Knowledge about diabetic ketoacidosis among parents of type 1 diabetic children

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Abstract

Aim of Study: To assess knowledge of parents of type 1 diabetes mellitus (T1DM) children about diabetic ketoacidosis (DKA).

Methodology: A cross-sectional study was conducted among 385 parents of T1DM children attending the Diabetes Center in Abha City. A questionnaire was designed in simple Arabic Language by the researcher. It included personal data and knowledge about DKA.

Results: More than one-third of parents (37.9%) had poor grade of knowledge regarding DKA. Their main knowledge deficits were related to normal range of fasting and post-prandial blood sugar, normal range for HbA1c, when the diabetic child should see a doctor and causes of DKA. 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, and having a monthly income <5000 SR.

Conclusions: Parents' knowledge about DKA is suboptimal. Some characteristics are significantly associated with lower knowledge regarding diabetes and diabetic ketoacidosis, i.e., being a father of a diabetic child, older parents, being less educated or unemployed parents, those whose occupation is not healthcare-related, having low monthly income and having diabetic siblings.

Recommendations: Health education to T1DM patients and their guardians should be fulfilled. It must cover information related to independent management of diabetes and diabetic ketoacidosis and how to identify symptoms of DKA.

Key words: Type 1 diabetes mellitus, diabetic ketoacidosis, parents' knowledge, health education.

Introduction

During childhood and adolescence, type 1 diabetes mellitus (T1DM) is the most common endocrine-metabolic disorder (1-2). Almost one in 300 youth develop type 1 diabetes (3). Worldwide, it has been reported that the incidence of type 1 diabetes is increasing by 3-4% per year (4).

Diabetic ketoacidosis (DKA) usually occurs as a result of insulin deficiency. It is a serious acute complication of DM, which accounts for most hospitalizations due to severe insulin deficiency (5). It consists of the biochemical triad of ketonemia, hyperglycemia and acidemia (6). Among children, the criteria for diagnosis of DKA include blood glucose above 11 mmol/L, venous pH less than 7.3, or bicarbonate less than 15 mmol/L, and ketonemia with ketonuria [7].

The incidence of DKA is difficult to establish, but it continues to increase, accounting for about 140,000 hospitalizations in the US in 2009 and more than 500,000 hospital days per year (8). Despite the promising statistics and raised awareness, prevalence of DKA continues to be as high as 30% in children with type 1 diabetes (9).

Several risk factors for DKA have been reported. In Al-Baha, Saudi Arabia, Satti et al. (1) noted that the incidence of DKA increases with increasing diabetic child's age, reaching its maximum during preadolescence and adolescence. Similarly, in Leicester, UK, Skinner (10) reported that the incidence of DKA peaked during adolescence.

In Germany, Neu et al. (11) reported that the frequency of DKA is higher among diabetic girls than that among diabetic boys. Similarly, in Saudi Arabia, Hamed (12), in Al-Madina Region, reported a higher incidence of DKA among females (58.7%) than males (41.3%). Moreover, Satti et al. (1), in Al-Baha reported a female to male ratio of 1.22:1.

Satti et al. (1) found first degree consanguinity among 27.5% of parents of diabetic ketoacidotic children. Moreover, 74% of their admitted children with DKA had positive family history of diabetes, of whom 52.5% were first degree relatives.

Worldwide, acute infections, especially pneumonia and urinary tract infections, constitute the most common precipitating factor for DKA (13). In Addis Ababa, Ethiopia, Desta (14) reported that the most common precipitating factors for children with DKA were infections (52%), omission of insulin (16%) and parasitic infestation (12%). Jayashree and Singhi (15), in North India stated that precipitating factors for DKA among children were sepsis (37%), omitting insulin (15%) or both sepsis with insulin omission (7%). In Jeddah, Saudi Arabia, Qari (16) showed that poor compliance e.g., omitting insulin injections, was the most common precipitating factor for DKA (54.4%), followed by infections (28%). In Al-Baha, Saudi Arabia, Satti et al. (1) found that the commonest precipitating factor was infections (82.1%).

