**DOI: 10.4274/jcrpe.galenos.2024.2024-6-4**

**Research Article**

# Hospital Admission for Diabetic Ketoacidosis in Thai Children and Adolescents with Type 1 Diabetes: A National Study during 2015-2019

**Wankanit S et al. Diabetic Ketoacidosis in Thai Youth**

Somboon Wankanit[1], Kaewjai Thepsuthammarat[2], Preamrudee Poomthavorn[1], Taninee Sahakitrungruang[3], Pat Mahachoklertwattana[1]
on behalf of the Thai Society for Pediatric Endocrinology
[1]Department of Pediatrics, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand
[2]Epidemiology Unit, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand
[3]Department of Pediatrics, Faculty of Medicine, Chulalongkorn University, Bangkok, Thailand

**What is already known on this topic?**
Despite a globally increasing incidence of pediatric type 1 diabetes (T1D), the incidence of hospitalization for diabetic ketoacidosis (DKA), a life-threatening yet preventable complication of T1D, varies among countries. Understanding the incidence trend of DKA admission could strengthen the preventive measure of DKA.

**What this study adds?**
The incidence of T1D and DKA admissions in Thailand increased progressively during 2015-2019. School-aged children, adolescents, females, and those residing in the Northeast area were at increased risk for DKA admission. This study underscores the importance of diabetic care among Thai youth with T1D, particularly for those with higher risks.

**Abstract**
**Objective:** To study the national incidence of admission for diabetic ketoacidosis (DKA) in Thai children and adolescents with type 1 diabetes (T1D) and characterize risk factors for DKA admission.
**Methods:** Admission records of children and adolescents with T1D during the years 2015-2019 were retrieved from the Thai health coverage system of all schemes. Hospitalization was categorized according to patients' age groups (<1, 1-5, 6-12 and 13-17 years), sex and geographical regions (Bangkok, Central, Northeast, North and South). DKA admission incidence and rate were calculated and compared among subgroups.
**Results:** The annual incidences of T1D and DKA admissions progressively increased over the study period (T1D: 12.0 to 15.0, $p<0.001$ and DKA: 4.8 to 7.3 per 100,000 child-years, $p<0.001$). About half of DKA admissions (52%) were recurrent episodes. DKA admission rate was 1.49 admissions/patient. The incidence of DKA admission was greatest in individuals aged 13-17 years (13-17 years: 10.3; 6-12 years: 6.3; 1-5 years: 1.7; and <1 year: 0.6 per 100,000 child-years, $p<0.001$). DKA admission incidence was greater in females than males (7.6 vs. 4.3 per 100,000 child-years, $p<0.001$). Among 5 geographical regions, greatest percentage of recurrent DKA (57%), rate of increased annual incidence of DKA admission (3.8 to 7.8 per 100,000 child-years), and DKA admission rate (1.64 admissions/patient) were found in the Northeast region.
**Conclusions:** During the years 2015-2019, rising annual incidences of T1D and DKA admissions among Thai youth were observed. Individuals older than 6 years, being females, and resided in the Northeast region had higher risk for DKA hospitalization.
**Keywords:** Diabetic ketoacidosis, type 1 diabetes, hospitalization, children, adolescent

Pat Mahachoklertwattana, M.D., Department of Pediatrics, Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok 10400, Thailand
pat.mah@mahidol.ac.th
+662 201 1394
0000-0002-5670-2963
07.06.2024
10.07.2024

Published: 07.08.2024

## Introduction
Diabetic ketoacidosis (DKA) is a life-threatening complication that occurs mainly in patients with type 1 diabetes (T1D). DKA is a common manifestation at the initial diagnosis of T1D in children and adolescents, with incidence varying from 13% to 80% (1). The worldwide incidence of T1D in children and adolescents has dramatically increased during the last 20 years, and nowadays, over 100,000 children develop T1D annually (2). Unlike the rising trend of T1D, hospitalization for DKA differs among countries. The incidence of DKA admission increases in the United States of America (USA)

and Canada (3,4) but decreases in the Netherlands, Italy and Korea (5–7), whereas it remains stable in Germany and China (8,9). This diversity might be due to international variations in the recurrent DKA rate of individuals with established T1D, accessibility to the healthcare system, and early recognition of hyperglycemia and DKA (1,5,6).

In parallel with the global trend, the incidence of T1D in Thai children and adolescents rose from 0.14 in 1984 to 0.6 per 100,000 person-years in 2014 (10,11). A previous nationwide population-based study demonstrated a decreasing trend of DKA incidence in Thailand during the years 2015-2020. However, the DKA incidence was calculated per the number of youth with T1D, not the total population (12). That study also excluded recurrent DKA admissions. Additionally, only data from the Universal Health Coverage Scheme was analyzed (12), despite the fact that the Thai health coverage system consists of 3 public insurance programs, including the Universal Health Coverage Scheme, the Social Health Insurance, and the Civil Servant Medical Benefit Scheme (13). As a result, national data focusing specifically on the incidence of DKA admission and its secular trends in Thai children and adolescents with T1D remain unavailable. Recent studies revealed increased risk factors for DKA development in patients who had limited access to medical services and delayed recognition of hyperglycemia (1,14). Despite having national coverage, access to health care services is limited, particularly in rural areas where public transportations are unreachable and travel expenses are unaffordable among local low-socioeconomic populations (15,16). Moreover, the cost of the testing strip for self-monitoring blood glucose (SMBG) is currently not covered by most insurances (17). These factors might cause a delay in detection of hyperglycemia and thus DKA.

