

Original Article

Declining trends in diabetic ketoacidosis after type 1 diabetes Diagnosis: A 22-year experience at a pediatric medical center in Northern Taiwan

Kai-Hsiang Chang^a, Wei-Hsin Ting^{a,b,*}, Yann-Jinn Lee^{a,b,c}, Chi-Yu Huang^{a,b},
Chao-Hsu Lin^{d,e}, Shih-Kang Huang^a, Yi-Chen Lee^{a,f}, Lu-Ting Wang^a, Yu-En Kao^a,
Yi-Hsin Wu^{a,g}, Lun-Chin Lin^{a,h}

^a Department of Pediatric Endocrinology, MacKay Children's Hospital, Taipei, Taiwan

^b Department of Medicine, MacKay Medical College, New Taipei City, Taiwan

^c Department of Medical Research, Tamsui MacKay Memorial Hospital, New Taipei City, Taiwan

^d Department of Pediatric Endocrinology, Hsinchu MacKay Memorial Hospital, Hsinchu City, Taiwan

^e Department of Biological Science and Technology, National Chiao-Tung University, Hsinchu City, Taiwan

^f Department of Pediatrics, Cathay General Hospital, Taipei, Taiwan

^g Department of Pediatrics, Shin-Kong Wu Ho-Su Memorial Hospital, Taipei, Taiwan

^h Department of Pediatrics, Cardinal Tein Hospital, Taipei, Taiwan



ARTICLE INFO

Keywords:

Secular trend

Diabetic ketoacidosis

Type 1 diabetes

Diabetes care

Trend analysis

ABSTRACT

Introduction: Diabetic ketoacidosis (DKA) is a severe complication of type 1 diabetes (T1D). Hospitalizations for DKA after T1D diagnosis can serve as an indicator of diabetes care quality. Our study investigated the secular trend of DKA after T1D diagnosis in children and adolescents over 22 years and compared clinical characteristics of DKA at and after diagnosis.

Materials and methods: The study enrolled T1D patients under 18 years, followed at MacKay Children's Hospital from 2000 to 2022. DKA was defined by glucose ≥ 200 mg/dL, pH ≤ 7.3 or HCO₃ ≤ 15 mmol/L, with positive ketones. DKA was further classified as AfterDx (DKA occurring >14 days after T1D diagnosis) and AtDx (within 14 days of diagnosis). Statistical analysis included ARIMA models for secular trend of AfterDx, chi-square and Fisher's exact tests for categorical data, and t-tests for continuous data. *P-value* < 0.05 was considered significant.

Results: A total of 681 T1D patients contributed to 590 DKA episodes, of which 397 episodes were analyzed. There were 180 AfterDx episodes and 217 AtDx episodes. The AfterDx incidence declined between 2000 and 2022, especially after 2017, with an annual decrease of 43.1 %. Females (66.1 %) and adolescents (55.0 %) were more prevalent in the AfterDx group. In contrast, preschool children predominated in the AtDx group (43.3 %). Notably, 61.1 % of AfterDx episodes occurred within the first 6 years after T1D diagnosis.

Conclusion: Our study identified a statistically significant 43.1 % annual decline in AfterDx incidence from 2017 to 2022, reflecting advancements in diabetes care. Females and adolescents were high-risk groups, emphasizing the necessity for targeted interventions. Additionally, sixty percent of DKA episodes occurred within 6 years of T1D diagnosis, highlighting the importance of more diabetes education and enhanced monitoring during the early years after T1D diagnosis.

1. Introduction

Diabetic ketoacidosis (DKA) is one of the most common causes of morbidity and mortality among children with type 1 diabetes (T1D), with cerebral edema being its primary underlying factor [1,2]. These acute complications impose a significant burden in terms of morbidity, mortality, and healthcare costs. Nonetheless, proper diabetes

management can prevent these complications [3,4].

DKA after T1D diagnosis (AfterDx), defined as episodes occurring more than 14 days after the initial T1D diagnosis, serves as a specific indicator of diabetes care quality [5]. This measure excludes complications related to the acute diagnostic phase and emphasizes systemic and long-term care effectiveness [5]. Findings from Kao et al. demonstrated that AfterDx occurrences are tied to demographic disparities and long-term management issues, highlighting the need for focused

* Corresponding author. Department of Pediatric Endocrinology, MacKay Children's Hospital, Taipei, Taiwan.

E-mail address: stczge@ms27.hinet.net (W.-H. Ting).

<https://doi.org/10.1016/j.pedneo.2025.10.010>

Received 7 March 2025; Received in revised form 15 October 2025; Accepted 27 October 2025

Available online 21 January 2026

1875-9572/© 2026 Taiwan Pediatric Association. Published by Elsevier Taiwan LLC. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Abbreviation:

DKA	Diabetic Ketoacidosis
T1D	Type 1 Diabetes
AfterDx	DKA after T1D Diagnosis
AtDx	DKA at T1D Diagnosis
ARIMA	Autoregressive Integrated Moving Average
CGM	Continuous Glucose Monitoring
CSII	Continuous Subcutaneous Insulin Infusion
AHCL	Automated Hybrid Closed Loop

interventions [5].

