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Predictors and Trends of Diabetic Ketoacidosis at Diagnosis of Type 1 Diabetes Mellitus in Malaysian Children

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What is already known on this topic?

The average diabetic ketoacidosis (DKA) rate in Malaysian children with type 1 diabetes mellitus ranged between 54-75% between 2000-2010.

What this study adds?

The DKA rate has remained persistently high since the year 2000 and severe DKA comprised the largest proportion. 96% of children under five year presented in DKA. Predictive factors for DKA were age ≥5 years and misdiagnosis. There were no significant trends in the rates of children <5 years presenting in DKA nor the rates of severe DKA.

Abstract

Objective: Previous reports indicate that diabetic ketoacidosis (DKA) rates in Malaysian children with type 1 diabetes mellitus (T1DM) range between 54-75%, which is higher than most European nations. Knowledge of trends and predictors of DKA can be helpful to inform measures to lower the rates of DKA. However, this data is lacking in Malaysian children. Hence, the aim of this study was to determine the predictors and trends of DKA in Malaysian children at the initial diagnosis of T1DM.

Methods: This cross-sectional study examined demographic, clinical and biochemical data of all newly diagnosed Malaysian children aged 0-18 years with T1DM over 11 years from a single centre. Regression analyses were used to determine predictors and trends.

Results: The overall DKA rate was 73.2%, 54.9% of the DKA cases were severe. Age ≥5 years [odds ratio (OR): 12.29, 95% confidence interval (CI): 1.58, 95.58, p=0.017] and misdiagnosis (OR: 3.73, 95% CI: 1.36, 10.24 p=0.01) were significant predictors of a DKA presentation. No significant trends in the annual rates of DKA, severe DKA nor children <5 years presenting with DKA were found during study period.

Conclusion: DKA rates at initial diagnosis of T1DM in Malaysian children are high and severe DKA accounts for a notable proportion of these. Though misdiagnosis and age ≥5 years are predictors of DKA, misdiagnosis can be reduced through better awareness and education. The lack of downward trends in DKA and severe DKA highlights the urgency to develop measures to curb its rates.

Keywords: Diabetic ketoacidosis, childhood, Malaysia, type 1 diabetes, trend

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Introduction

Type 1 diabetes mellitus (T1DM) is an autoimmune condition, which peaks in children between 10-14 years of age (1). There is a wide variation in the incidence of T1DM worldwide, with higher incidence rates reported in Northern Europe as compared to Western Africa and South America (2,3). Within Asia, childhood T1DM rates have been rising in several regions, including Thailand, Hong Kong and Indonesia (4,5,6,7). In Malaysia, T1DM is the most common type of childhood diabetes, accounting for >69% of all diabetes mellitus cases. The International Diabetes Federation World Diabetes Atlas reported that in Malaysia in 2021, the estimated number of new cases of T1DM in the 0-19 age group was 100 and that the total number of cases was 1000 (5). A prior study by Hong et al. (8,9), showed that diabetic ketoacidosis (DKA) at diagnosis occurs in 65% of paediatric T1DM cases in Malaysia; however, analysis of the risk factors for DKA nor its trends have been conducted.

Paediatric DKA (pDKA) is a severe and potentially fatal presentation of T1DM that is characterised by hyperglycaemia, dehydration, ketosis and acidosis (10). Early recognition and management of pDKA are essential for reducing mortality, morbidity and financial burden. The incidence of pDKA at initial diagnosis of T1DM varies between countries, with lower rates reported in Northern Europe and higher rates in other regions, such as the United Arab Emirates, Saudi Arabia, Kuwait, Malaysia and Indonesia (11,12,13,14). This variation may be explained by several contributing factors, including age, socioeconomic status, delayed diagnosis or misdiagnosis, poor public awareness, educational background of the parents and the background frequency of paediatric T1DM in the population (15,16,17).

