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Research Article

Disrupted Pediatric Diabetes Trends in the Second Year of the COVID-19 Pandemic

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Abstract

Context: Increases in incident cases of pediatric type 1 (T1D) and type 2 diabetes (T2D) were observed during the first year of the COVID-19 pandemic.

Objective: This work aimed to identify trends in incidence and presentation of pediatric new-onset T1D and T2D during the second year of the COVID-19 pandemic.

Methods: A retrospective chart review was conducted. Demographics, anthropometrics, and initial laboratory results from patients aged 0 to 21 years who presented with new-onset diabetes to a pediatric tertiary care center were recorded.

Results: The incident cases of T1D (n = 46) and T2D (n = 46) in 2021-2022 (second year of the pandemic) were consistent with the incident cases of T1D (n = 46) and T2D (n = 53) in 2020 to 2021 (first year of the pandemic). Compared to the incident cases of diabetes in the prepandemic years, in the second year, the incident cases of T1D increased 48%, and the incident cases of T2D increased 188%. In the second year of the pandemic, incident cases of T2D represented half (50%) of all newly diagnosed pediatric diabetes cases. Patients with T2D were more likely to present in diabetic ketoacidosis, though this was not statistically significant ($P = .08$).

Conclusion: The increase in incident cases of pediatric T1D and T2D observed during the first year of the COVID-19 pandemic persisted during the second pandemic year. This suggests that despite pediatric vaccination efforts and return to social in-person activities, we may continue to see effects of the pandemic on pediatric diabetes trends.

Key Words: pediatric diabetes, type 1 diabetes, type 2 diabetes, COVID-19, diabetic ketoacidosis

Abbreviations: BMI, body mass index; BOHB, β-hydroxybutyrate; BUN, blood urea nitrogen; DKA, diabetic ketoacidosis; HbA_{1c}, glycated hemoglobin A_{1c}; IgA, immunoglobulin A; T1D, type 1 diabetes; T2D, type 2 diabetes.

The COVID-19 pandemic had substantial effects on pediatric diabetes regionally, nationally, and globally, with an increase in incident cases of pediatric type 1 (T1D) and type 2 (T2D) diabetes; there was also an increase in severity of diabetic ketoacidosis (DKA) in T1D and T2D during the first year of the pandemic [1-8]. More important, incident T2D cases were higher than incident T1D cases during the first year of the pandemic, suggesting a disruption and change in pediatric diabetes trends that historically have favored T1D 4:1 over T2D in pediatric populations [9].

Multiple theories have been proposed to explain the increasing incident and severity of pediatric diabetes cases during the COVID-19 pandemic. SARS-CoV-2 may be damaging pancreatic β cells and promoting autoimmunity; proposed mechanisms include viral entry into islets (via specific viral entry proteins), replication within islets, and cytokine storming through the proinflammatory state created by SARS-CoV-2 [10, 11]. There are also data demonstrating COVID-19–induced inflammation exacerbating insulin resistance, lowering the threshold for metabolic decompensation into DKA for T1D [12]. During the COVID-19 pandemic there were decreased clinic visits and delays in seeking urgent medical treatment, which could correlate with an increased severity of DKA presentations [13-15]. Additionally, the increase in sedentary lifestyle and decrease in physical activity observed during the pandemic led to an increase in childhood obesity rates [16, 17], subsequently placing youth at higher risk of developing T2D [18].

COVID vaccination rates increased in 2021 to 2022, the second year of the pandemic, especially in pediatric populations [19, 20]. Additionally, schools started returning to in-person learning as well as resuming in-person social and physical activities [21]. Given these changes, it was unknown whether the previously established pandemic diabetic trends would persist during the second year. Our objective in this study was to determine the trend in incident cases and presentation of pediatric new-onset T1D and T2D during the second year of the COVID-19 pandemic.

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Materials and Methods

Study Design and Data Collection

All the data reported in the present study were obtained by retrospective chart review of patients admitted to Duke University Hospital or seen in Duke diabetes outpatient clinics with new-onset diabetes during a 4-year period. Four distinctive cohorts were created for patients included from April 1, 2018 through March 31, 2022. The first 2 cohorts representing the prepandemic era span April 1, 2018 through March 31, 2020. The latter 2 cohorts representing the postpandemic era span April 1, 2020 through March 31, 2021 and April 1, 2021 through March 31, 2022.