Advancements in diabetic care systems have identified several strategies to reduce the risk of DKA. First, one study revealed that the use of long-acting insulin degludec, compared to insulin glargine, reduced the rate of DKA in adolescent patients [6]. Second, the provision of continuing diabetes education has been highlighted as a key factor in reducing subsequent DKA. These organizations provide ongoing education, empowering patients with the knowledge and skills necessary for effective self-management [4]. Finally, the adoption of advanced diabetes technologies, including continuous glucose monitoring (CGM), continuous subcutaneous insulin infusion (CSII), and automated hybrid closed loop (AHCL) system, has significantly improved glycemic control and reduced the risk of DKA [7–9]. Specifically, AHCL systems demonstrate superior performance over traditional methods in improving time in range (TIR), reducing HbA1c levels, and minimizing glycemic variability without elevating hypoglycemia risk [10].

Our hypothesis is that advancements in diabetes care may lead to a declining trend in the incidence of AfterDx. The primary objective of our study was to investigate the secular trend of AfterDx in children and adolescents over the past 22 years. Additionally, we aimed to compare various clinical characteristics between patients with DKA developed at and after T1D diagnosis. Confirming this hypothesis could have significant implications for refining diabetes management strategies and improving care protocols.

2. Material and methods

2.1. Data collection

We retrospectively collected data on patients with T1D diagnosed between January 1, 2000, and December 31, 2022, who were under 18 years of age at the time of diagnosis, from MacKay Children's Hospital. The annual number of new T1D diagnoses at our center ranged from 13 to 39 cases per year, with a total of 512 new cases over the 22-year period. Expanding the analysis to account for patients diagnosed at other hospitals but subsequently followed at our center, a total of 681 cases were tracked during this period, which served as the basis for calculating follow-up person-years in this study.

T1D diagnosis followed the established criteria outlined by the American Diabetes Association [11] and the International Society for Pediatric and Adolescent Diabetes [12,13]. Diagnostic criteria included hyperglycemia symptoms, confirmed by random plasma glucose ≥ 200 mg/dL, fasting plasma glucose ≥ 126 mg/dL, or HbA1c $\geq 6.5\%$, and supported by autoantibody testing to establish autoimmune etiology [11,12]. Clinical variables recorded for each patient included age at T1D diagnosis, gender, date of birth, date of initial T1D diagnosis, date of initial and last outpatient visits, follow-up person-years, and details of each DKA episode. Additionally, we recorded monitoring methods, such as self-monitoring of blood glucose (SMBG) or CGM, and treatment regimens, including basal bolus regimens with insulin degludec or other long-acting insulins, conventional regimens, CSII or AHCL systems, to evaluate their impact on DKA incidence.

2.2. Case definition

The DKA episodes were initially identified based on ICD-10 (International Classification of Diseases, 10th Revision) codes indicating a DKA diagnosis or mentioning DKA or ketosis in the hospital discharge summaries. DKA was defined as having blood glucose levels exceeding 200 mg/dL, the presence of ketonuria or ketonemia, and a venous pH value below 7.3 or bicarbonate below 15 mmol/L [13]. The severity of DKA was categorized as mild with a venous pH range of 7.2–7.3, moderate with a pH between 7.1 and 7.2, and severe with a pH of 7.1 or lower [14].

DKA cases were further categorized into two groups: DKA after T1D diagnosis (AfterDx), defined as episodes occurring more than 14 days after the initial T1D diagnosis, and DKA at T1D diagnosis (AtDx), defined as episodes occurring within 14 days of T1D diagnosis [5]. We also categorized the age group of DKA episodes as under 5.99 years, 6–11.99 years, 12–17.99 years, and over 18 years. DKA episodes were excluded based on the following criteria: (1) cases that did not meet the DKA criteria after detailed review; (2) episodes where the initial diagnosis or partial treatment occurred at other hospitals before transferring to Mackay Children's Hospital; and (3) loss of essential clinical data.

For trend analysis, we calculated the annual incidence rate of AfterDx by dividing the annual number of AfterDx hospitalizations by the T1D follow-up person-years, as illustrated in Fig. 2B. Follow-up person-years were determined by measuring the time span from the initial T1D diagnosis or the first outpatient visit for T1D at our hospital to the last DKA hospitalization or outpatient visit for T1D, within the study period between 2000 and 2022.

2.3. Diabetes management strategies and team composition

Early T1D management involves MDI (multiple daily injections) combined with SMBG. Since 2020, CGM has been gradually adopted, improving glycemic control in the newly diagnosed patients. The number of patients initiating CSII or AHCL systems is gradually increasing, reflecting the growing adoption of these advanced technologies.

The diabetes care team comprises pediatric endocrinologists, diabetes educators, dietitians and psychologists, providing comprehensive medical and psychosocial support for diabetes management.

Pediatric diabetes educators are integral to delivering education, offering emotional support, and ensuring consistent follow-up care from the time of diagnosis.