The primary fatal complication of DKA is cerebral edema. Moreover, vascular, musculoskeletal, pulmonary, gastrointestinal, and cognitive complications of DKA may rarely occur, but can result in acute and long-term morbidity (17).

DKA case fatality rates in developed countries range from 0.15% to 0.31%. In developing countries, it is higher (13%), where infections continue as one of the most important precipitating factors for DKA (15,18).

The clinical presentation of DKA usually develops rapidly, over a period of less than 24 hours. Several days before development of DKA, several symptoms may develop, i.e., polyuria, polydipsia, and weight loss. Vomiting and abdominal pain are frequently the presenting symptoms (19). The assessment of ketonemia is usually performed by the nitroprusside reaction. Direct measurement of β-hydroxybutyrate is currently available by finger stick method, which is a more accurate indicator of DKA (19).

The prevention of DKA can be successfully done by better access to medical care, proper health education, and effective communication with a health care provider during an intercurrent illness. Involvement of family members should be encouraged. They need to be educated on insulin regimen and how to perform measurements of blood glucose. Also, a written care plan should be provided to the patient and/or caregiver, as this enhances understanding and emphasizes the importance of self-management of diabetes (20).

Advances in technology have provided more efficient means of monitoring diabetes and maintaining glycemic control in an outpatient setting. The use of real-time continuous glucose monitoring in patients with T1DM has been shown to significantly lower hemoglobin A1c. Real-time continuous glucose monitoring also has the advantage of signaling to patients the early detection of glucose abnormalities, allowing for prompt intervention (21). At-home use of ketone meters that detect blood β-hydroxybutyrate has also been shown to aid in early detection and management of ketosis, which may decrease the need for specialized care. Short-acting insulin can be administered with fluids early on to prevent DKA (22). Atkilt et al. (23) reported that the odds of developing DKA in newly diagnosed T1D children was 49% lower for children whose parents knew its sign and symptoms than parents' who didn't know. They explained their finding by that parents who know its sign and symptoms seek health care before their children develop DKA. Thus, this study aimed to assess knowledge of parents of T1DM children about DKA.

Methodology

This cross-sectional study was conducted among parents of children with T1DM registered at the Diabetes Center, Abha. A total of 385 parents of type 1 diabetic children were interviewed. Based on relevant literature, a study questionnaire was designed in simple Arabic Language by the researcher. It included the following two parts:

- Personal data: Parents' age, gender, education, nationality, employment, being diabetic, and child's age, gender, duration of diabetes, previous hospitalization and having diabetic siblings.
- Knowledge about DKA and prevention of diabetes: Fourteen items including 40 statements.

The study questionnaire validity (face and content) was assessed by three consultants of Family Medicine.

A correct response was assigned a score of (1) and an incorrect response was assigned a score of (0). Therefore, for the 40 knowledge statements, parents' total knowledge score ranged from 0 to 40. Parents who attained total scores less than 20 (i.e., <50%) were considered to have "poor" knowledge, those who attained a score of 30 or more were considered to have "good" knowledge, while those who attained a score of 20-29 were considered to have "fair" knowledge.

A pilot was conducted on 20 parents of T1DM children. The objectives of the pilot study were to test the clarity and wording of the study questionnaire. Data collected within the pilot study were excluded from the main study.

During the period from December 2018 till February 2019, the researcher visited the Diabetes Center in Abha City on a daily basis. All potential participant parents of T1DM children attending the Diabetes Center were briefed regarding the objectives of the study and then were invited to participate in the current study. The study questionnaire was distributed to each participant and was then collected after being filled. The researcher repeated the daily visits till the required sample size was fulfilled.

Collected data were verified prior to computerized data entry. The Statistical Package for Social Sciences (SPSS version 23) was utilized for that purpose. Descriptive statistics were applied (e.g., frequency, percentage, mean and standard deviation). Tests of significance were applied (e.g. X^2-test). P-values less than 0.05 were considered as statistically significant.

All necessary official approvals were secured by the researcher prior to data collection. The researcher clearly informed all potential participants (and their caregivers) about the subject and objectives of the study. Then she explained to them the study questionnaire. Collected data were kept confidential and the researcher provided the necessary health education to all participants to prevent the incidence or recurrence of DKA.