DKA is primarily preventable, while the cost of DKA treatment is high (18). Understanding the trend of DKA admission, individuals who are vulnerable to DKA development, and consequences of DKA is essential for implementing the national preventive strategy of DKA. Therefore, this study aimed to describe the national trend of pediatric DKA hospitalization and identify characteristics of T1D youth who had higher risks for DKA admission.

**Methods**

*Study population and data collection*

We retrospectively retrieved the admission data of T1D and DKA between the years 2015 and 2019 from databases of the Universal Health Coverage Scheme, the Social Health Insurance, and the Civil Servant Medical Benefit Scheme. Inclusion criteria were hospital admissions of children and adolescents aged under 18 years who had T1D and DKA diagnosis using the International Code of Diseases (ICD)-10 of E10 and E10.1, respectively. Exclusion criteria were admissions of diabetic patients with ICD-10s other than E10. Duplicated DKA admissions of the same patients over the study period were labelled as recurrent DKA episodes. However, among the first-recorded DKA admissions, we could not distinguish DKA in individuals with newly-diagnosed diabetes from those with known diabetes due to the lack of a specific ICD-10 code. Characteristics including patient age and sex, hospital level and region, climate season, comorbidity, and discharge status were collected. Age ranges of the patients were <1, 1-5, 6-12, and 13-17 years. The hospital level included primary, secondary, tertiary, and private hospitals. The hospital region was determined based on five geographical areas of Thailand: Bangkok, Central, Northeast, North, and South. According to the data of the Thai Meteorological Department, the climate consists of three seasons, including summer, rains, and winter (19). We reported the groups of comorbidities according to ICD-10 classification, and infectious diseases were further categorized into organ systems.

The study was approved by the Ethics Committee on Human Research of the Faculty of Medicine Ramathibodi Hospital, Mahidol University, Bangkok, Thailand (MURA2024/136) and conformed to the provisions of the Declaration of Helsinki. Informed consent was not obtained from the patients because the data were anonymous and were extracted from the health care schemes with permission.

*Hospitalization parameters and statistical analysis*

The parameters of hospitalization are as follows.

- Incidence of hospital admission for T1D or DKA (per 100,000 child-years) =

The number of T1D or DKA admissions x 100,000 / Total population

- The percentage of DKA admission among patients with T1D (%) =

The number of DKA admissions x 100 / The number of T1D admissions

- The admission rate of DKA (admissions/patient) =

The number of DKA admissions / The number of patients admitted for DKA

- The mortality rate of DKA (%) = The number of deceased patients admitted for DKA x 100 / The number of DKA admissions

The IBM SPSS Statistics for Windows (version 24.0; IBM Corp. Armonk, NY, USA), and RStudio (R version 4.2.3; RStudio Inc, Vienna, Austria) were used for statistical analysis. Datasets were compared using the Chi-squared test. A *p*-value of less than 0.05 was considered statistical significance.

**Results**

*Overall pediatric hospitalization for T1D and DKA*

Of 64,677,608 child-years, 8,708 admissions from individuals with T1D (13.5 per 100,000 child-years) and 3,846 admissions from individuals with DKA (5.9 per 100,000 child-years) were recorded (Tables 1 and 2). DKA was the main indication (44%) of hospital admission among patients with T1D. The admission rates of T1D and DKA were 1.66 and 1.49 admissions/patient, respectively. The majority of the hospitalized patients with T1D were individuals aged 13-17 years (50%), female (60%), and those residing in the Northeast region (35%) (Table 1). Among DKA hospitalizations, 2007 (52%) were recurrent episodes, and 226 (5.9%) were identified referrals. The majority of patients with DKA were admitted to tertiary (48%) and secondary hospitals (43%), whereas the remaining patients were admitted to primary (6%) and private hospitals (3%). In addition, most DKA admissions occurred in rainy season (mid-May to mid-October, 40%) and winter (mid-October to mid-February, 34%), while 26% were observed in summer (mid-February to mid-May).

*The trend of DKA admission during the study period*

The annual incidence of T1D admission rose from 12.0 in 2015 to 15.0 per 100,000 child-years in 2019 ($p$<0.001) (Figure 1). Likewise, the respective annual incidences of DKA admission increased from 4.8 to 7.3 per 100,000 child-years ($p$<0.001). Following these findings, the respective percentages of DKA admission among T1D hospitalization increased progressively from 40% to 49%

($p$<0.001) (Figure 2). Despite overall increases in the incidence and percentage of DKA admission, the mortality rate of DKA admission reduced from 2.4% to 1.2% ($p$ = 0.06). The median (interquartile range) length of hospital stay for DKA was 5 (3, 9) days, without significant change throughout the study.

*DKA admissions according to age group, sex and region*

The majority of pediatric DKA admissions in this study were patients of the age groups of 13-17 (50%) and 6-12 years (42%) (Table 2). Accordingly, the highest incidence of DKA admission was identified in individuals aged 13-17 years (10.3 per 100,000 child-years), and it was followed by that of children aged 6-12 years (6.3 per 100,000 child-years). Recurrent DKA episodes frequently occurred in patients aged 13-17 years (57%) and those aged 6-12 years (51%). The annual incidences of DKA admission in these two groups increased from the year 2015 to 2019 [13-17 years: 9.0 to 12.7 (↑41%); 6-12 years: 4.6 to 7.8 (↑68%) per 100,000 child-years]. The percentages of DKA admission were 46% in individuals aged 6-12 years and 44% in those aged 13-17 years. Individuals aged 6-12 years also had the highest mean DKA admission rate (1.55 admissions/patient).