2.4. Statistical analysis

Continuous variables were expressed as means (SD, standard deviation) and categorical variables as numbers and percentages. Categorical variables were compared using the chi-square test or Fisher's exact test when expected frequencies were below 5; continuous variables were compared using a two-tailed independent *t*-test. The parameters of the ARIMA (autoregressive integrated moving average) model were employed to depict the trends in DKA incidence rate throughout the study period [15]. The ARIMA model was selected due to its robustness in identifying and forecasting trends in the time-series data, which is particularly suitable for modeling the fluctuations in DKA incidence over the extended 22-year study period. All statistical analyses were performed using IBM SPSS Statistics 26.0 (IBM Corp., Armonk, NY, USA). A *P*-value of less than 0.05 was regarded as statistically significant.

3. Results

3.1. Study population

Between January 1, 2000, and December 31, 2022, a total of 681

patients diagnosed with T1D under the age of 18 at Mackay Children's Hospital were enrolled in the study. These 681 patients collectively contributed to a total of 590 DKA hospitalizations. A total of 193 DKA episodes were excluded, including 127 episodes that did not meet the criteria for DKA after detailed review, 57 episodes where initial diagnosis or partial treatment occurred at other hospitals, and 9 hospitalizations with the loss of critical clinical data. 397 hospitalizations were included in our analysis. Of these, 180 episodes of DKA were categorized as DKA after T1D diagnosis (AfterDx) and 217 episodes as DKA at T1D diagnosis (AtDx). Fig. 1 depicts the inclusion and exclusion flow chart for DKA episodes in this study.

3.2. Trend analysis

We utilized autoregressive integrated moving average (ARIMA) model parameters to analyze the secular trend of AfterDx [15]. Over the 22-year period, the overall mean incidence of AfterDx was 30.0 episodes per 1000 person-years, as illustrated in Fig. 2A. The denominator was defined as the cumulative number of T1D patients under follow-up since the year 2000, which contributed to greater fluctuations in the incidence rate during the initial years. As shown in Fig. 2B, follow-up person-years increased steadily over time, whereas the earlier years from 2000 to 2006 had relatively few person-years, making the incidence rate more sensitive to small changes in hospitalization numbers. There was an increase in the incidence rate of AfterDx from 2000 to 2006, with a *P*-value of 0.021. This increase may be attributed to (1) the relatively small number of follow-up person-years during this early period and (2)

a higher number of DKA hospitalizations within the first 6 years after T1D diagnosis, as demonstrated in Fig. 3. Between 2006 and 2016, there was a declining trend in the incidence rate, although it did not reach statistical significance. However, from 2017 to 2022, the incidence rate for AfterDx steadily decreased from 38.23 to 2.28 per 1000 person-years. This decline reached statistical significance with a *P*-value of less than 0.01, representing an annual percentage change of 43.1 %, as illustrated in Fig. 2A. Notably, between 2005 and 2009, the incidence rate of AfterDx was 62 episodes per 1000 person-years (58 episodes/932.6 person-years), which was significantly higher than that during 2011–2019 (30 episodes per 1000 person-years, 95 episodes/3217.3 person-years). This finding further confirmed that the incidence of AfterDx has decreased over time, consistent with the overall secular trend demonstrated in Fig. 2A.

3.3. Treatment change

The adoption of insulin degludec has increased significantly since 2017. Among 534 patients followed up after 2017, 295 (55.2 %) were treated with insulin degludec. For newly T1D diagnosed patients after 2017, 81.7 % initiated treatment with insulin degludec as their basal insulin. Of the 51 AfterDx hospitalizations recorded after 2017, only 5 (9.8 %) were associated with the use of insulin degludec. Patients managed with insulin degludec-based regimens demonstrated a hospitalization rate of 1.6 %, which was significantly lower than the 25.0 % observed in patients receiving other long-acting insulin regimens.

