, but 61.6 precent did not realize it could also cause brain enlargement, and 63.3 precent saw something it can cause severe dehydration (Kaabba et al., 2021).

Regarding prevention of diabetes complications another study reported that 92.7% of cases stated intake of healthy foods, exercise and proper treatment of diabetes, 92.2% stated daily blood sugar monitoring, 82.3% stated proper insulin dose administration, 81% stated assessment of ketones in urine, 79% stated going to the emergency department in case of uncontrolled hyperglycemia or ketonuria (Alhomood et al., 2020). In Riyadh city, another study reported that regarding the severity of DKA, more individuals (78.7%) thought it was a very bad situation for the child, while fewer (7.5%) thought it was a straightforward issue (Kaabba et al., 2021). In accordance with this another study conducted in Abha city found about three quarters of parents (75.1%) correctly stated that ketoacidosis among children is a dangerous condition (Alhomood et al., 2020).

In our study, knowledge of ketoacidosis was significantly associated with age, having diabetes, employment and child age. Another study found that a greater knowledge score was more closely related with those who were younger in age, gender female, being unmarried, being a student, having type 1 diabetes, While differences in understanding scores according to responders' levels of education, those who have diabetes and the length of their diabetes in Hail-City did not achieve statistical-significance (P> 0.05), DKA diagnosis and having adequate information about DKA did (P 0.05) (Alreshidi et al., 2022). In contrast, results from another study showed that characteristics that were significantly associated with lower parents' knowledge included being a father, aged >40 years, less than university educated, unemployed or those whose occupation was not healthcare-related (Alhomood et al., 2020).

5. CONCLUSION

The majority of caregivers in this study demonstrate good knowledge and awareness of the signs and symptoms of DKA, but they still require additional education because most of them are unaware of the importance of managing sick days. The results of this study imply that it might be advantageous to inform those who care for type-1 diabetic patients as well as the patients themselves about the self-management of DKA, the use of insulin and blood glucose monitoring in order to avoid complications.

Recommendations

We recommend that further educational campaigns should be inaugurated to raise awareness about Diabetic ketoacidosis and possible associated complications.

Ethical approval

The research was approved by the Regional Research and Ethics committee of Almaarefa University, with letter number (IRB09-28122022-110)

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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.

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