Regarding sex predominance, the majority of individuals admitted for DKA were female (63%). Compared to males, females had higher incidence of DKA admission (7.6 vs. 4.3 per 100,000 child-years), percentage of DKA admission (46% vs. 41%), percentage of recurrent DKA events (55% vs. 47%), and DKA admission rate (1.56 vs. 1.39 admissions/patient) (Table 2). Furthermore, the annual incidences of DKA admission from 2015 to 2019 increased more pronouncedly in females than males [5.9 to 9.5 (↑63%) vs. 3.8 to 5.2 (↑39%) per 100,000 child-years].

Among 5 geographical regions, Bangkok had the highest incidence of DKA admission (9.1 per 100,000 child-years) but the lowest DKA admission rate (1.31 admissions/patient) (Table 2). The peak percentage of DKA admission was in the Central region (52%). Recurrent DKA events most frequently occurred in the Northeast region (57%). Compared with other regions, the Northeast area also had the maximum increase in annual incidence of DKA admission from 2015 to 2019 [Northeast: 3.8 to 7.8 (↑108%), North: 3.1 to 5.0 (↑62%), South: 4.3 to 6.2 (↑44%), Central: 6.5 to 8.2 (↑25%), Bangkok: 8.3 to 9.6 (↑16%) per 100,000 child-years]. In addition, the highest DKA admission rate was observed in the Northeast region (1.64 admissions/patient), which remained far above other areas for most of the study period (Figure 3).

*Comorbidities of T1D and DKA admissions*

T1D patients hospitalized for DKA shared similar comorbidities to those admitted for non-DKA conditions (Table 3). Respiratory tract infections were the most common comorbidities in hospitalized T1D patients, irrespective of the presence of DKA. Mental and behavioral disorders were among the most frequent comorbidities in both groups, while adjustment disorder and major depressive disorder were common diagnoses.

**Discussion**

From 2015 to 2019, the annual incidence of DKA admission increased progressively, highlighting the importance of DKA prevention. Recurrent DKA events accounted for more than half of DKA admissions. Indeed, such a proportion could be underestimated because first-recorded hospitalizations might be repeated DKA episodes in individuals with known T1D. The findings were consistent with data observed in both the USA and Canada, where incidences of DKA admission increased with the rising of recurrent DKA events (3,4). Accordingly, the increased percentage of recurrent DKA episodes might explain the increased annual incidence of DKA admission in our study. Risk factors for DKA admission could be multifactorial, and some of them affect most T1D individuals while others impact a specific group of individuals (1,3,4). Data from the Thai T1D registry show that only 28% of youth had at least 4 times/day of SMBG which is below the standard of care (17,20). On top of that, low frequency of SMBG was significantly associated with poor diabetes control, a known risk factor for developing recurrent DKA (14,17). Lack of coverage for glucose strip tests is likely the main issue for a number of Thai children and adolescents with T1D. Together with the increased incidence of DKA admission found in our study, the support for blood glucose strip tests in Thai T1D youth should be endorsed.

Compared to their younger counterparts, T1D patients over 6 years of age had a significantly higher incidence of DKA admission. Previous reports also showed the maximum rates of DKA admission in adolescents followed by school-aged children (18,21). Non-adherence to treatment is a common risk factor for developing DKA in adolescents (22). According to the data of T1D patients in the Thai registry, school-aged children had the lowest proportion of achieving hemoglobin A1c targets (17). High admission rates in school-aged children might reflect a lack of comprehensive diabetic education of school personnel, which is indispensable for these vulnerable individuals (23). In fact, diabetic education for school nurses in Thailand is still lacking.

Consistent with other studies, we found that females had higher incidence of DKA admission than males (3,4,6,7,9,24). Possible explanations might include insulin omission and intentional insulin restriction, which were more common in females and were risk factors for DKA in patients with known diabetes (14,25). Females were also more likely to receive the diagnoses of psychosocial adjustment and psychiatric disorders, which were associated with poor glycemic control and diabetes-related complications (26). Interestingly, we found that mental and behavioral disorders were not uncommon in hospitalized T1D patients (Table 3). These findings reflect that female youth with T1D must require more intensive and holistic care in which diabetes self-education and routine psychosocial support is essential.

Bangkok had the highest incidence of DKA admission but the second lowest DKA admission number and the lowest DKA admission rate. The total number of individuals in Bangkok was undeniably the smallest of all regions (Table 1). Additionally, Bangkok has the most referral tertiary medical centers. These factors might lead to a falsely high incidence of DKA admission. In contrast, the Northeast region had the highest hospitalization parameters, including recurrent DKA admission, increased incidence of DKA admission, and DKA admission rate. Residents of the Northeast area have the lowest socioeconomic status according to poverty indices, such as the lowest average monthly profits and the highest numbers of poor people (27). Traveling in the area is inconvenient while the transportation costs are high and the health care availability is the least of all regions in Thailand (16). As a result, the Northeast region had the maximum rate of unmet healthcare needs for both in-patient and out-patient departments (16). Limited access to medical services, a potential risk factor for developing DKA, would contribute to the highest DKA admission in the Northeast area (1,14).