Results

Table 1 shows that 49.6% of interviewed parents were mothers of type 1 diabetic children, while 50.4% were fathers. More than half of parents (56.4%) were aged 30-40 years, while 12.7% were aged less than 30 years, and 30.9% were aged more than 40 years. Only 18.7% of parents were diabetic. More than half of parents (58.2%) were university educated, while 1.8% were illiterate, 7.8% had primary education, 10.1% had intermediate education and 22.1% had secondary education. The occupation of 66.2% of parents was unrelated to the healthcare field, while that of 11.2% was related to the healthcare field and 22.6% were unemployed. The majority of parents (96.6%) were Saudi. The monthly income of 17.7% of parents was less than 5000 SR, while that of 41.8% was 5000-10000 SR and that of 40.5% was more than 10000 SR.

Table 2 shows that 54% of type 1 diabetic children were males. Almost half of children were aged above 10 years (50.9%). The duration of diabetes was <4 years among 59% of children. About two thirds of diabetic children (65.7%) were previously hospitalized for complications of diabetes. More than two-thirds of those who were hospitalized (67.1%) were hospitalized several times, while 32.9% were hospitalized only once. About one quarter of diabetic children (23.1%) had diabetic siblings.

Table 3 shows that only 40.8% of parents correctly stated normal range for fasting blood sugar, while 15.1% correctly stated the normal range for postprandial blood sugar and 31.9% correctly stated the normal range for glycosylated hemoglobin. Regarding seeking medical advice, 37.4% correctly stated that diabetic children should go to the doctor when having repeated vomiting, 53.5% correctly stated that he/she should go to the doctor when having high uncontrolled blood sugar, while only 9.1% correctly stated that diabetic children should go to the doctor when having ketonuria. Regarding causes of ketoacidosis, 43.9% of parents correctly denied high insulin dose, hypoglycemia (49.1%) but due to low insulin dose (46.2%) or low food intake (35.6%), while 46.2% correctly stated low insulin dose or severe infections (34.8%). Regarding symptoms and signs of ketoacidosis, parents 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%). About three quarters of parents (75.1%) correctly stated that ketoacidosis among children is a dangerous condition, while 91.2% correctly stated that the hospital is the place for its management. Regarding laboratory investigations for ketoacidosis, 70.6% of parents correctly stated assessment of blood glucose level, 28.8% stated assessment of serum potassium level, while 60.3% stated assessment of ketonuria.

Regarding management of ketoacidosis, 86.8% of parents correctly stated hospitalization, 55.1% stated insulin administration, while 53% stated intravenous fluids administration. Regarding prevention of ketoacidosis,

83.9% of parents correctly stated administration of the proper dose of insulin, and 82.3% stated blood sugar monitoring. Regarding complications of ketoacidosis, 68.1% correctly stated severe dehydration, 63.6% stated coma, while 22.6% stated brain edema. Regarding prevention of type 1 diabetes complications, 92.7% of parents 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 (77.1%).

Figure 1 shows that 29.6% of parents had good knowledge regarding diabetic ketoacidosis, while 32.5% had fair grade and 37.9% had a poor grade of knowledge.

Table 4 shows that parents' good knowledge grade was significantly less among fathers than mothers of type 1 diabetic children (25.3% and 34% respectively, $p<0.001$). Parents aged >40 years had significantly less good knowledge grade than younger parents aged 30-40 years or <30 years (22.7%, 30% and 44.9%, respectively, $p=0.018$). Diabetic parents had less good knowledge grade than non-diabetic ones (19.4% and 31.9%, respectively). However, the difference was not statistically significant. Less than university educated parents had significantly less good knowledge grade than those university educated ($p=0.035$). Unemployed parents and those whose occupation was not healthcare related had a significantly less good knowledge grade than those whose occupation is healthcare related ($p<0.001$). Non-Saudi parents had a lower good knowledge grade than Saudi parents (15.4%, and 30.1% respectively). However, the difference was not statistically significant. Parents with monthly income <5000 SR had significantly less good knowledge grade than those with higher monthly income ($p=0.021$).