The electronic medical record search included any patient between ages 0 and 21 years (inclusive), who had a diagnosis of new-onset diabetes mellitus at Duke University Medical Center. These included International Classification of Diseases, tenth revision codes E10 (T1D) and E11.0 to E11.8 (T2D) admitted to Duke University or seen in diabetes outpatient clinics (Lenox Baker Children's Hospital, Children's Health Center, Duke Children's Apex and Raleigh Endocrinology) between April 1, 2018 and March 30, 2022. The data curated from electronic medical records included patient information regarding sex, race, ethnicity, date of birth, date of diagnosis, insurance, and anthropometric measures (height, weight, body mass index [BMI], BMI %, and BMI SD score [BMI *z* score]). We collected the following measurements and laboratory results during initial presentation: blood pressure (systolic and diastolic), heart rate, respiratory rate, glycated hemoglobin A_{1c} (HbA_{1c}), glucose, pH (venous), bicarbonate, β-hydroxybutyrate (BOHB), anion gap, initial C-peptide, and plasma osmolality (when available). Additionally, we collected alanine transaminase and alanine transaminase, along with blood urea nitrogen (BUN) and creatinine levels to reflect liver and kidney function tests, respectively. Given the effects of COVID-19 on inflammatory and autoimmune processes, we also collected white blood cell count, hemoglobin, platelet count, thyrotropin, free thyroxine, and celiac panel (total immunoglobulin A and tissue transglutaminase antibodies) at presentation. COVID test results were recorded if tested, using COVID-19 SARS-CoV-2 polymerase chain reaction or point-of-care COVID-19 SARS-CoV-2 Rapid Test.

This protocol was approved and deemed exempt by Duke University Health System institutional review board.

Definitions

The criteria used in the present study for new-onset diabetes mellitus are in line with the guidelines of the American Diabetes Association. This requires a patient to have an HbA_{1c} greater than or equal to 6.5%, a fasting plasma glucose greater than or equal to 126 mg/dL, or a random glucose greater than or equal to 200 mg/dL with symptoms of diabetes [22]. T1D diagnosis was based on the presence of positive autoantibodies against GAD65, islet antigen 2, insulin, or zinc transporter 8, and a requirement for insulin. The diagnosis of T2D in patients was based on the absence of autoantibodies and BMI % of at least 85% within 6 months of diagnosis. Patients whose autoantibody test results were not available were categorized based on the impression of the pediatric endocrinologist with consideration of their initial presentation, weight trends, and insulin requirements.

The following definitions referred to in this study are similar to those described in our previous publication [1]. DKA was defined as a serum pH less than or equal to 7.3 or bicarbonate less than or equal to 15 mmol/L, with ketonemia or ketonuria and glucose of 200 mg/dL or greater. DKA was further categorized as severe with venous pH less than 7.1, moderate with venous pH between 7.1 and 7.19, or mild with venous pH between 7.2 and 7.3 [1]. Plasma osmolality was calculated by using the following formula (Posm = 2 [Na] + glucose (mg/dL)/18 + BUN (mg/dL)/2.8) unless it was measured directly [23]. For calculations, uncorrected sodium levels were used. Celiac screening was considered positive if the tissue transglutaminase antibodies were 20 units or greater.

Statistical Analysis

Descriptive statistics (eg, mean, SD) and statistical analyses of continuous variables (eg, analysis of variance) were performed using Excel (2016). Statistical analyses of categorical variables were performed by χ^2 test or Fisher test using R studio version 3.5.2. Cochran Armitage trend tests (1-tailed; P value cut = .05) were performed to assess for increases in diabetes severity and T1D vs T2D proportion across the 4 year-study-period using R (version 1.4.1106) and the DescTools package [24, 25].

Results

Demographic and Anthropometric Trends

From April 2018 through March 2022, a total of 286 pediatric patients were diagnosed with diabetes: 154 patients with T1D and 132 patients with T2D (Tables 1 and 2). During the 4 years, there were no significant changes in the trends of demographics (age, sex, race, or ethnicity) of the newly diagnosed patients, for T1D or T2D. In 2021 to 2022, for patients with T1D, 46% were White, 37% were Black or African American, and 7% were Hispanic or Latino. In the same year, for patients with T2D, 17% were White, 66% were Black or African American, and 17% were Hispanic or Latino (see Tables 1 and 2). For patients with T2D, there was a significant change in the type of insurance recorded in 2021 to 2022; 39% of patients with public insurance and 57% with private insurance ($P = .002$), compared to the prior year, during which 73% and 23% of patients had public or private insurance, respectively. In 2021 to 2022, 53 patients were tested for COVID-19 and 2 patients tested positive.