Among these 534 patients, 18 were treated with CSII or AHCL

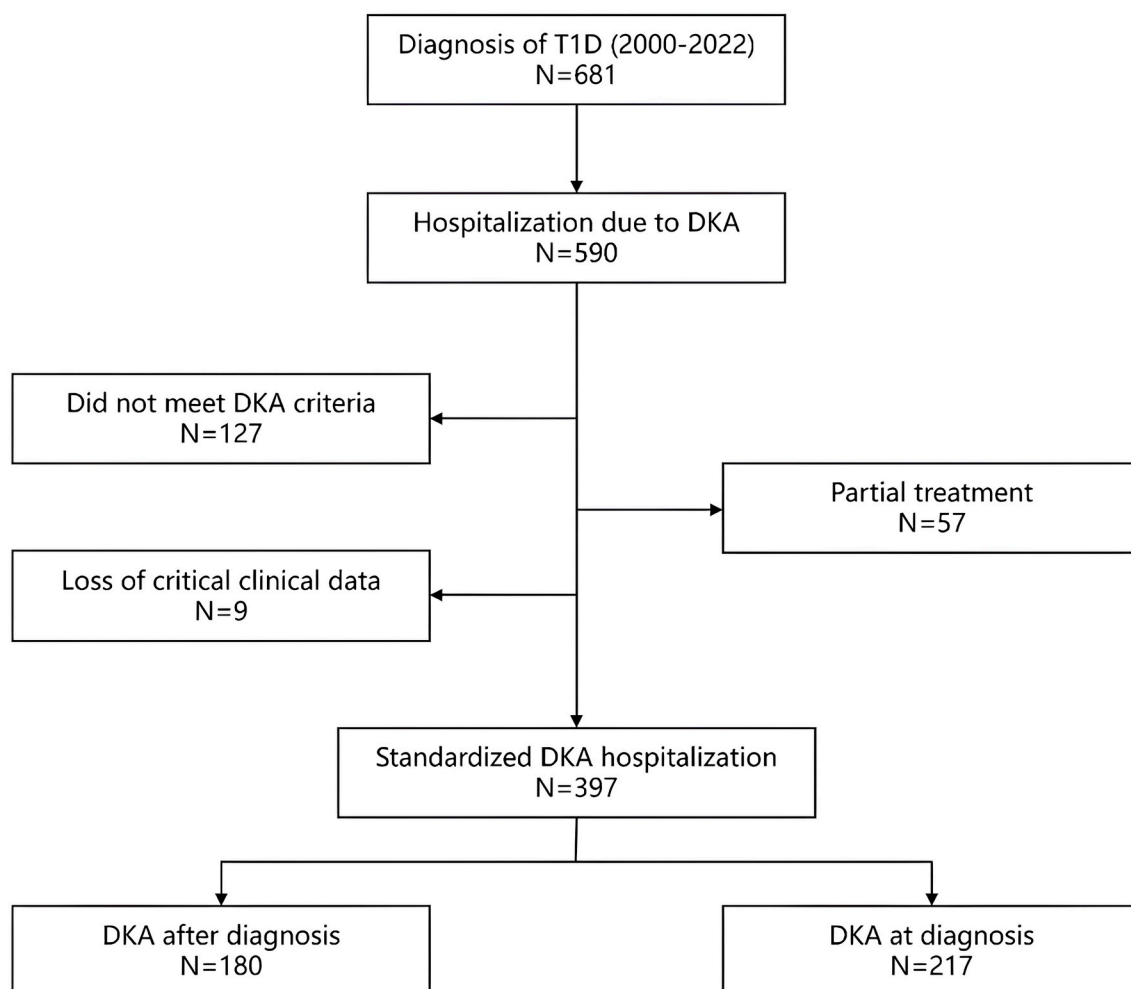


Fig. 1. The inclusion and exclusion flow chart of the 397 DKA episodes in this study.

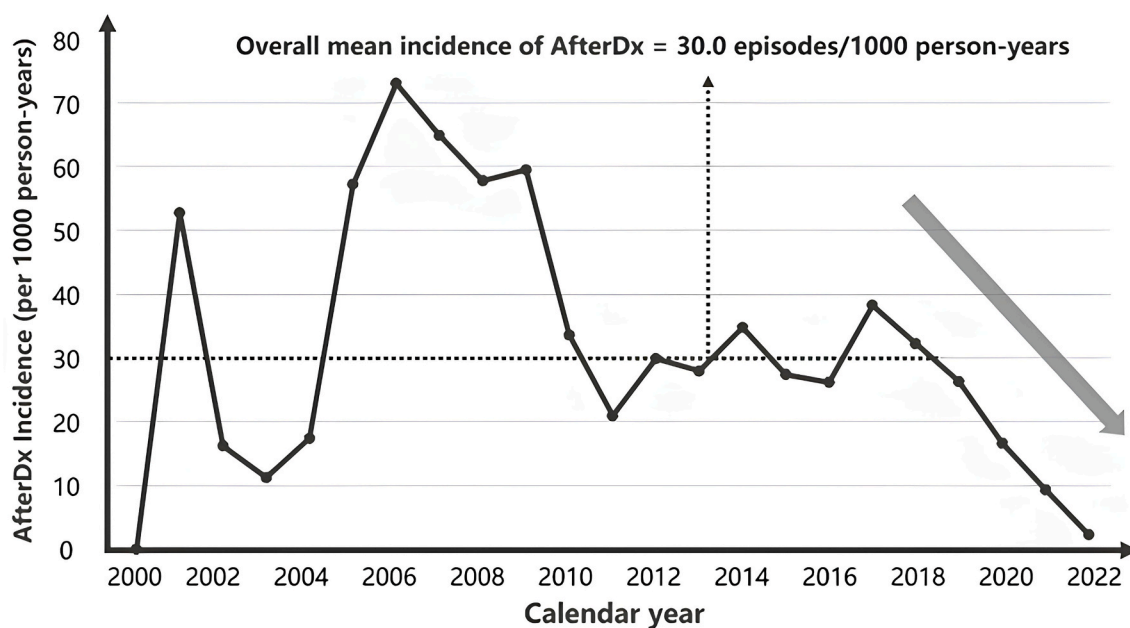


Fig. 2A. Trend analysis of AfterDx from 2000 to 2022. The annual incidence of AfterDx (solid line, per 1000 person-years) is shown. The overall mean incidence of AfterDx was 30.0 episodes per 1000 person-years. A significant decline in the incidence rate of AfterDx was observed from 2017 to 2022. The denominator was defined as the cumulative number of T1D patients under follow-up since the year 2000.