Trend analysis of pDKA at initial diagnosis of T1DM in children and determination of its associated risk factors has been conducted in several countries. Data from such studies are important because these may be informative in terms of developing interventions to reduce the incidence of pDKA. A recent epidemiological study from Thailand has reported that there has been a reduction in pDKA over the 20-year study period (4). New Zealand and Indonesia, on the other hand, have reported a sustained high incidence of pDKA at initial diagnosis or a rise in the incidence over the respective study periods (6,18). In Malaysia, Hong et al. (9), reported that the rate of pDKA at initial diagnosis of T1DM in 490 children from multiple centres between 2000-2010 varied between 54-75% of new cases. Though they reported that pDKA rates were mostly high throughout the study period, there was no evaluation of severe DKA rates nor a determination of the predictors of pDKA. Furthermore, data on trends in pDKA in Malaysian children with T1DM is limited since the study by Hong et al. (9) Nonetheless, their data highlighted the high rates of pDKA which is undoubtedly associated with significant morbidity and financial costs (19,20). In view of the burden associated with DKA, it is important that collective efforts are made to reduce the incidence of pDKA. Hence the objective of this study was to determine the predictors of pDKA at initial diagnosis of T1DM and to describe its trends in Malaysian children over an 11-year period.

Experimental Subjects

All newly diagnosed cases of paediatric T1DM in Malaysian children who were managed at Universiti Malaya Medical Centre (UMMC) between January 1st 2010 to December 31st 2020 were included. A diagnosis of T1DM and/or DKA was made in accordance with the International Society for Pediatric and Adolescent Diabetes (ISPAD) guideline for the year in which the diagnosis was made. Body mass index status was categorised using the World Health Organization Z-score cut-offs (21). Non-T1DM diabetes, non-Malaysians and subjects with incomplete data concerning DKA at diagnosis were excluded from the analysis.

Methods

A cross-sectional study was conducted using retrospective data that was extracted from the hospital electronic medical record system and letters from the referring physicians. Details on age, gender, ethnicity, DKA, misdiagnosis, anthropometry, intensive care admission and inpatient stay were obtained. DKA was defined as children presenting with hyperglycaemia (blood glucose >11 mmol/L) acidosis with a venous pH <7.3 or bicarbonate <15 mmol/L and ketonaemia or ketonuria. Mild cases were those with either venous pH <7.3 or bicarbonate <15 mmol/L, moderate cases were those with either a venous pH <7.2 or bicarbonate <10 mmol/L and severe were those with a venous pH <7.1 or bicarbonate <5 mmol/L. These definitions were in accordance with the ISPAD relevant to the year the diagnosis was made in. Misdiagnosis was defined as defined as any case that was given a diagnosis *other than diabetes* mellitus by a physician at UMMC. UMMC has an electronic medical record system with a proforma for in-patient admission clerking, into which details on the presenting history are entered on admission. All new diagnoses of paediatric T1DM are always admitted as inpatients, irrespective of whether they present in DKA or not, and all are reviewed by the Paediatric Endocrinology team.

This study was approved by the UMMC Institutional Ethics Board MREC ID no: 2019325-7251, date: 29.04.2019.

Statistical Analysis

The Statistical Package for Social Sciences (SPSS) for Windows, version 28.0 (SPSS Corp., Chicago, IL, USA) was used for statistical analysis. Demographic, clinical and biochemical data were analysed using descriptive statistics; mean ± standrad deviation for continuous variables and frequencies or percentages for categorical variables. Comparison of DKA and non-DKA groups were conducted using independent Student's t-test and Pearson's chi-squared test (χ^2) for continuous and categorical variables respectively. A logistic regression model was used to determine the predictors of DKA at initial diagnosis of T1DM. Gender and ethnicity were adjusted for as potential confounders. The odds ratios (OR) along with the respective 95% confidence intervals (CIs) were reported. The trend in DKA incidence rates over the 11-year period was analysed using Poisson regression. A two-sided 5% significance level was used for all statistical inferences.

Results

Demographic, Clinical and Biochemical Characteristics of the Overall Cohort

A total of 127 children aged 0-18 years with T1DM were identified during the 11-year study period. Males constituted 46.5% (n = 59) and the mean age of the cohort was 8.06 ± 3.78 years. Children ≥5 years comprised 78.7% (n = 100) of the whole cohort. The predominant ethnic group was Malay, 39.4 % (n = 50). The overall rate of DKA at presentation was 73.2% (n = 93) of which more than half were severe DKA (Table 1).