The BMI-related metrics of patients with T2D continued to be higher than those with T1D; BMI *z* scores of 2.41 ± 0.46 (98.17 ± 2.51 percentile) compared to -0.002 ± 1.35 (51.42 ± 33.26 percentile) in 2021 to 2022 (Tables 3 and 4). Anthropometric data did not significantly change over the 4-year period for T2D. In 2020 to 2021, BMI was increasing in T1D; however, in the most recent year, BMI *z* score decreased to -0.002 ± 1.35 (51.42 ± 33.26 percentile), compared to 0.49 ± 1.21 (64.83 ± 28.62 percentile) the year prior (see Tables 3 and 4).

Changes in Incident Cases of Type 1 Diabetes and Type 2 Diabetes

The incident cases of T1D (n = 46) and T2D (n = 46) in 2021 to 2022 were similar to the incident cases of T1D (n = 46) and T2D (n = 53) in 2020 to 2021. New cases of T1D increased by 48% compared to prepandemic rates. The diagnoses of T2D

Table 1. Type 1 diabetes demographic data in prepandemic and pandemic years

	2018-2019 (n-31)	2019-2020 (n-31)	2020-2021 (n-46)	2021-2022 (n-46)	*P*
Age at Dx, y	9.87 (3.49)	10.39 (4.89)	10.46 (3.67)	9.65 (3.72)	.7419
Sex					
Male	14 (45%)	14 (45%)	30 (65%)	22 (48%)	.195
Female	17 (55%)	17 (55%)	16 (35%)	24 (52%)	.195
Race					
White	20 (65%)	18 (58%)	30 (65%)	21 (46%)	.2219
Black or African American	8 (26%)	10 (33%)	10 (22%)	17 (37%)	.4175
More than one race	1 (3%)	0 (0%)	0 (0%)	0 (0%)	.4026
American Indian or Alaska Native	0 (0%)	1 (3%)	0 (0%)	0 (0%)	.4026
No response/other	2 (6%)	2 (6%)	6 (13%)	6 (13%)	.4926
Asian	0 (0%)	0 (0%)	0 (0%)	2 (4%)	.3362
Ethnicity					
Hispanic or Latino	3 (10%)	3 (10%)	6 (13%)	3 (7%)	.7474
Non-Hispanic or Latino	27 (87%)	27 (87%)	39 (85%)	42 (91%)	.6207
No response	1 (3%)	1 (3%)	1 (2%)	1 (2%)	≥.999
Insurance					
Public	9 (29%)	15 (48%)	19 (41%)	13 (28%)	.1881
Private	21 (68%)	16 (52%)	24 (52%)	30 (65%)	.3474
Uninsured	1 (3%)	0 (0%)	3 (7%)	3 (7%)	.5335

Abbreviation: Dx, diagnosis.

in 2021 to 2022 (n = 46) continued to be dramatically elevated compared to prepandemic cases in 2018 to 2019 (n = 17) and 2019 to 2020 (n = 16); this reflected an incident increase of 188%. In the second year of the pandemic, incident cases of T2D represented half (50%) of all newly diagnosed pediatric diabetes cases, similarly identified in 2020 to 2021, the first year of the pandemic (Fig. 1).

Clinical Severity

In 2021 to 2022, the average HbA_{1c} at diagnosis was 12.31% for T1D (Table 5) and 9.55% for T2D, consistent with trends seen in years prior (Table 6). There were no statistical differences in liver or kidney function at diagnosis over the 4 years (Tables 7 and 8). Over the 4 years, 51% (n = 78) of patients with new-onset T1D presented with DKA, with 45% in 2018 to 2019, 55% in 2019 to 2020, 49% in 2020 to 2021, and 52% in 2021 to 2022 (Table 9 and Fig. 2). During this time, 17% (n = 22) of patients with new-onset T2D presented with DKA, with 12% (n = 2) in 2018 to 2019, 6% (n = 1) in 2019 to 2020, 22% (n = 12) in 2020 to 2021%, and 15% (n = 7) in 2021 to 2022 (Table 10 and Fig. 2). Overall, compared with prepandemic years, patients with T2D were more likely to present with DKA, though this was not statistically significant ($P = .08$). We did not observe any differences in white blood cell or platelet counts, thyroid functions or celiac screening results over the 4 years (Table 11).