Infections were among the common precipitating causes of DKA, with varied frequency from 14% to 58% in different countries (28). Korbel *et al.* demonstrated that respiratory infections were the most common infectious disease in hospitalized children with T1D in the USA (29). Similarly, we found that respiratory tract infections were prevalent in patients with T1D hospitalized for DKA and non-DKA. Our findings thus emphasized the importance of preventive measures for respiratory infections and sick day management among youth with T1D.

Over 4 decades, several studies among Thai children and adolescents focused on the regional or national incidence of T1D using either questionnaires or medical records, but none specifically reported the incidence of DKA admission (10,11,30–35). To the best of our knowledge, this is the first study using databases of all Thai health coverage systems that show national hospitalization data of patients with T1D and DKA.

**Study Limitations**

Limitations of this study included a relatively short study period (5 years) and the diagnosis of T1D and DKA, which were based solely on ICD-10 codes. Hence, newly diagnosed and known T1D were indistinguishable.

**Conclusions**

We observed increased incidences of T1D and DKA admissions among Thai youth during 2015-2019. Individuals who had a higher risk of being admitted for DKA were those over 6 years of age, being female, and residing in the Northeast region.

**Authorship contribution**

Concept and design: Pat Mahachoklertwattana, Taninee Sahakitrungruang; Data collection or processing: Somboon Wankanit, Kaewjai Thepsuthammarat, Pat Mahachoklertwattana; Analysis or interpretation: Somboon Wankanit, Kaewjai Thepsuthammarat, Preamrudee Poomthavorn, Pat Mahachoklertwattana; Literature search: Somboon Wankanit, Preamrudee Poomthavorn, Pat Mahachoklertwattana; Writing: Somboon Wankanit, Kaewjai Thepsuthammarat, Preamrudee Poomthavorn, Taninee Sahakitrungruang, Pat Mahachoklertwattana

**References**

1. Dhatariya KK, Glaser NS, Codner E, Umpierrez GE. Diabetic ketoacidosis. Nat Rev Dis Primers 2020;6:40.
2. Patterson CC, Karuranga S, Salpea P, Saeedi P, Dahlquist G, Soltesz G, Ogle GD. Worldwide estimates of incidence, prevalence and mortality of type 1 diabetes in children and adolescents: Results from the International Diabetes Federation Diabetes Atlas, 9th edition. Diabetes Res Clin Pract 2019;157:107842.
3. Everett EM, Copeland TP, Moin T, Wisk LE. National trends in pediatric admissions for diabetic ketoacidosis, 2006-2016. J Clin Endocrinol Metab 2021;106:2343-2354.
4. Kao K-T, Islam N, Fox DA, Amed S. Incidence trends of diabetic ketoacidosis in children and adolescents with type 1 diabetes in British Columbia, Canada. J Pediatr 2020;221:165-173.
5. Hirasing RA, Reeser HM, de Groot RR, Ruwaard D, van Buuren S, Verloove-Vanhorick SP. Trends in hospital admissions among children aged 0-19 years with type I diabetes in The Netherlands. Diabetes Care 1996;19:431-434.
6. Lombardo F, Maggini M, Gruden G, Bruno G. Temporal trend in hospitalizations for acute diabetic complications: a nationwide study, Italy, 2001-2010. PLoS One 2013;8:e63675.
7. Choe J, Won SH, Choe Y, Park SH, Lee YJ, Lee J, Lee YA, Lim HH, Yoo JH, Lee SY, Kim EY, Shin CH, Kim JH. Temporal trends for diabetes management and glycemic control between 2010 and 2019 in Korean children and adolescents with type 1 diabetes. Diabetes Technol Ther 2022;24:201-211.
8. Neu A, Hofer SE, Karges B, Oeverink R, Rosenbauer J, Holl RW; DPV Initiative and the German BMBF Competency Network for Diabetes Mellitus. Ketoacidosis at diabetes onset is still frequent in children and adolescents: a multicenter analysis of 14,664 patients from 106 institutions. Diabetes Care 2009;32:1647-1648.
9. Peng W, Yuan J, Chiavaroli V, Dong G, Huang K, Wu W, Ullah R, Jin B, Lin H, Derraik JGB, Fu J. 10-Year incidence of diabetic ketoacidosis at type 1 diabetes diagnosis in children aged less than 16 years from a large regional center (Hangzhou, China). Front Endocrinol (Lausanne) 2021;12:653519.
10. Tuchinda C, Wiriyankula S, Angsusingha K, Punnakanta L, Vannasaeng S. The epidemiology of diabetes mellitus in Thai children in 1984. J Med Assoc Thai 1987;70(Suppl 2):36-41.
11. Jaruratanasirikul S, Thammaratchuchai S, Sriplung H. Trends of childhood diabetes in Southern Thailand: 20-year experience in a tertiary medical center. World J Pediatr 2017;13:566-570.
12. Rittiphairoj T, Owais M, Ward ZJ, Reddy CL, Yeh JM, Atun R. Incidence and prevalence of type 1 diabetes and diabetic ketoacidosis in children and adolescents (0-19 years) in Thailand (2015-2020): A nationwide population-based study. Lancet Reg Health West Pac 2022;21:100392.
13. Tangcharoensathien V, Witthayapipopsakul W, Panichkriangkrai W, Patcharanarumol W, Mills A. Health systems development in Thailand: a solid platform for successful implementation of universal health coverage. Lancet 2018;391:1205-1223.
14. Wolfsdorf JI, 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.
15. Sritart H, Tuntiwong K, Miyazaki H, Taertulakarn S. Disparities in healthcare services and spatial assessments of mobile health clinics in the border regions of Thailand. Int J Environ Res Public Health 2021;18:10782.
16. Chongthawonsatid S. Identification of unmet healthcare needs: A national survey in Thailand. J Prev Med Public Health 2021;54:129-136.
17. Dejkhamron P, Santiprabhob J, Likitmaskul S, Deerochanawong C, Rawdaree P, Tharavanij T, Reutrakul S, Kongkanka C, Suprasongsin C, Numbenjapon N, Sahakitrungruang T, Lertwattanarak R, Engkakul P, Sriwijitkamol A, Korwutthikulrangsri M, Leelawattana R, Phimphilai M, Potisat S, Khananuraksa P, Nopmaneejumruslers C, Nitiyanant W; Thai Type 1 Diabetes and Diabetes Diagnosed Before Age 30 Years Registry, Care, and Network (T1DDAR CN). Type 1 diabetes management and outcomes: A multicenter study in Thailand. J Diabetes Investig 2021;12:516-526.
18. Maahs DM, Hermann JM, Holman N, Foster NC, Kapellen TM, Allgrove J, Schatz DA, Hofer SE, Campbell F, Steigleder-Schweiger C, Beck RW, Warner JT, Holl RW; National Paediatric Diabetes Audit and the Royal College of Paediatrics and Child Health, the DPV Initiative, and the T1D Exchange Clinic Network. Rates of diabetic ketoacidosis: international comparison with 49,859 pediatric patients with type 1 diabetes from England, Wales, the U.S., Austria, and Germany. Diabetes Care 2015;38:1876-1882.
19. The climate of Thailand. Thai Meteorological Department. Cited: 08.01.2022. Available from: https://www.tmd.go.th/en/archive/thailand_climate.pdf
20. American Diabetes Association Professional Practice Committee. 14. Children and adolescents: standards of medical care in diabetes-2022. Diabetes Care 2022;45:S208-S231.
21. Ampt A, van Gemert T, Craig ME, Donaghue KC, Lain SB, Nassar N. Using population data to understand the epidemiology and risk factors for diabetic ketoacidosis in Australian children with type 1 diabetes. Pediatr Diabetes 2019;20:901-908.
22. Edge JA, Nunney I, Dhatariya KK. Diabetic ketoacidosis in an adolescent and young adult population in the UK in 2014: a national survey comparison of management in paediatric and adult settings. Diabet Med 2016;33:1352-1359.
23. Bratina N, Forsander G, Annan F, Wysocki T, Pierce J, Calliari LE, Pacaud D, Adolfsson P, Dovč K, Middlehurst A, Goss P, Goss J, Janson S, Acerini CL. ISPAD clinical practice consensus guidelines 2018: Management and support of children and adolescents with type 1 diabetes in school. Pediatr Diabetes 2018;19(Suppl 27):287-301.