Diabetic Ketoacidosis vs. Non-diabetic Ketoacidosis Groups

The DKA group was significantly younger at diagnosis (7.64 ± 4.03 vs. 9.19 ± 2.77 years, p = 0.03) with 72.6% (n = 69) of pDKA group being represented by the ≥5 years age category (p = 0.003). Notably, 26 of 27 (96%) new diagnoses of T1DM presenting < 5 years of age had DKA. Misdiagnosis rates were significantly higher in the DKA group (43% vs. 17.6%, p = 0.004), as were pediatric intensive care units (PICU) admission rates (57.1% vs. 12%, p < 0.001) and the length of hospital stay (7.72 vs. 5.90, p = 0.01) (Table 2). Comparison of the three categories of severity of DKA showed that the severe DKA group had a significantly higher rate of admission to PICU (p = 0.001) (Table 3).

Predictors of Paediatric Diabetic Ketoacidosis: Logistic Regression Analysis

Binary logistic regression modelling, using DKA and non-DKA groups as the dependent variables, showed that age was a significant predictor of pDKA with ≥5 years age group (OR: 12.29, 95% CI: 1.58, 95.85, p = 0.017) was approximately 12 times more likely to have DKA. Similarly, misdiagnosis was determined to be a significant predictor of DKA (OR: 3.73, 95% CI: 1.36, 10.24, p = 0.01).

Trends in Diabetic Ketoacidosis Over the Decade

The annual rate of DKA varied from between 20% and peaking at 85% in 2015 (Figure 1). The rates of severe DKA fluctuated between 28.6% to 100% over the 11-year study period. In terms of age group, the percentage of children < 5 years of age who presented in DKA at the initial diagnosis of T1DM, varied from 0-46%. The lowest rates were in 2011-2012 and the highest in 2017.

Poisson regression analysis demonstrated that there were no significant increasing nor decreasing trends in the annual

Table 1. Demographic and clinical characteristics at diagnosis of T1DM

Age at diagnosis (years)	
Mean (± SD)	8.06 (± 3.78)
Age group, n (%)	
< 5 years	27 (21.3)
≥5 years	100 (78.7)
Gender, n (%)	
Male	59 (46.5)
Female	68 (53.5)
Ethnicity, n (%)	
Malay	50 (39.4)
Chinese	42 (33.1)
Indian	35 (27.6)
BMI status, n (%)[¥]	
Underweight	19 (20.7)
Normal weight	61 (66.3)
Overweight or obese	12 (13.0)
Blood glucose level (mmol/L)[#]	
Mean (± SD)	27.13 (9.03)
HbA1c (IFCC) at diagnosis (mmol/mol)[#]	
Mean (± SD)	115 (5)
Presence of DKA, n (%)	
DKA	93 (73.2)
Non-DKA	34 (26.8)
Severity of DKA, n (%)[*]	
Mild	19 (23.2)
Moderate	18 (22.0)
Severe	45 (54.9)

Data is presented as mean (± SD) for continuous variables (age, and biochemical parameters) and as a frequency and percentage for categorical variable. All percentages were calculated accounting for missing data.
[¥]Data was analysed for n = 92.
[#]Data was analysed for n = 107.
[*]Data was analysed for n = 82.
[$]Data was analysed for n = 50.
SD: standard deviation, DKA: diabetic ketoacidosis, T1DM: type 1 diabetes mellitus, IFCC: International Federation of Clinical Chemistry and Laboratory Medicine

Table 2. A comparison of DKA vs. non-DKA cases

	DKA (n = 93)	Non-DKA (n = 34)	p value
Age (year)			
Mean age (± SD)	7.65 (4.03)	9.19 (2.77)	**0.03**
< 5 years	26 (27.4%)	1 (2.9%)	**0.003**
≥5 years	67 (72.6%)	33 (97.1%)	
Gender			
Male	43 (46.2%)	16 (47.1%)	0.93
Female	50 (53.8%)	18 (52.9%)	
Ethnicity			
Malay	41 (44.1%)	9 (26.5%)	0.16
Chinese	27 (29.0%)	15 (44.1%)	
Indian	25 (26.9%)	10 (29.4%)	
BMI status[¥]			
Underweight	18 (26.5%)	1 (4.2%)	0.07
Normal weight	42 (61.8%)	19 (79.2%)	
Overweight or obese	8 (11.8%)	4 (16.7%)	
HCP contact prior to diagnosis[*]			
Less than 2	55 (70.5%)	23 (85.2%)	0.13
2 or more	23 (29.5%)	4 (14.8%)	
Misdiagnoses, n (%)[**]			
Misdiagnosis	40 (43.0%)	6 (17.6%)	**0.004**
Biochemical parameters			
Mean pH (± SD)	7.07 (0.16)	7.33 (0.15)	**< 0.001**
Mean bicarbonate (mmol/l) (± SD)	8.48 (4.77)	18.64 (5.74)	**< 0.001**
Mean glucose (mmol/l) (± SD)	28.47 (8.56)	23.26 (9.39)	**0.01**
Mean HbA1c, IFCC (mmol/mol) (± SD)	115 (7.0)	115 (1.0)	**0.89**
Current HbA1c, IFCC (mmol/mol)	80 (3)	77 (5.0)	**0.68**
PICU admission, n (%)[#]			
Yes	40 (57.1)	3 (12.0)	**< 0.001**
No	26 (37.1)	22 (88.0)	
Length of hospital stay, days (± SD)	7.72 (2.74)	5.90 (2.22)	**0.01**