Discussion

The increase in incident cases of pediatric T1D and T2D observed during the first year of the COVID-19 pandemic persisted during the second pandemic year despite pediatric vaccination efforts and return to social in-person activities. More important, in the second year of the pandemic, incident cases of T2D represented half (50%) of all newly diagnosed pediatric diabetes cases and patients with T2D were more likely to present with DKA. This has profound implications for long-term complication risks in children and for community health consequences as we may continue to see effects of the pandemic on pediatric diabetes trends.

Emerging epidemiologic evidence suggests worrisome increases in the incident cases of T1D and T2D in adults and children during the first year of the pandemic [2-8, 26]. Findings at the American Family Children's Hospital in Madison, Wisconsin, revealed the incidence of T1D and T2D increased significantly: 69% and 225% respectively in 2020 to 2021 ($P < .001$) [2]; in addition, a multicenter analysis of 24 US children's hospitals demonstrated new cases of T2D increased by 77.2% in 2020 to 2021 [6]. However, studies investigating the effect in the second pandemic year are sparse [27, 28].

Our study is one of the first studies to assess the pediatric diabetes trends in later months of the pandemic, specifically into 2022. Additionally, by measuring a 12-month interval after the onset of the COVID-19 pandemic, our cross-sectional study accounted for seasonal variation in the onset of new T1D cases [29, 30]. The persistent increase in pediatric diabetes diagnoses seen in the second year of the pandemic (48% for T1D and 188% for T2D) is drastically different from trends in prepandemic years. A recent study analyzing data from the SEARCH for Diabetes in Youth study reported that between 2002 and 2017 there were increased incidences of 3% for T1D and 69% for T2D [31]. Our data demonstrate that for the second consecutive year of the pandemic, we are seeing incident case rates that far surpass trends in prepandemic years.

Physiologic and psychosocial factors have been cited as etiologies to explain these new and persistent trends in pediatric diabetes cases during the COVID-19 pandemic [10-17]. In the

Table 2. Type 2 diabetes demographic data in prepandemic and pandemic years

	2018-2019 (n-17)	2019-2020 (n-16)	2020-2021 (n-53)	2021-2022 (n-46)	*P*
Age at Dx, y	14.00 (2.35)	12.94 (2.64)	13.81 (2.35)	14.00 (2.28)	.4634
Sex					
Male	7 (41%)	7 (44%)	25 (47%)	25 (54%)	.7656
Female	10 (59%)	9 (56%)	28 (53%)	21 (46%)	.7656
Race					
White	2 (12%)	3 (19%)	4 (8%)	8 (17%)	.4064
Black or African American	12 (70%)	13 (81%)	33 (62%)	30 (66%)	.5751
More than one race	0 (0%)	0 (0%)	0 (0%)	0	≥.999
American Indian or Alaska Native	0 (0%)	0 (0%)	2 (4%)	0	.7180
No response	3 (18%)	0 (0%)	14 (26%)	8 (17%)	.2042
Ethnicity					
Hispanic or Latino	3 (18%)	0 (0%)	11 (20%)	8 (17%)	.2309
Non-Hispanic or Latino	14 (82%)	16 (100%)	39 (74%)	37 (81%)	.1128
No response	0 (0%)	0 (0%)	3 (6%)	1 (2%)	.8820
Insurance					
Public	12 (71%)	12 (75%)	39 (73%)	18 (39%)	.0020
Private	5 (29%)	3 (19%)	12 (23%)	26 (57%)	.0018
Uninsured	0 (0%)	1 (6%)	2 (4%)	2 (4%)	.8371

Abbreviation: Dx, diagnosis.

Table 3. Body mass index–related metrics in type 1 diabetes cases

	2018-2019 Mean (SD)	2019-2020 Mean (SD)	2020-2021 Mean (SD)	2021-2022 Mean (SD)	*P*
Height, cm	144.78 (20.47)	144.09 (27.36)	145.25 (23.16)	144.29 (21.11)	.996
Weight, kg	39.59 (17.40)	45.17 (23.81)	45.20 (21.57)	38.89 (17.11)	.325
BMI	18.13 (4.27)	20.52 (5.56)	20.68 (5.64)	18.23 (4.07)	.030
BMI, %	47.48 (35.48)	61.71 (33.27)	64.83 (28.62)	51.42 (33.26)	.071
BMI, *z* score	−0.10 (1.55)	0.40 (1.62)	0.49 (1.21)	−0.002 (1.35)	.197

Abbreviation: BMI, body mass index.