24. Malik FS, Hall M, Mangione-Smith R, Keren R, Mahant S, Shah SS, Srivastava R, Wilson KM, Tieder JS. Patient characteristics associated with differences in admission frequency for diabetic ketoacidosis in United States children's hospitals. J Pediatr 2016;171:104-110.
25. Wisting L, Frøisland DH, Skrivarhaug T, Dahl-Jørgensen K, Rø O. Disturbed eating behavior and omission of insulin in adolescents receiving intensified insulin treatment: a nationwide population-based study. Diabetes Care 2013;36:3382-3387.
26. Delamater AM, de Wit M, McDarby V, Malik JA, Hilliard ME, Northam E, Acerini CL. ISPAD clinical practice consensus guidelines 2018: Psychological care of children and adolescents with type 1 diabetes. Pediatr Diabetes 2018;19(Suppl 27):237-249.
27. Revenue and household expenditure branch. National Statistical Office. Cited: 19.11.2023. Available from: http://statbbi.nso.go.th/staticreport/page/sector/en/08.aspx
28. Umpierrez G, Korytkowski M. Diabetic emergencies - ketoacidosis, hyperglycaemic hyperosmolar state and hypoglycaemia. Nat Rev Endocrinol 2016;12:222-232.
29. Korbel L, Easterling RS, Punja N, Spencer JD. The burden of common infections in children and adolescents with diabetes mellitus: A Pediatric Health Information System study. Pediatr Diabetes 2018;19:512-519.
30. Tuchinda C, Angsusingha K, Chaichanwalanakul K, Likitmaskul S, Vannasaeng S. The epidemiology of insulin-dependent diabetes mellitus (IDDM): report from Thailand. J Med Assoc Thai 1992;75:217-222.
31. Likitmaskul S, Angsusingha K, Morris S, Kiattisakthavee P, Chaichanwatanakul K, Tuchinda C. Type 1 diabetes in Thai children aged 0-14 years. J Med Assoc Thai 1999;82:826-832.
32. Unachak K, Tuchinda C. Incidence of type 1 diabetes in children under 15 years in northern Thailand, from 1991 to 1997. J Med Assoc Thai 2001;84:923-928.
33. Patarakujvanich N, Tuchinda C. Incidence of diabetes mellitus type 1 in children of southern Thailand. J Med Assoc Thai 2001;84:1071-1074.
34. Tuchinda C, Likitmaskul S, Unachak K, Panamonta O, Patarakijavanich N, Chetthakul T. The epidemiology of type 1 diabetes in Thai children. J Med Assoc Thai 2002;85:648-652.
35. Panamonta O, Thamjaroen J, Panamonta M, Panamonta N, Suesirisawat C. The rising incidence of type 1 diabetes in the northeastern part of Thailand. J Med Assoc Thai 2011;94:1447-1450