Data is presented as mean (± SD) for continuous variables (age, biochemical parameters, and length of hospital stay) and as a frequency and percentage for categorical variable. Comparisons between T1DM participants with DKA versus those who did not have DKA used independent t-test for continuous variables and χ^2 test between categorical variables. Significant findings appear in bold.
[¥]Data was analysed for n = 92.
[*]Data was analysed for n = 105.
[**]Data was analysed for n = 46.
[#]Data was analysed for n = 91.
SD: standard deviation, DKA: diabetic ketoacidosis, T1DM: type 1 diabetes mellitus, IFCC: International Federation of Clinical Chemistry and Laboratory Medicine, PICU: pediatric intensive care units, BMI: body mass index

rates of DKA (p = 0.09), rates of severe DKA (p = 0.64) nor the rates of younger age children (< 5 years) presenting in DKA (p = 0.70) at initial diagnosis, over the 11 years.

Discussion

This single centre study over 11 years showed an overall pDKA rate at initial diagnosis of T1DM in Malaysian children of 73.2%. A disproportionately large percentage of the cases were severe DKA (54.9%). Children presenting in DKA were significantly younger than those presenting with new T1DM but without DKA. The DKA group was more likely to be misdiagnosed and require PICU admission with a longer length of inpatient stay. In particular, PICU admission rates were significantly higher in severe DKA cases. Logistic regression analysis demonstrated that children ≥5 years and misdiagnosis were the two main predictors of pDKA in this cohort. No significant increasing nor decreasing trends were demonstrated in the incidence of pDKA, rates of severe DKA, nor the rates of young children (< 5 years) presenting in DKA at diagnosis over the 11-year study period.

Rates of Diabetic Ketoacidosis

This is the second study to investigate the annual incidence of pDKA in Malaysian children at initial diagnosis of T1DM. A previous multicentre study by Hong et al. (9), reported an overall pDKA rate of 64.7%. Over their 10-year study period, the pDKA rate fluctuated between 54.5% and 75%. The mean age of their cohort presenting in DKA at diagnosis was 7.2 years and 70.4% of their < 5-year-old cohort presented in DKA. Gender and ethnicity were not different between the DKA and non-DKA groups. In the context of the study by Hong et al. (9), our study highlights that DKA rates in Malaysian children have remained high since 2010 and have failed to diminish over the last 20 years. Though rates of DKA in the current 11-year study also fluctuated, it never fell below 20%. Furthermore, a finding that was not previously reported is that this high burden of DKA is characterized by a high rate of severe DKA cases. Interestingly, over the last 20 years, the average age of pDKA has remained stable, 7.2 year in the earlier study and 7.65 year in the current study. However, though the mean age of children presenting with DKA is represented by the "school-going" age group, it is important to note that the frequency of DKA was higher in children < 5 years; 70.4% in the study of Hong et al. (9) compared with 96.3% in the current study.

Malaysian rates of pDKA are significantly higher than several Northern European countries but comparable to those reported within the Association of Southeast Asian Nations (ASEAN) region (22,23,24,25,26). We hypothesize that the sustained high rates of pDKA, are related to several factors.