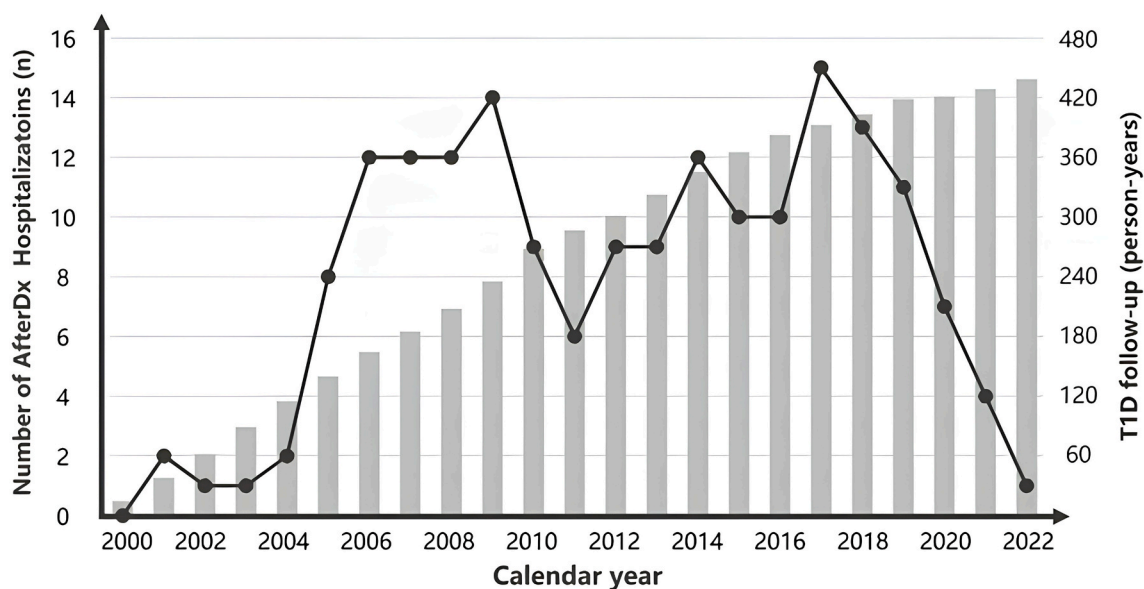


Fig. 2B. Annual number of AfterDx hospitalizations (solid line, n) and T1D follow-up (bars, person-years) from 2000 to 2022. This presentation illustrates the relationship between the number of AfterDx events and the increasing T1D follow-up person-years over time.

systems. Notably, none of the 51 AfterDx hospitalizations recorded during the same period involved patients using CSII or AHCL as their insulin treatment method.

3.4. CGM adoption

Since 2020, the use of CGM devices at our institution has shown a steady increase, with the number of CGM sensors prescribed rising from 193 in 2020 to 791 in 2022. Among the 12 recorded AfterDx hospitalizations since 2020, none of the patients had used CGM prior to admission.

3.5. DKA group comparison

In the AfterDx group, females accounted for a higher proportion compared to the AtDx group (AfterDx vs. AtDx, 66.1 vs. 53.9 %, $p = 0.013$). The mean hospital stay was also shorter in the AfterDx group compared to the AtDx group (AfterDx vs. AtDx, 5.4 vs. 8.9 days, $p < 0.001$). Adolescents comprised the majority in the AfterDx group (55.0 %), while preschool children predominated in the AtDx group (43.3 %). No significant difference was found in the severity of DKA between the groups (Table 1). Furthermore, 61.1 % of DKA hospitalizations occurred within the first 6 years after T1D diagnosis, as demonstrated in Fig. 3. These results indicated the importance of targeted care within the first 6 years after T1D diagnosis, particularly for females and adolescents, to