Table 5 shows that parents of female type 1 diabetic children had less good knowledge grade than those of male children (27.7% and 31.3%, respectively). However, the difference was not statistically significant. Parents of younger type 1 diabetic children (<10 years) had less good knowledge grade than those of older children (28.5% and 30.6%, respectively). However, the difference was not statistically significant. Parents of type 1 diabetic children whose duration was four years or less had less good knowledge grade than parents whose children had a longer disease duration (28.2% and 31.6%, respectively). However, the difference was not statistically significant. Parents of children who were not hospitalized for complications of their diabetes had less good knowledge than those whose children were hospitalized (25% and 32%, respectively). However, the difference was not statistically significant. Parents of children who were hospitalized once had significantly less good knowledge grade than parents of children who were hospitalized several times (26.9% and 34.3%, respectively). However, the difference was not statistically significant. Parents of diabetic children who did not have other diabetic children had significantly less good knowledge grade than those who had other diabetic children (27% and 38.2%, respectively, $p<0.001$).

Table 1: Personal characteristics of interviewed parents of type 1 diabetic children

Personal characteristics of parents	No.	%
Interviewed parent		
• Mother	191	49.6
• Father	194	50.4
Age groups of parents		
• <30 years	49	12.7
• 30-40 years	217	56.4
• >40 years	119	30.9
Diabetic parent		
• No	313	81.3
• Yes	72	18.7
Parent's education		
• Illiterate	7	1.8
• Primary	30	7.8
• Intermediate	39	10.1
• Secondary	85	22.1
• University	224	58.2
Parent's occupation		
• Related to the healthcare field	43	11.2
• Unrelated to healthcare field	255	66.2
• Unemployed	87	22.6
Nationality		
• Saudi	372	96.6
• Non-Saudi	13	3.4
Monthly income		
• <5000 SR	68	17.7
• 5000-10000 SR	161	41.8
• >10000 SR	156	40.5

Table 2: Characteristics of type 1 diabetic children

Characteristics	No.	%
Gender		
• Male	208	54.0
• Female	177	46.0
Age groups		
• ≤10 years	189	49.1
• >10 years	196	50.9
Duration of diabetes		
• ≤4 years	227	59.0
• >4 years	158	41.0
Hospitalization for diabetes complications:	253	65.7
• Once	57	32.9
• Several times	111	67.1
Diabetic siblings	89	23.1

Table 3: Frequency and percentage of parents' correct responses regarding their knowledge about diabetes and diabetic ketoacidosis

Knowledge items	No.	%
Normal range for fasting blood sugar	157	40.8
Normal range for post-prandial blood sugar	58	15.1
Normal range for HbA1c	123	31.9
The diabetic child should go to the doctor if he/she:		
• Has repeated vomiting	144	37.4
• Has high uncontrolled blood sugar	206	53.5
• Has ketonuria	35	9.1
Causes of ketoacidosis		
• High insulin dose	169	43.9
• Hypoglycemia	189	49.1
• Low food intake	137	35.6
• Low insulin dose	178	46.2
• Severe infections	134	34.8
Symptoms and signs of ketoacidosis		
• Polyuria	302	78.4
• Severe thirst	299	77.7
• Abdominal colic	251	65.2
• Repeated vomiting	247	64.2
• Loss of weight	214	55.6
• Acetone-odor of breath	203	52.7
• Cold skin	167	43.4
• Disturbed consciousness	155	40.3
• Muscle weakness	238	61.8
Ketoacidosis among children is dangerous	289	75.1
The hospital is the place for management of ketoacidosis	351	91.2
Lab investigations for ketoacidosis		
• Assessment of blood glucose level	272	70.6
• Assessment of serum potassium level	111	28.8
• Assessment of ketonuria	232	60.3
Steps for management of ketoacidosis		
• Hospitalization	334	86.8
• Insulin administration	212	55.1
• Intravenous fluids	204	53.0
How to prevent ketoacidosis?		
• Administering the proper dose of insulin	323	83.9
• Blood sugar monitoring	317	82.3
Complications of ketoacidosis		
• Severe dehydration	262	68.1
• Coma	245	63.6
• Brain edema	87	22.6
How to avoid complications of type 1 diabetes?		
• Healthy food, exercise and proper treatment	357	92.7
• Daily blood sugar monitoring	355	92.2
• Proper insulin dose administration	317	82.3
• Assessment of ketones in urine	312	81.0
• Going to the ED in case of uncontrolled hyperglycemia	304	79.0
• Going to the ED in case of ketonuria	297	77.1