Table 3. Demographics at presentation of children with DKA at diagnosis of T1DM according to DKA severity

	Mild DKA (n = 19)	Moderate DKA (n = 18)	Severe DKA (n = 45)	p value
Age at diagnosis (years)	9.04 (4.01)	7.42 (3.72)	7.32 (4.20)	0.29
Gender (males) %	47.4	44.4	46.7	0.99
Ethnicity %				
Malay	47.4	38.9	46.7	0.69
Chinese	26.3	44.4	26.7	
Indian	26.3	16.7	26.7	
BMI SDS¥	-1.37 (1.77)	-1.19 (1.62)	-0.81 (1.83)	0.61
Biochemical parameters, mean (± SD)				
pH	7.26 (0.05)	7.16 (0.03)	6.95 (0.10)	**< 0.001**
Bicarbonate (mmol/l)	13.18 (4.22)	10.22 (2.97)	5.39 (1.93)	**< 0.001**
Glucose (mmol/l)	26.31 (7.63)	28.21 (9.25)	29.30 (8.78)	0.47
HbA1c, IFCC (mmol/mol)	129 (9.0)	111 (0)	113 (5.0)	0.10
PICU admission, n (%)¥	2 (15.4)	3 (25.0)	32 (88.9)	**< 0.001**
Length of hospital stay, days, mean (± SD)	6.46 (3.37)	7.47 (2.23)	8.31 (2.65)	0.11

Data is presented as mean (± SD) for continuous variables (age, biochemical parameters, and length of hospital stay) and as a frequency and percentage for categorical variable. Comparisons between DKA severity groups used independent t-test for continuous variables and χ^2 test between categorical variables. Significant findings appear in bold.

¥Data was analysed for n = 61.

SDS: standard deviation (SD) score, DKA: diabetic ketoacidosis, BMI: body mass index, T1DM: type 1 diabetes mellitus, IFCC: International Federation of Clinical Chemistry and Laboratory Medicine, PICU: pediatric intensive care units

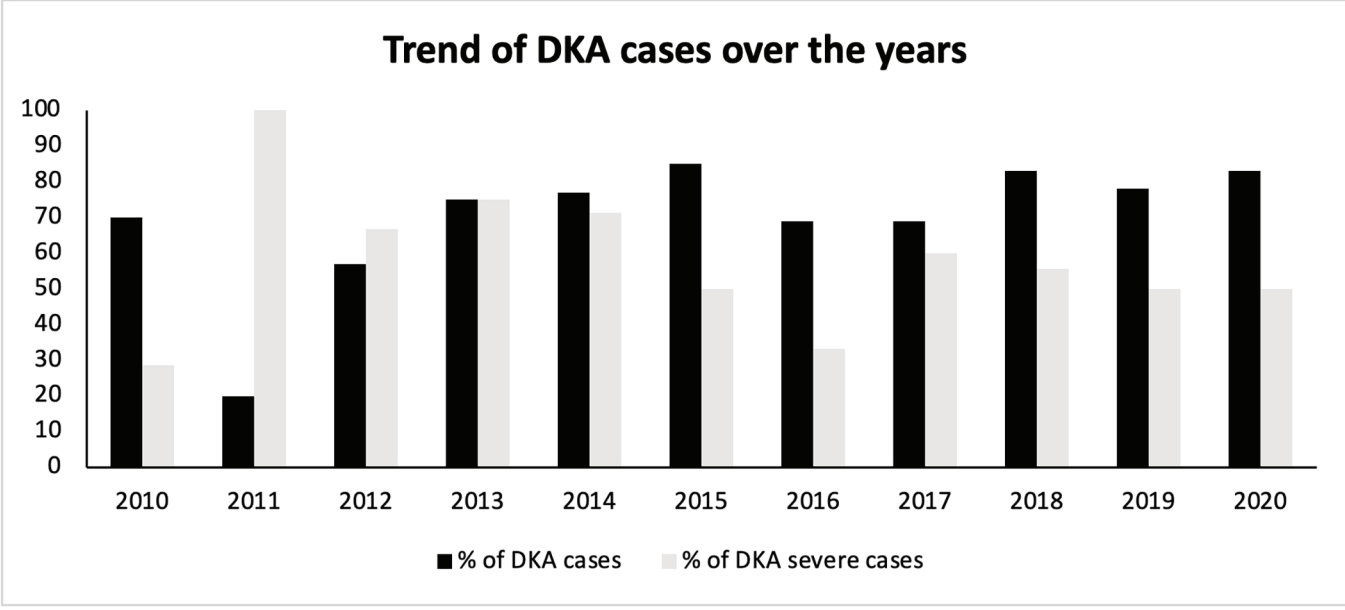

Figure 1. Percentage distribution of total and severe DKA cases at initial diagnosis of T1DM from 2010 to 2020 (n = 127)