**Figure 1.** Incidence trend of hospital admission for type 1 diabetes (T1D) and diabetic ketoacidosis (DKA)

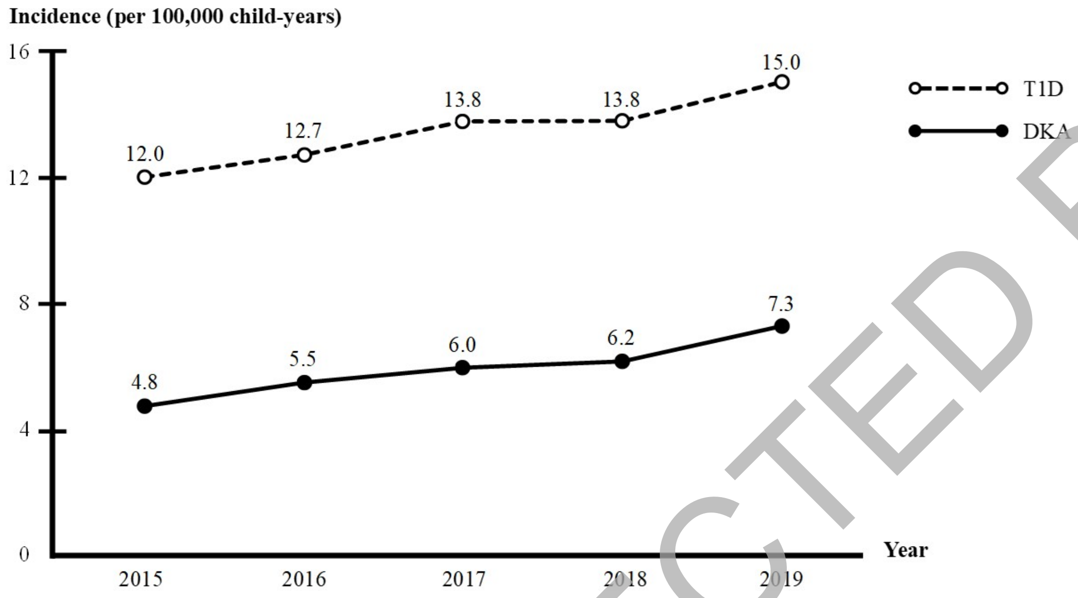

**Figure 2.** Hospital admission for type 1 diabetes (T1D) and diabetic ketoacidosis (DKA) of individuals aged under 18 years

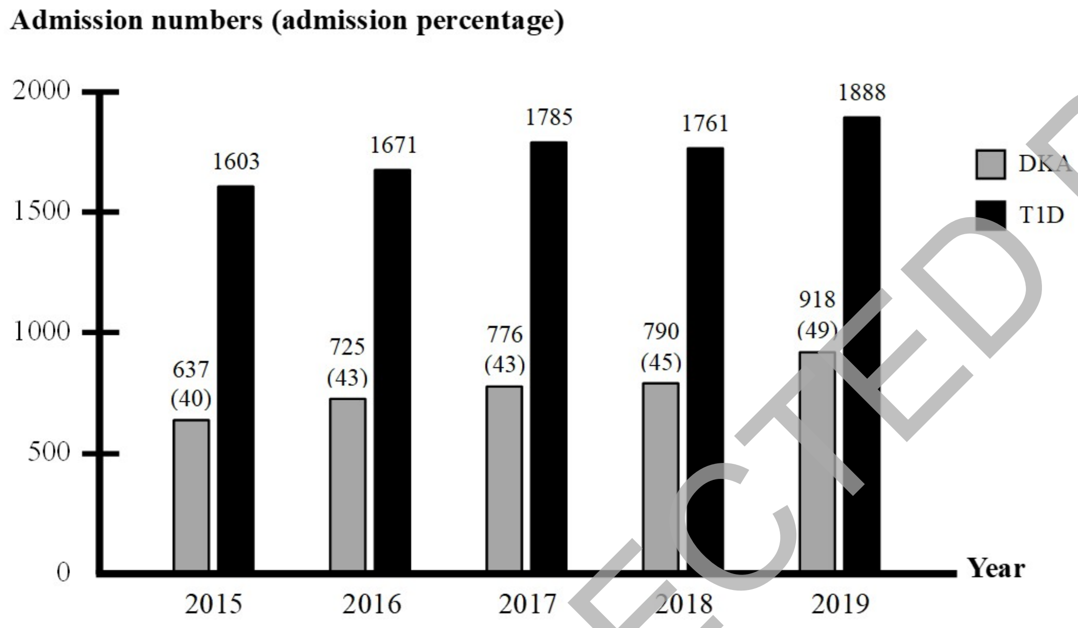

**Figure 3.** Trend in hospital admission rate for diabetic ketoacidosis (the number of admissions/the number of patients) according to regions