Table 4: Parents' knowledge grades according to their personal characteristics

Personal characteristics of parents	Poor		Fair		Good		P Value
	No.	%	No.	%	No.	%	
Interviewed parent							
Mother	44	23.0	82	42.9	65	34.0	
Father	102	52.6	43	22.2	49	25.3	<0.001
Age groups of parents							
<30 years	18	36.7	9	18.4	22	44.9	
30-40 years	85	39.2	67	30.9	65	30.0	
>40 years	43	36.1	49	41.2	27	22.7	0.018
Diabetic parent							
No	118	37.7	95	30.4	100	31.9	
Yes	28	38.9	30	41.7	14	19.4	0.066
Parent's education							
Illiterate	3	42.9	4	57.1	0	0.0	
Primary	11	36.7	13	43.3	6	20.0	
Intermediate	15	38.5	19	48.7	5	12.8	
Secondary	35	41.2	26	30.6	24	28.2	
University	82	36.6	63	28.1	79	35.3	0.035
Parent's occupation							
Related to healthcare field	3	7.0	12	27.9	28	65.1	
Unrelated healthcare field	115	45.1	77	30.2	63	24.7	
Unemployed	28	32.2	36	41.4	23	26.4	<0.001
Nationality							
Saudi	143	38.4	117	31.5	112	30.1	
Non-Saudi	3	23.1	8	61.5	2	15.4	0.074
Monthly income							
<5000 SR	34	50.0	25	36.8	9	13.2	
5000-10000 SR	59	36.6	51	31.7	51	31.7	
>10000 SR	53	34.0	49	31.4	54	34.6	0.021

Table 5: Parents' knowledge grades according to their diabetic children's characteristics

Personal characteristics of children	Poor		Fair		Good		P Value
	No.	%	No.	%	No.	%	
Gender							
• Male	82	39.4	61	29.3	65	31.3	
• Female	64	36.2	64	36.2	49	27.7	0.358
Age groups							
• ≤10 years	68	36.0	67	35.4	54	28.5	
• >10 years	78	39.8	58	29.6	60	30.6	0.467
Duration of diabetes							
• ≤4 years	94	41.4	69	30.4	64	28.2	
• >4 years	52	32.9	56	35.4	50	31.6	0.237
Hospitalization for diabetes complications							
• No	56	42.4	43	32.6	33	25.0	
• Yes	90	35.6	82	32.4	81	32.0	0.284
Frequency of hospitalization							
• Once	36	46.2	21	26.9	21	26.9	
• Several times	54	30.9	61	34.9	60	34.3	0.064
Diabetic siblings							
• No	129	43.6	87	29.4	80	27.0	
• Yes	17	19.1	38	42.7	34	38.2	<0.001

Discussion

Findings of the present study indicated that almost two thirds of diabetic children were previously hospitalized for complications of diabetes, mostly several times.

This finding is in accordance with that reported by Al-Hayek et al. (24), in Saudi Arabia, who found that all their adolescent type 1 diabetic patients had experienced diabetic ketoacidosis, while only 54.4% experienced one episode, 39.8% had two episodes and 5.8% had three episodes of ketoacidosis or more. In Nigeria, Onyiriuka et al. (25) reported that about three-quarters of type 1 diabetics had presented with diabetic ketoacidosis. However, lower rates were reported by Jefferies et al. (26) in New Zealand, which found that that one-quarter of type 1 diabetic children presented with diabetic ketoacidosis at their first diagnosis, while in New-Zealand, Szypowska et al. (27) found that one-quarter of type 1 diabetic children presented with DKA at their first diagnosis.