DKA: diabetic ketoacidosis, T1DM: type 1 diabetes mellitus

These may include a lower background prevalence rate of T1DM in Malaysian children and potentially a reduced awareness that T1DM is a disease of childhood amongst the general public as well as differences in healthcare system structures. However, though these factors have been shown to correlate with high DKA rates in other countries, they have yet to be studied in the Malaysian context as potential risk factors for DKA and would require multicentre prospective studies (14,15).

Predictors of Diabetic Ketoacidosis at Initial Diagnosis of Type 1 Diabetes Mellitus

This study showed that the predictors of DKA at initial diagnosis of T1DM in Malaysian children were age ≥5 years and misdiagnosis. The study by Hong et al. (9), did show that school-aged children comprised the largest proportion of children presenting in DKA. This study expands on these earlier findings by showing that age ≥5 years is indeed a

predictor of DKA at initial diagnosis of T1DM. This finding is unexpected and contrary to other studies, which report that age <5 years is a risk factor for DKA, for the reasons that younger children present with less discernible symptoms and they lack the eloquence to explain their symptoms which may lead to diagnostic delays and errors (15,16). It is possible that our finding is influenced by the fact that a large proportion of our cohort (78.7%) were of school-going age, which is not dissimilar from the cohort in the study by Hong et al. (9). Nonetheless, both studies do demonstrate that the incidence of DKA in the <5-year-old age group was comparably higher than in older children, and so should still remain a cause for concern.

Misdiagnosis was another predictor of pDKA, increasing the risk of presenting in DKA by 3.5-fold which is in line with prior studies which have reported that misdiagnosis is a risk factor for DKA (15,16). However, unlike age, misdiagnosis is a modifiable factor for pDKA, suggesting that future efforts should focus on improving the diagnostic accuracy of pDKA by doctors through continuing professional development and implementing the recent ISPAD 2022 DKA guideline, which recommends that all children who present with breathlessness or vomiting and abdominal pain without diarrhoea should have a finger prick glucose performed as these signs and syptoms may herald DKA (27).

Trends

This study did not demonstrate any significant increasing nor decreasing trends in the annual incidence of DKA at diagnosis. However, it is important to note that the annual rates of DKA never fell below 20%. New Zealand and Austria have also reported that the incidence of pDKA has remained stable over a period of time (13,18) and the SEARCH study in the US, showed that the rates of pDKA with T1DM between 2002-2010 were sustainedly high without any reprieve (28). Within the ASEAN region, Thailand has shown that the rates of pDKA have been reducing (29).

The trends in the annual rates of severe DKA in this study were also not significant, but never fell below 30%. These findings are not unlike what was reported by a paediatrics DKA study from New Zealand which showed high rates of severe DKA that fluctuated between 10-40% over the 15-year study period (18). On the other hand, a study from China reported that their rates of severe DKA had increased in the younger age groups (29).

The proportion of children <5 years presenting in DKA at their initial diagnosis of T1DM did not demonstrate any significant trends but fluctuated between 0-46% over the 11 years. There were some years where there were no DKA presentations in <5 year old children, for the reason that only children ≥5 years were diagnosed with T1DM in those years. This is contrary to epidemiological data from New Zealand, Italy and Finland which show that rates of DKA in children <5 year are increasing over time (12,18,23,30). This result may be explained by the fact that Malaysian children with T1DM presenting in DKA are predominantly represented by the ≥5 year age group.

The wide variation in trends of pDKA between nations may be related to a multitude of factors, such as differences in the local prevalence of T1DM and public awareness of childhood T1DM, amongst others. A study conducted in New Zealand has demonstrated that in a group of 263 children the factors which contributed to an increased risk of DKA were reduced family awareness, prolonged delay in laboratory testing and a low level of health care professional suspicion for T1DM (31). Thus, preventing a DKA presentation at initial diagnosis of T1DM requires several key components which include: a) early recognition of symptoms by the parents and child; b) clinical suspicion of diabetes mellitus by the healthcare professional; and c) easy access to a medical professional with the appropriate point of care testing to diagnose diabetes mellitus. These three elements rely on public awareness of diabetes mellitus as well as healthcare professional knowledge about the clinical presentation and diagnosis of paediatric diabetes mellitus and the accessibility to basic tests to confirm the diagnosis.