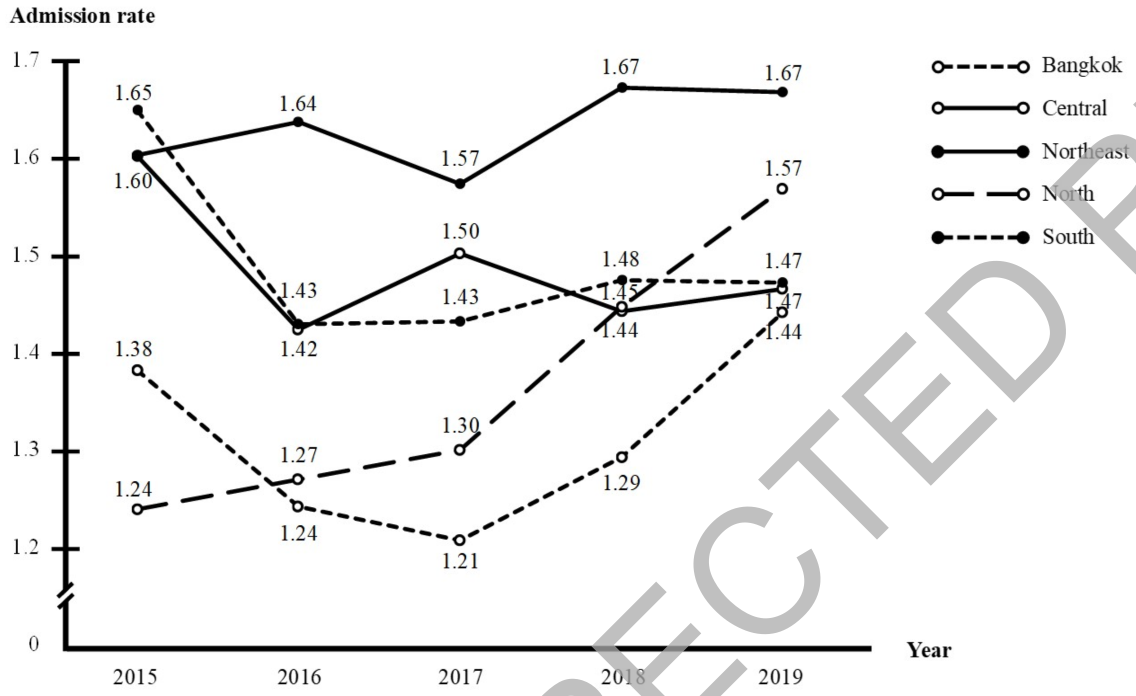

**Table 1.** Total admission, population and incidence of hospital admissions in patients with type 1 diabetes during the year 2015-2019

| Year | Admission numbers | | | | | | Total population | | | | | | Incidence per 100,000 child-years | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **All** | **2015** | **2016** | **2017** | **2018** | **2019** | **All** | **2015** | **2016** | **2017** | **2018** | **2019** | **All** | **2015** | **2016** | **2017** | **2018** | **2019** |
| Total | 8,708 | 1,603 | 1,671 | 1,785 | 1,761 | 1,888 | 64,677,608 | 13,321,565 | 13,121,876 | 12,939,015 | 12,747,946 | 12,547,206 | 13.5 | 12.0 | 12.7 | 13.8 | 13.8 | 15.0 |
| Age groups (years) | | | | | | | | | | | | | | | | | | |
| <1 | 50 | 12 | 19 | 3 | 9 | 7 | 3,009,424 | 637,546 | 623,309 | 607,525 | 584,548 | 556,496 | 1.7 | 1.9 | 3.0 | 0.5 | 1.5 | 1.3 |
| 1-5 | 742 | 150 | 155 | 172 | 153 | 112 | 17,194,614 | 3,628,116 | 3,566,589 | 3,469,736 | 3,328,164 | 3,202,009 | 4.3 | 4.1 | 4.3 | 5.0 | 4.6 | 3.5 |
| 6-12 | 3,545 | 588 | 705 | 766 | 715 | 771 | 25,758,480 | 5,189,861 | 5,179,687 | 5,140,056 | 5,139,904 | 5,108,972 | 13.8 | 11.3 | 13.6 | 14.9 | 13.9 | 15.1 |
| 13-17 | 4,371 | 853 | 792 | 844 | 884 | 998 | 18,715,090 | 3,866,042 | 3,752,291 | 3,721,698 | 3,695,330 | 3,679,729 | 23.4 | 22.1 | 21.1 | 22.7 | 23.9 | 27.1 |
| Gender | | | | | | | | | | | | | | | | | | |
| Male | 3,497 | 655 | 674 | 701 | 749 | 718 | 33,230,782 | 6,842,917 | 6,740,708 | 6,648,212 | 6,551,186 | 6,447,759 | 10.5 | 9.6 | 10.0 | 10.5 | 11.4 | 11.1 |
| Female | 5,211 | 948 | 997 | 1,084 | 1,012 | 1,170 | 31,446,826 | 6,478,648 | 6,381,168 | 6,290,803 | 6,196,760 | 6,099,447 | 16.6 | 14.6 | 15.6 | 17.2 | 16.3 | 19.2 |
| Region | | | | | | | | | | | | | | | | | | |
| Bangkok | 1,010 | 203 | 234 | 193 | 216 | 164 | 4,811,349 | 999,836 | 984,944 | 970,192 | 942,542 | 913,835 | 21.0 | 20.3 | 23.8 | 19.9 | 22.9 | 17.9 |
| Central | 2,286 | 432 | 438 | 496 | 438 | 482 | 16,429,931 | 3,341,918 | 3,316,553 | 3,286,895 | 3,257,522 | 3,227,043 | 13.9 | 12.9 | 13.2 | 15.1 | 13.4 | 14.9 |
| Northeast | 3,084 | 525 | 556 | 631 | 650 | 722 | 21,725,957 | 4,524,269 | 4,425,863 | 4,340,872 | 4,259,661 | 4,175,292 | 14.2 | 11.6 | 12.6 | 14.5 | 15.3 | 17.3 |
| North | 1,114 | 214 | 220 | 214 | 222 | 244 | 10,444,785 | 2,155,930 | 2,118,232 | 2,087,249 | 2,057,531 | 2,025,843 | 10.7 | 9.9 | 10.4 | 10.3 | 10.8 | 12.0 |
| South | 1,214 | 229 | 223 | 251 | 235 | 276 | 11,265,586 | 2,299,612 | 2,276,284 | 2,253,807 | 2,230,690 | 2,205,193 | 10.8 | 10.0 | 9.8 | 11.1 | 10.5 | 12.5 |