Zhong et al. (28) noted that recurrent diabetic ketoacidosis accounted for a significant portion of the hospitalizations, mainly for type 1 diabetes. Jefferies et al. (26) stated that, worldwide, 12.8–80% of type 1 diabetic patients present with diabetic ketoacidosis as their initial presentation of diabetes.

In North America, Cengiz et al. (29) reported an exponential rise of hospital admissions for ketoacidosis with increasing HbA1c among type 1 diabetic patients. Poor metabolic control was the strongest predictor of hospital admission for DKA in the study of Karges et al. (30).

Wolfsdorf et al. (31) stressed that treatment of diabetic ketoacidosis in children frequently requires hospitalization since experienced nursing staff and specialized pediatricians are highly needed.

Fazeli Farsani et al. (32) reported that worldwide incidence of ketoacidosis among type 1 diabetics ranges from 8 to 51.3 cases/1000 patient-years. However, Li et al. (33) in China, reported a higher incidence rate (i.e., 263/1,000 patient-years). This high rate has been explained by differences in national health care systems, with limited access to routine health care for type 1 diabetics and the infrequent self-monitoring of blood glucose (32).

Several epidemiological studies have reported that hospitalizations for diabetic ketoacidosis have recently increased worldwide (34). Vellanki and Umpierrez (35) explained this increased incidence of hospitalization among type 1 diabetics by the increased admissions for mild diabetic ketoacidosis.

The present study revealed that 18.7% of type 1 diabetic children's parents and 23.1% of siblings were diabetic. Moreover, more than half of type 1 diabetic children were males.

This finding reflects the strong family history among type 1 diabetes children. Parkkola et al. (36) reported that 12.2% of the children with newly diagnosed type 1 diabetes had at least one affected first-degree relative. Sipetić et al. (37) reported that risk of type 1 diabetes is significantly associated with a positive family history for type 1 diabetes.

Gale and Gillespie (38) stated that generally, populations of type 1 diabetes show a male excess, with an approximate 3:2 male:female ratio. Moreover, fathers with type 1 diabetes are more likely than affected mothers to transmit the condition to their offspring.

The present study showed that participant parents of type 1 diabetic children had suboptimal knowledge regarding diabetes and diabetic ketoacidosis. More than one-third of parents had poor knowledge, while only 29.6% had good knowledge. Their main knowledge deficits were related to normal range of fasting and post-prandial blood sugar, normal range for HbA1c, when the diabetic child should see a doctor and causes of diabetic ketoacidosis.

Similarly, in East England, Usher-Smith et al. (39) reported that half the parents of children with type 1 diabetes did not have knowledge about symptoms of diabetes prior to their child being diagnosed. It was clear that this lack of knowledge did not prompt earlier help-seeking and diagnosis. Moreover, even among knowledgeable parents, symptoms and presentation of diabetes differed from what they expected. This mismatch with their prior beliefs also appeared to delay help-seeking.

Pulungan et al. (40) stressed that lack of parental knowledge on type 1 diabetes treatment plays a major role in non-compliance, causing insulin omission or failure to routinely visit the physician for insulin adjustment.

It has been observed that diabetic ketoacidosis is decreasing in several European countries, e.g., Sweden (41) and Finland (42). This decrease was coincident with national health education programs, which aimed at increasing knowledge and awareness about diabetic ketoacidosis (9). Moreover, The Environmental Determinants of Diabetes in the Young (TEDDY) study reported a lower incidence of diabetic ketoacidosis at diagnosis when parents were made aware of the high risk of diabetes in their children (43).

Rosenbauer et al. (44) reported significant improvement in metabolic control and a simultaneous decrease in hypoglycemic events among type 1 diabetic children and adolescents. They explained that this improvement was achieved not only through the application of modern therapy methods, but also through improved education methods for the patients and their families.

Araszkiewicz et al. (45) stated that improved knowledge about diabetes and its complications is the foundation for better metabolic control among type 1 diabetic patients and is associated with decreased risk of complications.