Malaysia is a low-middle income nation within the ASEAN region that has a well-supported public healthcare system and has undergone significant advances in infrastructure over the past several decades. In relation to childhood T1DM, several measures are already in place to facilitate a timely diagnosis. For instance, point of care testing is readily available for hospital-based healthcare professionals to diagnose hyperglycaemia, ketonaemia and acidosis in children suspected to have T1DM or DKA. Training of hospital doctors within the public sector on the updated versions of the National Clinical Practice Guidelines (CPG) on childhood T1DM take place with every iteration of the CPG. Educational sessions are also conducted by the National Paediatric Endocrine Society (Malaysian Paediatric Endocrine & Diabetes Group) for trainee paediatricians and family medicine doctors. Furthermore, the National Diabetes Institute of Malaysia and Diabetes Malaysia are instrumental in supporting people with diabetes and disseminating information about diabetes to the general public through their websites and magazines. The recently launched "Hello Type 1" by Action for Diabetes (A4D) for the Malaysian population is a website aimed at raising awareness about T1DM in the local language of Bahasa Melayu (32). Despite these efforts, rates of pDKA have remained high. However,

most of these measures have been in effect only over the last few years.

As such, future efforts should include research to understand the level of awareness of the general public and healthcare professionals about the clinical presentation of T1DM in children, in tandem with measures to raise public awareness about childhood diabetes and DKA, which has been shown to be beneficial in reducing rates of DKA in the UK, with the 4 T's campaign, and the Parma campaign in Italy (17,33). Regular continuous medical education about paediatric diabetes mellitus and DKA for primary care and hospital professionals may also help to improve diagnostic accuracy.

Study Limitations

A major limitation of this study is that it was retrospective, from a single centre and that it served an urban catchment area which is home to pockets of affluence and a highly educated population. This region is also home to a large concentration of paediatric endocrinologists and tertiary paediatric centres with dedicated PICUs which often receive referrals for severe DKA. These limitations may inflate the rates of severe DKA and PICU usage in this study. Future studies should include multiple centres from different regions of Malaysia, so that regional differences, risk factors and trends may be evaluated.

Conclusion

In summary, this study demonstrated that the incidence of pDKA at initial diagnosis of T1DM in Malaysian children has remained high over the 11-year study period. Severe DKA rates comprise a significant burden of the cases and has not reduced over the 11 years. Age >5 years and misdiagnosis emerged as two predictors of pDKA, of which misdiagnosis is a modifiable risk factor. Measures to reduce DKA rates need to focus on raising public awareness and physician awareness about T1DM and DKA in children. Future research should gather data on relevant socioeconomic factors which could influence a DKA presentation. The data should also be from multiple centres or a national registry to determine the true national rate of pDKA and to compare regional differences. This data could assist in developing needs-based strategies to curb the rates of DKA throughout the nation by implementing cost-effective methods for resource allocation.

Ethics

Ethics Committee Approval: This study was approved by the Universiti Malaya Medical Centre Institutional Ethics Board MREC ID no: 2019325-7251, date: 29.04.2019.

Informed Consent: Retrospective study.

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Footnotes

Authorship Contributions

Surgical and Medical Practices: Meenal Mavinkurve, Muhammad Yazid Bin Jalaludin, Nurshadia Samingan, Azriyanti Anuar Zaini, Concept: Azriyanti Anuar Zaini, Design: Meenal Mavinkurve, Nurul Hanis Ramzi, Azriyanti Anuar Zaini, Data Collection or Processing: Meenal Mavinkurve, Azriyanti Anuar Zaini, Analysis or Interpretation: Nurul Hanis Ramzi, Muhammad Yazid Bin Jalaludin, Azriyanti Anuar Zaini, Literature Search: Meenal Mavinkurve, Muhammad Yazid Bin Jalaludin, Azriyanti Anuar Zaini, Writing: Meenal Mavinkurve, Nurul Hanis Ramzi, Muhammad Yazid Bin Jalaludin, Nurshadia Samingan, Azriyanti Anuar Zaini.

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