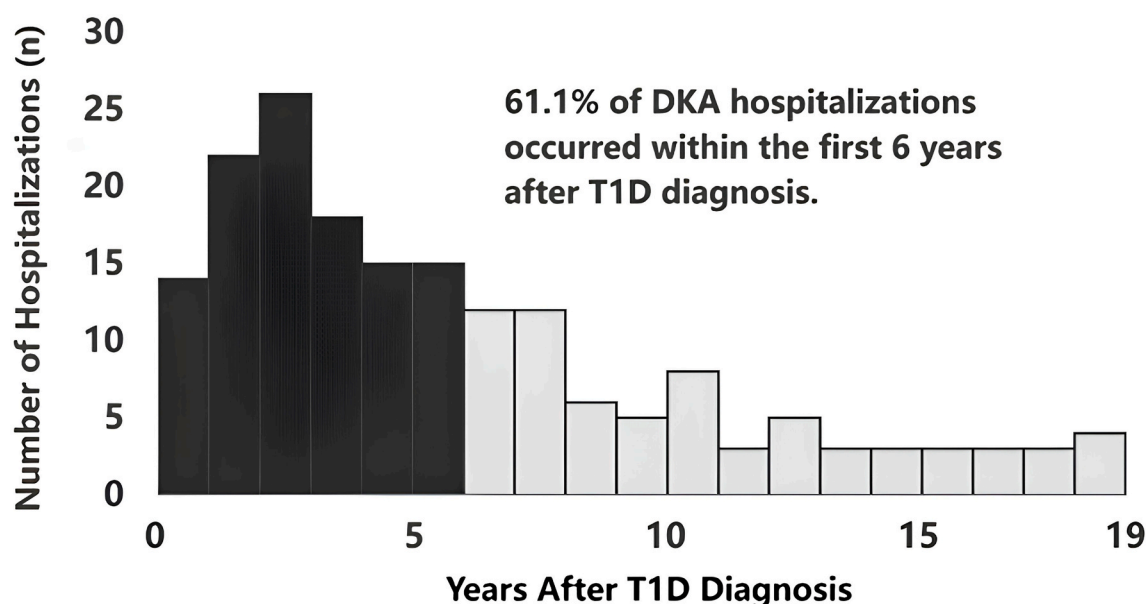


Fig. 3. Distribution of DKA hospitalizations (n) by years after T1D diagnosis in the AfterDx group. 61.1 % of DKA hospitalizations occurred within the first 6 years after T1D diagnosis.

Table 1

Comparison between groups of diabetic ketoacidosis while hospitalization.

Clinical Characteristics at hospitalization	AfterDx	AtDx	P* value
	N = 180	N = 217	
	Number of Participants (percent)		
Sex, female, no. (%)	119 (66.1)	117 (53.9)	0.013
DKA severity, no. (%)			0.095
mild	60 (33.3)	89 (41.0)	
moderate	61 (33.9)	53 (24.4)	
severe	59 (32.8)	75 (34.6)	
Age of hospitalization, no. (%)			< 0.001
0–5.99	1 (0.6)	64 (29.5)	
6–11.99	34 (18.9)	94 (43.3)	
12–17.99	99 (55)	59 (27.2)	
> 18	46 (25.5)	0 (0)	
Days of hospitalization, mean ± SD	5.4 ± 2.64	8.9 ± 2.42	< 0.001#

AfterDx: DKA after T1D diagnosis, DKA happened 14 days after diagnosis; AtDx: DKA at T1D diagnosis, DKA happened 14 days within diagnosis.

*Chi-squared test unless otherwise indicated.

#Two-tailed independent t-test.

reduce the incidence of AfterDx.

4. Discussion

Our study revealed a marked decline in the incidence of DKA after T1D diagnosis (AfterDx) in recent years, especially from 2017 to 2022, reflecting advancements in diabetes care. Females and adolescents were identified as high-risk groups, highlighting the importance of targeted interventions, including personalized education and psychosocial support. Moreover, the majority of AfterDx episodes occurred within the first six years after T1D diagnosis. This highlights the importance of proactive monitoring and education during this period. Our findings aligned with the reports from U.S. studies [16], both demonstrating a declining trend in DKA incidence. Notably, our study further highlighted that this decrease was primarily observed in AfterDx, reflecting advancements in diabetes care.

The factor contributing to the decline in AfterDx might be the increased adoption of insulin degludec, which was introduced in 2017 as

a basal insulin option in our population. Its stable pharmacokinetic and pharmacodynamic profile reduces glycemic variability, thereby lowering the likelihood of severe hypoglycemia and DKA events. For example, Schmitt et al. reported that insulin degludec usage is associated with a lower risk of DKA compared to other long-acting insulins such as insulin glargine [6]. In contrast, findings from Karges et al. reported that neither insulin glargine nor detemir, despite their long-acting properties, significantly reduced DKA incidence when compared to NPH insulin [17]. Our study was consistent with Schmidt's finding [6], supporting the role of insulin degludec to decrease the incidence of AfterDx. Infections, other medical illnesses, and trauma are common precipitants of AfterDx [12]. During pandemic periods such as the 2003 SARS outbreak and the 2019–2023 COVID-19 pandemic, widespread mask-wearing and preventive measures may have reduced the transmission of respiratory and other viral infections [18,19]. This reduction in infection rates may have lowered the risk of infection-related DKA episodes, thereby potentially influencing the observed temporal trends in our study. Excluding the two pandemic period, we found that the incidence of AfterDx during 2005–2009 was higher than that in 2011–2019. This finding confirms that the incidence of AfterDx has decreased over time, which is consistent with the overall secular trend demonstrated in Fig. 2A.

Our study demonstrated that among the twelve episodes of AfterDx hospitalization recorded since 2020, none involved patients using CGM prior to admission. This observation supports the consensus that CGM reduces glycemic variability, improves HbA1c, and lowers the risk of acute complications such as DKA [20]. Additionally, a recent large-scale study reported that the widespread adoption of CGM was significantly associated with a reduction in DKA incidence among individuals with type 1 diabetes, further reinforcing the critical role of CGM in comprehensive diabetes management [21]. These findings highlight the role of CGM in T1D management and align our results with existing studies. CSII and AHCL systems have been shown to enhance glycemic control and reduce the risks of severe hypoglycemia and DKA, particularly among younger patients with T1D [9,10]. Our results revealed that none of the AfterDx hospitalizations involved these advanced technologies, highlighting their potential to mitigate DKA risk and aligning with prior studies demonstrating their protective effects against acute complications [9,10].