**Table 2.** Diabetic ketoacidosis (DKA) hospitalization parameters of patients with type 1 diabetes during the year 2015-2019

| **Year** | **Total admissions (Incidence per 100,000 child-years)** | | | | | | **Percentage of DKA admission** | **Recurrent DKA events (%)** | **DKA Admission rate** |
|---|---|---|---|---|---|---|---|---|---|
| | **2015-2019** | **2015** | **2016** | **2017** | **2018** | **2019** | **2015-2019** | **2015-2019** | **2015-2019** |
| Total | 3,846 (5.9) | 637 (4.8) | 725 (5.5) | 776 (6.0) | 790 (6.2) | 918 (7.3) | 44 | 2007 (52) | 1.49 |
| Age groups (years) | | | | | | | | | |
| <1 | 18 (0.6) | 6 (0.9) | 7 (1.1) | 0 (0) | 4 (0.7) | 1 (0.2) | 36 | 5 (28) | 1.38 |
| 1-5 | 288 (1.7) | 42 (1.2) | 67 (1.9) | 70 (2.0) | 56 (1.7) | 53 (1.7) | 39 | 71 (25) | 1.20 |
| 6-12 | 1,616 (6.3) | 241 (4.6) | 314 (6.1) | 326 (6.3) | 337 (6.6) | 398 (7.8) | 46 | 831 (51) | 1.55 |
| 13-17 | 1,924 (10.3) | 348 (9.0) | 337 (9.0) | 380 (10.2) | 393 (10.6) | 466 (12.7) | 44 | 1,100 (57) | 1.50 |
| Gender | | | | | | | | | |
| Male | 1,442 (4.3) | 257 (3.8) | 266 (3.9) | 255 (3.8) | 328 (5.0) | 336 (5.2) | 41 | 673 (47) | 1.39 |
| Female | 2,404 (7.6) | 380 (5.9) | 459 (7.2) | 521 (8.3) | 462 (7.5) | 582 (9.5) | 46 | 1,334 (55) | 1.56 |
| Region | | | | | | | | | |
| Bangkok | 437 (9.1) | 83 (8.3) | 97 (9.8) | 81 (8.3) | 88 (9.3) | 88 (9.6) | 43 | 208 (48) | 1.31 |
| Central | 1,192 (7.3) | 218 (6.5) | 228 (6.9) | 251 (7.6) | 231 (7.1) | 264 (8.2) | 52 | 612 (51) | 1.48 |
| Northeast | 1,204 (5.5) | 170 (3.8) | 208 (4.7) | 233 (5.4) | 266 (6.2) | 327 (7.8) | 39 | 685 (57) | 1.64 |
| North | 424 (4.1) | 67 (3.1) | 89 (4.2) | 82 (3.9) | 84 (4.1) | 102 (5.0) | 38 | 189 (45) | 1.37 |
| South | 589 (5.2) | 99 (4.3) | 103 (4.5) | 129 (5.7) | 121 (5.4) | 137 (6.2) | 49 | 313 (53) | 1.48 |

**Table 3.** Five most common comorbidities of hospital admission for type 1 diabetes (T1D) and diabetic ketoacidosis (DKA) in children and adolescents

| **Rank** | **T1D** | | | **DKA** | | |
|---|---|---|---|---|---|---|
| | **ICD-10** | **Diagnosis** | **N (%)** | **ICD-10** | **Diagnosis** | **N (%)** |
| 1 | J00-J22 | Respiratory tract infections | 832 (9.6) | J00-J22 | Respiratory tract infections | 376 (9.8) |
| 2 | A00-A09 | Intestinal infections | 406 (4.7) | A30-A49 | Other bacterial diseases | 205 (5.3) |
| 3 | N30-N39 | Other diseases of urinary system | 375 (4.3) | N30-N39 | Other diseases of urinary system | 201 (5.2) |
| 4 | F00-F99 | Mental and behavioral disorders | 345 (4.0) | A00-A09 | Intestinal infections | 142 (3.7) |
| 5 | K20-K31 | Diseases of esophagus, stomach and duodenum | 309 (3.5) | F00-F99 | Mental and behavioral disorders | 141 (3.7) |

ICD-10, International Code of Diseases-10