Table 4. Body mass index–related metrics in type 2 diabetes cases

	2018-2019 Mean (SD)	2019-2020 Mean (SD)	2020-2021 Mean (SD)	2021-2022 Mean (SD)	*P*
Height, cm	162.46 (11.66)	164.19 (8.59)	167.02 (11.51)	168.48 (10.98)	.214
Weight, kg	95.02 (25.31)	96.20 (20.73)	106.71 (35.67)	107.14 (31.03)	.361
BMI	35.67 (6.46)	35.56 (6.33)	37.59 (9.90)	37.37 (7.88)	.746
BMI, %	98.05 (2.15)	98.18 (1.79)	96.83 (6.05)	98.17 (2.51)	.387
BMI, *z* score	2.42 (0.60)	2.40 (0.39)	2.36 (0.60)	2.41 (0.46)	.963

Abbreviation: BMI, body mass index.

second year of the COVID-19 pandemic, increased implementation of public safety measures assisted in the return to prepandemic life, notably vaccination efforts, mask mandates, and social distancing. The first child to be vaccinated against COVID-19 (outside clinical trials) occurred in November 2021 [19]. According to the Centers for Disease Control and Prevention, as of January 2023, 11.1 million US children aged 5 to 11 received at least 1 dose of COVID-19 vaccine (representing 39% of 5- to 11-year-olds), and 17.8 million US children aged 12 to 17 received at least 1 dose of COVID vaccine (representing 68% of 12- to 17-year-olds) [20]. This percentage varied from state to state. In North

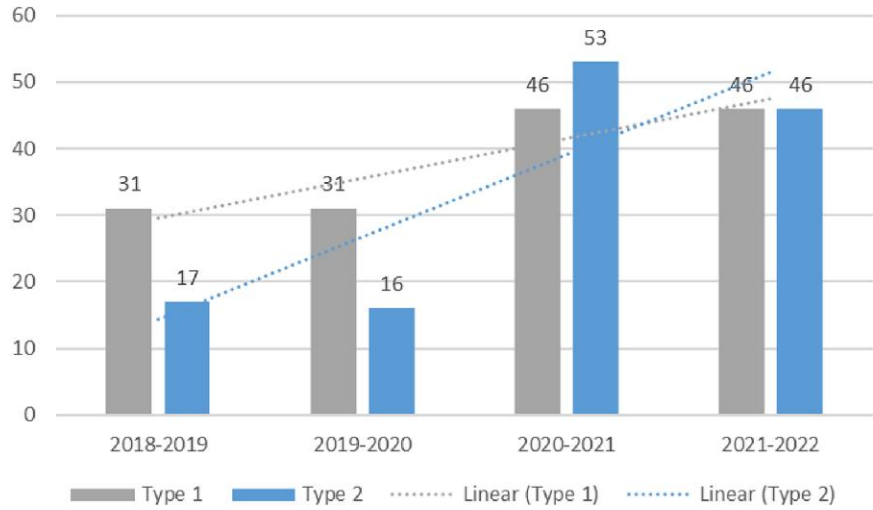

Figure 1. Incident cases of pediatric type 1 diabetes and type 2 diabetes rose significantly during the COVID-19 pandemic both the first and second year, compared with the prior 2 years. Exact number of cases are indicated at the top of each bar with a trend line.

Table 5. Initial laboratory results in type 1 diabetes cases

	2018-2019 Mean (SD)	2019-2020 Mean (SD)	2020-2021 Mean (SD)	2021-2022 Mean (SD)	*P*
HBA_{1c}	12.28 (2.52)	12.68 (2.06)	12.09 (2.54)	12.31 (2.32)	.759
Initial glucose	462.61 (151.14)	522.84 (172.35)	497.61 (257.95)	484.28 (271.86)	.766
pH	7.22 (0.18)	7.23 (0.16)	7.25 (0.17)	7.22 (0.18)	.899
Bicarbonate	16.36 (8.53)	15.51 (8.08)	17.08 (8.05)	17.78 (8.07)	.683
BOHB	5.68 (2.53)	4.79 (2.72)	4.89 (2.82)	5.20 (3.34)	.774
Anion gap	17.71 (6.27)	18.31 (5.47)	17.72 (6.28)	19.53 (6.67)	.506
Initial C-peptide	0.49 (0.44)	0.53 (0.32)	0.71 (1.01)	0.68 (0.52)	.458
Plasma osmolarity	298.86 (11.50)	299.08 (11.64)	298.42 (12.96)	301.30 (23.32)	.844

Abbreviations: BOHB, β-hydroxybutyrate; HbA_{1c}, glycated hemoglobin A_{1c}.