Our study demonstrated that females and adolescents had a higher

risk of developing AfterDx, with the majority of AfterDx episodes occurring within the first six years after T1D diagnosis. Female adolescents with T1D experience heightened pressure related to weight control and eating disorders, which may lead to intentional insulin omission, resulting in compromised glycemic control and an increased risk of DKA [22]. Similar trends were reported in U.S. studies, where females exhibited a higher incidence of DKA compared to males [16,23,24]. Furthermore, several sociodemographic and modifiable risk factors have been strongly associated with an increased risk of DKA. These include socioeconomic disadvantage, [24–27], adolescence [24,28], female sex [16,23,24,28], high HbA1c levels [29], prior episodes of DKA [29], and psychiatric comorbidities such as eating disorders and depression [29]. Certain demographic patterns reported in the U.S., such as the higher incidence in females and adolescents, align with our findings, underscoring the importance of addressing these risk factors in diabetes management.

The strength of our study lay in its use of AfterDx as an indicator of diabetes care quality. Our findings demonstrated a significant decline in AfterDx incidence in recent years, reflecting improvements in diabetes management. By incorporating data on both insulin therapies and glucose monitoring methods, our study provided indirect evidence of their combined impact on reducing AfterDx incidence. Furthermore, our analysis identified high-risk subgroups, including females, adolescents, and newly diagnosed patients as AfterDx risk factors. This detailed approach emphasizes the importance of targeted interventions and personalized care strategies to further reduce the burden of DKA. While our study provides valuable insights, several limitations should be acknowledged. The observed associations are correlational, limiting causal inferences. Being a single-center study, its generalizability may be constrained by regional and demographic differences. Additionally, the overlapping timeline of insulin degludec and CGM adoption with other care advancements makes it difficult to isolate specific contributions. The small number of patients using advanced technologies (CSII and AHCL) prevented us from robustly analyzing their individual effects on reducing AfterDx episodes. Although our data indirectly suggest a combined benefit, larger studies are needed to clarify each technology's specific contribution for reducing AfterDx incidence.

In conclusion, our study identified a statistically significant 43.1 % annual decline in AfterDx incidence from 2017 to 2022, emphasizing notable advancements in diabetes care and prevention. High-risk groups, particularly females and adolescents, require targeted interventions such as personalized education and psychosocial support. Additionally, sixty percent of DKA episodes occurred within the first 6 years of T1D diagnosis, emphasizing the need for enhanced education and monitoring during this critical period. Our findings also underscore the impact of new therapeutic technologies (e.g., adoption of insulin degludec and widespread application of CGM) on reducing AfterDx. By prioritizing patient education and resource allocation, healthcare policies can further reduce AfterDx incidence and improve long-term outcomes for patients with T1D.

Funding

This study was supported by grants NSC 100-2314-B-195-010 from the Ministry of Science and Technology, Executive Yuan, and MMH-E–108-07 from MacKay Memorial Hospital, Taipei, Taiwan.

Acknowledgments

We would like to thank the Department of Medical Research at Tamsui MacKay Memorial Hospital, especially statistician Miss FJ Sun, for her valuable assistance with statistical consultation.