Vanelli et al. (46) stated that raising awareness and improving knowledge through dissemination of information about diabetes mellitus could significantly reduce prevalence of diabetic ketoacidosis in type 1 diabetes mellitus. They emphasized that knowledge is one of the main factors in preventing diabetic ketoacidosis.

Therefore, Zhong et al. (28) emphasized the urgent need for health education programs to prevent diabetic ketoacidosis at new onset of diabetes and recurrent episodes of diabetic ketoacidosis. Strategies such as early screening, close follow-up of high-risk children, and education of parents and communities have been successful in prevention of diabetic ketoacidosis at onset of diabetes.

It is to be noted that the suboptimal knowledge level of parents of type 1 diabetic children in the present study possibly reflects deficient provision of health education to those parents.

Umpierrez and Kitabchi (13) reported that frequency of hospitalizations for diabetic ketoacidosis could be reduced after the implementation of diabetes education programs. Similarly, Szypowska et al. (27) emphasized that health education of patients and their guardians is essential and is considered as an effective method to decrease diabetic ketoacidosis episodes. Consequently, every consultation at a health care facility should be used ideally so that diabetic patients can get the maximum benefits from the health care providers. Moreover, information related to diabetes and diabetic ketoacidosis must be repeated at every visit.

Stefanowicz et al. (47) also stressed that health education programs for diabetic patients should be implemented as a constant, fundamental and essential component for management of diabetes during all patients' follow-up visits. It must be properly achieved in a structured manner based on a general outline that should include education at the onset of treatment and then repeated based upon an annual assessment of patients' training needs or upon their own request. The main objective of health education is to provide support toward independent management of diabetes and lifestyle modification associated with the recommended healthy diet and the appropriate physical activity.

Vellanki et al. (35) stated that prevention programs aiming at education of parents, pediatricians, and personnel at primary and secondary schools to recognize symptoms of diabetic ketoacidosis resulted in a significant decrease in the number of children presenting with diabetic ketoacidosis at initial diagnosis of diabetes.

The present study revealed that some characteristics were significantly associated with lower parents' knowledge regarding diabetes and diabetic ketoacidosis, e.g., fathers, older parents (aged >40 years), less than university educated parents, unemployed parents and those whose occupation was not healthcare-related, parents with monthly income <5000 SR had significantly less good knowledge grade than those with higher monthly income. These findings are in accordance with those reported by some other studies. Kim et al. (48) argued that, generally, knowledge of the population regarding diabetes mellitus has a positive association with their level of attained education. Rani et al. (49) reported that older age, higher socioeconomic class, and higher educational levels were associated with better knowledge among the population of rural India regarding diabetes mellitus.

In Brazil, dos Santos et al. (50) found that the frequency of correct answers tended to be higher amongst women compared to men, with statistically significant differences according to types of diabetes, symptoms of hyperglycemia, and normal blood glucose levels. Poor knowledge was related to symptoms of hyperglycemia, normal blood glucose levels, beneficial effects of physical activity on glycemia, and the increased risk of heart disease among diabetic patients.

In conclusion, most type 1 diabetic children are very frequently hospitalized for complications of diabetes, mostly more than once. Knowledge of more than one-third of parents of diabetic children about diabetic ketoacidosis is poor. Their main knowledge deficits were related to normal range of fasting and post-prandial blood sugar, normal range for HbA1c, when the diabetic child should see a doctor and causes of diabetic ketoacidosis. Some characteristics are significantly associated with lower knowledge regarding diabetes and diabetic ketoacidosis, i.e., being a father of a diabetic child, older parents, being less educated or unemployed parents, those whose occupation is not healthcare-related, having a monthly income <5000 SR, and having diabetic siblings.

Therefore, it can be recommended that health education to type 1 diabetic patients and their guardians should be fulfilled. It must be properly achieved in a structured manner based on a general outline that should include education at the onset of treatment and then repeated based upon an annual assessment of patients' training needs or upon their own request. During each consultation visit, health care providers should repeatedly offer information related to independent management of diabetes and diabetic ketoacidosis and how to identify symptoms of diabetic ketoacidosis. Areas of poor knowledge related to diabetes and diabetic ketoacidosis should be emphasized during health education sessions.

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