Table 6. Initial laboratory results in type 2 diabetes cases

	2018-2019 Mean (SD)	2019-2020 Mean (SD)	2020-2021 Mean (SD)	2021-2022 Mean (SD)	*P*
HBA_{1c}	9.04 (2.62)	9.56 (2.67)	10.31 (2.85)	9.55 (2.87)	.326
Initial glucose	248.06 (146.80)	276.13 (145.16)	358.64 (293.71)	296.93 (207.28)	.278
pH	7.27 (0.11)	7.27 (0.11)	7.26 (0.13)	7.28 (0.10)	.955
Bicarbonate	21.36 (6.98)	23.00 (4.81)	20.82 (7.03)	19.28 (8.57)	.594
BOHB	2.84 (3.51)	2.39 (1.67)	3.60 (3.12)	3.84 (3.61)	.876
Anion gap	11.82 (4.42)	12.10 (4.58)	15.00 (7.65)	14.10 (5.69)	.378
Initial C-peptide	3.68 (2.82)	3.10 (2.24)	2.84 (2.94)	2.75 (1.81)	.755
Plasma osmolarity	292.51 (6.31)	294.09 (9.89)	299.08 (21.35)	293.55 (14.03)	.449

Abbreviations: BOHB, β-hydroxybutyrate; HbA_{1c}, glycated hemoglobin A_{1c}.

Carolina (NC), according to the NC Department of Human and Health services, at least 37% of children aged 5 to 17 received 1 dose of the COVID-19 vaccine [32] by January 2023. In NC, in the beginning of the 2020 academic school year, most schools were using virtual or hybrid learning; by June 2021, most schools returned to an in-person format [21]. Our data suggest that the incident cases of new-onset pediatric diabetes remained at a persistently elevated level despite vaccination efforts and return to in-person activities.

We explored additional causes for increased diabetes diagnoses in 2021 to 2022, the second year of the pandemic. There was a slight decline in total number of children in NC from 2018 to 2021, from 2 304 529 to 2 301 503 [33]. The number of patients seen (virtual and in person) in Duke pediatric

Table 7. Initial secondary organ involvement and autoimmune laboratory results in type 1 diabetes cases

	2018-2019 Mean (SD)	2019-2020 Mean (SD)	2020-2021 Mean (SD)	2021-2022 Mean (SD)	*P*
ALT	19.69 (6.45)	16.65 (3.89)	23.46 (23.03)	18.17 (8.11)	.326
AST	17.38 (4.79)	17.26 (6.23)	20.75 (7.97)	19.44 (6.36)	.255
BUN	15.87 (11.50)	13.55 (5.57)	13.02 (4.67)	14.87 (9.01)	.417
Creatinine	0.87 (0.63)	0.83 (0.31)	0.83 (0.35)	0.91 (0.57)	.857
WBC	11.92 (8.10)	10.48 (6.16)	10.20 (6.39)	12.22 (9.57)	.613
Platelet	335.00 (78.66)	322.55 (10.65)	310.38 (91.77)	308.92 (87.10)	.655
Hgb	14.66 (1.06)	14.51 (1.32)	14.81 (1.54)	14.75 (1.39)	.827
Na	133.84 (4.08)	132.94 (4.73)	132.96 (3.83)	134.54 (6.10)	.365
Corrected Na	138.90 (3.75)	139.87 (5.38)	139.33 (4.12)	140.46 (8.68)	.693
FT4	0.97 (0.23)	0.93 (0.23)	0.94 (0.20)	0.89 (0.24)	.560
TSH	2.56 (2.80)	1.96 (1.46)	2.21 (1.31)	2.26 (1.98)	.700
IgA	169.46 (103.42)	167.34 (100.59)	176.21 (100.41)	238.68 (500.77)	.662
TTIgA	8.32 (10.96)	12.69 (25.17)	17.41 (36.53)	10.68 (21.23)	.501

Abbreviations: ALT, alanine transaminase; AST, aspartate transaminase; Hgb, hemoglobin; BUN, blood urea nitrogen; FT4, free thyroxine; IgA, immunoglobulin A, Na, sodium; TSH, thyrotropin; TTIgA, tissue transglutaminase immunoglobulin A; WBC, white blood cell count.