References

- [1] Daneman D. Diabetes-related mortality. A pediatrician's view. *Diabetes Care* 2001; 24:801–2.
- [2] Wolfsdorf J, Craig ME, Daneman D, Dunger D, Edge J, Lee WR, et al. Diabetic ketoacidosis. *Pediatr Diabetes* 2007;8:28–43.
- [3] Harding JL, Pavkov ME, Magliano DJ, Shaw JE, Gregg EW. Global trends in diabetes complications: a review of current evidence. *Diabetologia* 2019;62:3–16.
- [4] Skinner TC. Recurrent diabetic ketoacidosis: causes, prevention and management. *Horm Res* 2002;57(Suppl 1):78–80.
- [5] Kao KT, 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.e2.
- [6] Schmitt J, Scott ML. Insulin Degludec in adolescents with type 1 diabetes: is newer better? – a retrospective self-control case series in adolescents with a history of diabetic ketoacidosis. *Horm Res Paediatr* 2019;92:179–85.
- [7] Roussel R, Riveline JP, Vicaute E, de Pouvourville G, Detournay B, Emery C, et al. Important drop in rate of acute diabetes complications in people with type 1 or type 2 diabetes after initiation of flash glucose monitoring in France: the RELIEF Study. *Diabetes Care* 2021;44:1368–76.
- [8] Al Hayek AA, Al Dawish MA. Frequency of diabetic ketoacidosis in patients with type 1 diabetes using FreeStyle libre: a retrospective chart review. *Adv Ther* 2021; 38:3314–24.
- [9] Karges B, Schwandt A, Heidtmann B, Kordonouri O, Binder E, Schierloh U, et al. Association of insulin pump therapy vs. insulin injection therapy with severe hypoglycemia, ketoacidosis, and glycemic control among children, adolescents, and young adults with type 1 diabetes. *JAMA* 2017;318:1358–66.
- [10] Phillip M, Nimri R, Bergenstal RM, Barnard-Kelly K, Danne T, Hovorka R, et al. Consensus recommendations for the use of automated insulin delivery technologies in clinical practice. *Endocr Rev* 2023;44:254–80.
- [11] American Diabetes Association Professional Practice Committee. 2. Diagnosis and classification of diabetes: standards of care in Diabetes-2024. *Diabetes Care* 2024; 47(Suppl 1):S20–42.
- [12] Craig ME, Codner E, Mahmud FH, Marcovecchio ML, DiMeglio LA, Priyambada L, et al. ISPAD Clinical Practice Consensus Guidelines 2022: editorial. *Pediatr Diabetes* 2022;23:1157–9.
- [13] Wolfsdorf J, Glaser N, Agus M, Fritsch M, Hanas R, Rewers A, et al. ISPAD Clinical Practice Consensus Guidelines 2018: diabetic ketoacidosis and the hyperglycemic hyperosmolar state. *Pediatr Diabetes* 2018;19(Suppl 27):155–77.
- [14] Wolfsdorf J, Glaser N, Sperling MA, American Diabetes Association. Diabetic ketoacidosis in infants, children, and adolescents: a consensus statement from the American Diabetes Association. *Diabetes Care* 2006;29:1150–9.
- [15] Schaffer AL, Dobbins TA, Pearson SA. Interrupted time series analysis using autoregressive integrated moving average (ARIMA) models: a guide for evaluating large-scale health interventions. *BMC Med Res Methodol* 2021;21:58.
- [16] Li L, Andrews EB, Li X, Doder Z, Zalmover E, Sharma K, et al. Incidence of diabetic ketoacidosis and its trends in patients with type 1 diabetes mellitus identified using a U.S. claims database, 2007–2019. *J Diabet Complications* 2021;35:107932.
- [17] Karges B, Kapellen T, Neu A, Hofer SE, Rohrer T, Rosenbauer J, et al. Long-acting insulin analogs and the risk of diabetic ketoacidosis in children and adolescents with type 1 diabetes: a prospective study of 10,682 patients from 271 institutions. *Diabetes Care* 2010;33:1031–3.
- [18] Huang QS, Wood T, Jelley L, Jennings T, Jefferies S, Daniells K, et al. Impact of the COVID-19 nonpharmaceutical interventions on influenza and other respiratory viral infections in New Zealand. *Nat Commun* 2021;12:1001.
- [19] Lo JY, Tsang TH, Leung YH, Yeung EY, Wu T, Lim WW. Respiratory infections during SARS outbreak, Hong Kong, 2003. *Emerg Infect Dis* 2005;11:1738–41.
- [20] Kong APS, Lim S, Yoo SH, Ji L, Chen L, Bao Y, et al. Asia-Pacific consensus recommendations for application of continuous glucose monitoring in diabetes management. *Diabetes Res Clin Pract* 2023;201:110718.
- [21] Karges B, Tittel SR, Bey A, Freiberg C, Klinkert C, Kordonouri O, et al. Continuous glucose monitoring versus blood glucose monitoring for risk of severe hypoglycaemia and diabetic ketoacidosis in children, adolescents, and young adults with type 1 diabetes: a population-based study. *Lancet Diabetes Endocrinol* 2023;11:314–23.
- [22] Hanlan ME, Griffith J, Patel N, Jaser SS. Eating disorders and disordered eating in type 1 diabetes: prevalence, screening, and treatment options. *Curr Diabetes Rep* 2013;13:909–16.
- [23] 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.
- [24] 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: 901–8.
- [25] Lewis KR, Clark C, Velarde MC. Socioeconomic factors associated with pediatric diabetic ketoacidosis admissions in Southern West Virginia. *Clin Endocrinol* 2014; 81:218–21.
- [26] Cherubini V, Marino M, Scaramuzza AE, Tiberi V, Bobbio A, Delvecchio M, et al. The silent epidemic of diabetic ketoacidosis at diagnosis of type 1 diabetes in children and adolescents in Italy during the COVID-19 pandemic in 2020. *Front Endocrinol (Lausanne)* 2022;13:878634.
- [27] Gesuita R, Maffei C, Bonfanti R, Cardella F, Citriniti F, D'Annunzio G, et al. Socioeconomic Inequalities increase the Probability of Ketoacidosis at Diagnosis of

- Type 1 diabetes: a 2014–2016 Nationwide Study of 2,679 Italian children. *Front Pediatr* 2020;8:575020.
- [28] Cherubini V, Grimsmann JM, Åkesson K, Birkebæk NH, Cinek O, Dovč K, et al. Temporal trends in diabetic ketoacidosis at diagnosis of paediatric type 1 diabetes between 2006 and 2016: results from 13 countries in three continents. *Diabetologia* 2020;63:1530–41.
- [29] Ehrmann D, Kulzer B, Roos T, Haak T, Al-Khatib M, Hermanns N. Risk factors and prevention strategies for diabetic ketoacidosis in people with established type 1 diabetes. *Lancet Diabetes Endocrinol* 2020;8:436–46.