Table 8. Initial secondary organ involvement and autoimmune laboratory results in type 2 diabetes cases

	2018-2019 Mean (SD)	2019-2020 Mean (SD)	2020-2021 Mean (SD)	2021-2022 Mean (SD)	*P*
ALT	41.77 (45.36)	53.10 (99.38)	50.89 (53.89)	41.48 (41.67)	.870
AST	32.38 (33.63)	33.33 (46.48)	38.49 (32.44)	28.93 (25.12)	.701
BUN	9.61 (3.36)	10.67 (3.89)	10.11 (5.90)	10.67 (10.17)	.967
Creatinine	0.72 (0.22)	0.80 (0.34)	0.90 (0.72)	0.92 (0.65)	.725
WBC	10.00 (3.06)	9.46(3.65)	10.22 (4.67)	10.64 (4.48)	.936
Platelet	345.28 (73.35)	322.43 (49.77)	296.42 (69.90)	299.87 (104.88)	.435
Hgb	14.01 (1.71)	14.39 (1.20)	14.41 (1.83)	14.65 (1.95)	.875
Na	136.43 (3.34)	136.25 (2.60)	135.09 (4.52)	135.39 (3.44)	.618
Corrected Na	139.14 (2.35)	139.58 (2.50)	139.22 (3.90)	139.30 (3.60)	.989
FT4	2.21 (3.74)	1.03 (0.18)	0.94 (0.18)	0.91 (0.16)	.048
TSH	1.37 (0.79)	7.91 (15.90)	2.28 (1.15)	2.45 (1.67)	.012
IgA	170.8 (65.09)	143.00 (21.21)	199.60 (93.16)	187.00 (121.68)	.834
TTIgA	3.80 (1.64)	3.50 (0.71)	3.60 (2.08)	4.00 (1.51)	.923

Abbreviations: ALT, alanine transaminase; AST, aspartate transaminase; Hgb, hemoglobin; BUN, blood urea nitrogen; FT4, free thyroxine; IgA, immunoglobulin A, Na, sodium; TSH, thyrotropin; TTIgA, tissue transglutaminase immunoglobulin A; WBC, white blood cell count.

Table 9. Type 1 diabetes cases presenting in diabetic ketoacidosis (DKA) and DKA severity by pH

	pH	2018-2019	%	2019-2020	%	2020-2021	%	2021-2022	%
	<7.1	8	26%	8	26%	7	15%	10	22%
	7.1-7.19	4	13%	3	10%	5	11%	2	4%
	7.2-7.3	2	6%	6	19%	11	23%	12	26%
Total		14	45%	17	55%	23	49%	24	52%

outpatient diabetes clinics was also relatively consistent over the 4 years. Likewise, the number of referrals we received from different counties stayed consistent. Thus, the increased incident cases of pediatric T1D and T2D cannot solely be explained by changes in population, clinic visits, or referral numbers.

Although there were no statistically significant changes in the demographics of patients with newly diagnosed T1D over the 4 years, it should be noted that there is still a large racial and ethnic disparity between the patients with T1D and T2D. In the second year of the pandemic, 37% of the children diagnosed with T1D were Black and 7% were Hispanic or

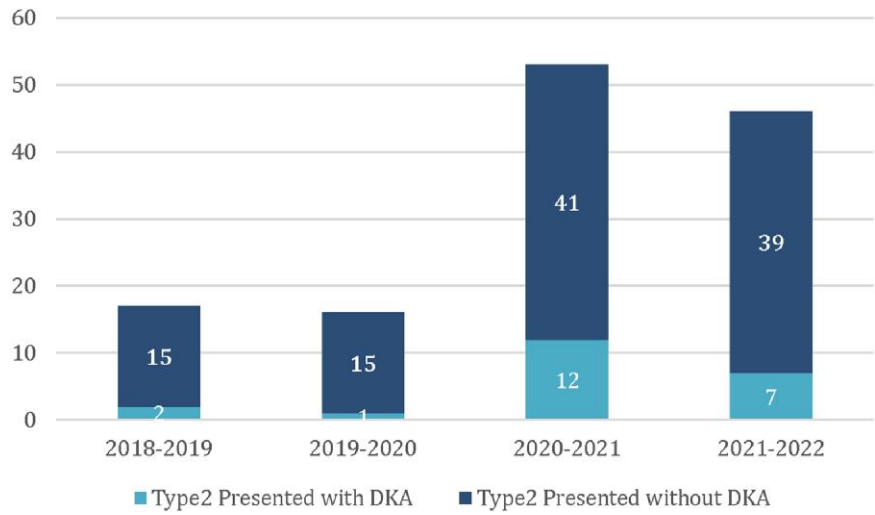

Figure 2. Number of type 2 diabetes patients presenting with diabetic ketoacidosis (DKA) in prepandemic and pandemic years.

Table 10. Type 2 diabetes cases presenting in diabetic ketoacidosis (DKA) and DKA severity by pH

	pH	2018-2019	%	2019-2020	%	2020-2021	%	2021-2022	%
	<7.1	0	0%	0	0%	4	8%	1	2%
	7.1-7.19	1	6%	1	6%	1	2%	2	4%
	7.2-7.3	1	6%	0	0%	7	13%	4	9%
Total		2	12%	1	6%	12	22%	7	15%

Table 11. Number of patients with abnormal celiac panel results in each year

		2018-2019		2019-2020		2020-2021		2021-2022	
IgA ≥ 203 mg/dL		**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
	Type 1	7	22.6	12	38.7	14	30.4	11	23.9
	Type 2	1	5.9	0	0	10	18.9	4	8.7
TTIgA ≥20 units		**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
	Type 1	4	12.9	4	12.9	8	17.4	4	8.7
	Type 2	0	0	0	0	0	0	0	0

Abbreviations: IgA, immunoglobulin A; TTIgA, tissue transglutaminase immunoglobulin A.

Latino; 66% of those patients diagnosed with T2D were Black and 17% were Hispanic or Latino. Although the trend over the past 2 years demonstrates T2D incidence approaching and even surpassing T1D incidence, the demographic makeup of the newly diagnosed pediatric patients is remaining largely stable. If the increased incidence of T2D continues to accelerate, minority children and youth will be disproportionally affected.

We found that BMI-related metrics for children and youth diagnosed with T1D declined in the second year of the pandemic; but not in children and youth diagnosed with T2D. Efforts to increase physical activity with group sports and in-person schooling in the second year of the pandemic may not have been equally effective with minority children and youth. We also found that percentages of patients in our clinics with public insurance decreased and those with private insurance increased among children and youth diagnosed with T2D. This is contradictory to national trends that reveal increased enrollment of public insurance, such as Medicaid/Children's Health Insurance Program, throughout the pandemic [34]. If the incidence of T2D in children continues to increase, we will possibly continue to see additional demographic changes in years to come.

Limitations of this study include our small sample size and confinement to a single medical center; our data may not be generalizable to a larger population. Our population did not include such high-risk racial and ethnic minority groups as American Indians, Pacific Islanders, and Asian Americans in our T2D cohort. It is important to highlight that only 2 patients tested positive for COVID-19, thus we cannot state

that the trends observed were due to direct effects of COVID-19 infection. Notably, we did not measure SARS-CoV-2 antibodies and therefore do not know if any of the patients presenting after March 2020 had a prior COVID-19 infection that could have contributed to pancreatic damage [35]. There was no COVID-19 testing completed in the outpatient setting. Lastly, we cannot derive the incidence data because of the lack of an appropriate denominator.

In summary, our study reports that the incident cases of T1D and T2D in 2021 to 2022 (second year of the pandemic) was consistent with the incident cases of T1D and T2D in the first year of the pandemic. Compared to prepandemic years, incident cases of T1D increased by 48% in the second year and the incident cases of T2D increased by 188%. New cases of T2D represented 50% of all newly diagnosed pediatric diabetes cases at Duke University Medical Center. Youth with newly diagnosed T2D were more likely to present with DKA than those pediatric T2D patients diagnosed before the pandemic. Increased pediatric vaccination efforts and a return to in-person activities did not decrease the marked rise in T2D diagnosis rate in our pediatric patients. Given that T2D has a more aggressive course in youth than in adults, with early and rapid deterioration of β-cell function, rapid progression to insulin dependence, and higher prevalence and earlier presentation of diabetes complications, this raises great concern for long-term complications and comorbidities leading to profound individual and community health consequences [36-38]. More longitudinal data are needed to establish if pediatric diabetes trends will return to prepandemic rates, or if this rate of acceleration will persist for years to come.

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Disclosures

The authors have nothing to disclose.

Data Availability

Some or all data sets generated or analyzed during this study are included in this published article or in the data repositories listed in the References.

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