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Key Insight: Providers should be aware of the escalating incidence of youth-onset type 2 diabetes to avoid delays in diagnosis and inform educational programs to combat the continued impact of the pandemic on health outcomes.

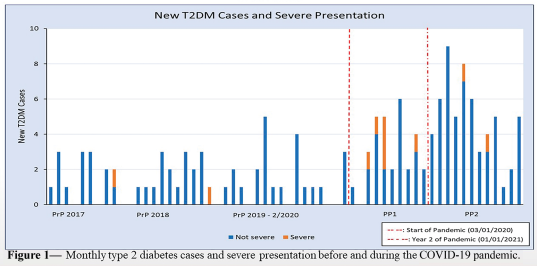
Context and Objective(s)

- Pediatric endocrinologists noted an increase in both the rates and severity of presentation of youth-onset type 2 diabetes during the start of the COVID-19 pandemic [1].
- We aimed to determine how the incidence and presentation evolved in the second year of the pandemic.

Design and Methods

- We performed a retrospective chart review of youth ≤ 21 years with new-onset type 2 diabetes treated at Hasbro Children's Hospital between 1/1/2017 and 2/29/2020 (prepandemic period, PrP), compared to those diagnosed between 3/1/2020 and 12/31/2021 (pandemic period, PP).
- The PP was divided by year: PP1:3/1/20-12/31/20; PP2:1/1/2021-12/31/2021.

Results



COVID-19, corona virus disease 2019, DKA, diabetic ketoacidosis; HHS, hyperglycemic hyperosmolar syndrome; T2DM, type 2 diabetes mellitus

Figure 1— Monthly type 2 diabetes cases and severe presentation before and during the COVID-19 pandemic.

Results continued

- The annualized incidence of type 2 diabetes increased nearly threefold during the pandemic vs. prior, with a 61% increase in the second vs. first year.
- BMI increased during the pandemic vs. prior (129% of 95th%tile vs. 141%, $P = 0.02$)
- In the first year, patients were younger (12.9 years vs. 14.8, $P < 0.001$), with higher incidence of DKA and/or HHS vs. prior (20% vs. 3.6%, $P = 0.03$) and PP2 (20% vs. 3.5%, $P = 0.02$).

1. Magge SN, Wolf RM, Pyle L, Brown EA, Benavides VC, Bianco ME, et al. The COVID-19 pandemic is associated with a substantial rise in frequency and severity of presentation of youth-onset type 2 diabetes. *J Pediatr.* 2022; 2022;251:51–59.e2.

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ARTICLE HIGHLIGHTS

- Pediatric endocrinologists noted an increase in the incidence and severity of presentation of youth-onset type 2 diabetes during the first year of the coronavirus disease 2019 pandemic.
- We aimed to determine how the incidence and presentation evolved in pandemic year 2.
- We found a nearly threefold increase in incidence, which continued to rise through 2021, aligned with increasing BMI percentile at presentation. In pandemic year 1, patients were younger and more likely to have severe presentation.
- Awareness of the escalating incidence of youth-onset type 2 diabetes is essential to avoid delays in diagnosis and inform educational programs.

Incidence, Severity, and Presentation of Type 2 Diabetes in Youth During the First and Second Year of the COVID-19 Pandemic

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OBJECTIVE

To describe the evolving impact of the coronavirus disease 2019 pandemic on the incidence and presentation of new-onset pediatric type 2 diabetes.

RESEARCH DESIGN AND METHODS

Retrospective medical record review of youth with new-onset type 2 diabetes comparing the prepandemic period (1 January 2017–29 February 2020) with the first (1 March 2020–31 December 2020) and second pandemic year (1 January 2021–31 December 2021).

RESULTS

The annualized incidence of type 2 diabetes increased nearly threefold during the pandemic versus prior, with a 61% increase in the 2nd versus 1st year. BMI increased during the pandemic versus prior (129% of 95th percentile vs. 141%, $P = 0.02$). In the 1st year, patients were younger (12.9 years vs. 14.8, $P < 0.001$), with higher incidence of diabetic ketoacidosis and/or hyperglycemic hyperosmolar syndrome (20% vs. 3.5%, $P = 0.02$) versus prior.

CONCLUSIONS

Providers should be aware of the escalating incidence of youth-onset type 2 diabetes to avoid delays in diagnosis and inform educational programs to combat the continued impact of the pandemic on health outcomes.

An increase in the rate and severity of presentation of youth-onset type 2 diabetes during the initial phase of the coronavirus disease 2019 (COVID-19) pandemic was observed (1–10). To better understand the changing incidence and presentation of youth-onset type 2 diabetes during the continued course of the COVID-19 pandemic, we analyzed the incidence and presentation during the pandemic period (PP) compared with the prepandemic period (PrP). The PP period was further evaluated by looking at the changes in the 1st year (PP1) versus the 2nd year (PP2) of the pandemic.

RESEARCH DESIGN AND METHODS

We performed a retrospective medical record review of youth with new-onset type 2 diabetes during the PP (1 March 2020–31 December 2021) compared with the PrP

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Table 1—Demographic factors during the study period: PrP vs. PP, PrP vs. PP1/PP2, and PP1 vs. PP2

	PrP 1/1/17–2/29/20 (*n* = 56)	PP 3/1/20–12/31/21 (*n* = 88)	*P* value	PP1 3/1/20–12/31/20 (*n* = 30)	*P* value (PrP vs. PP1)	PP2 1/1/21–12/31/21 (*n* = 58)	*P* value (PrP vs. PP2)	*P* value (PP1 vs. PP2)
Age (years), mean (SD)	14.8 (1.9)	14.1 (2.2)	0.08[1]	12.9 (2.4)	0.001[1]	14.8 (2.1)	1.00[1]	<0.001[1]
Age ≤10 years	0 (–)	7 (7.9)		6 (20.0)	0.016[3]	1 (1.7)	—	0.02[3]
Male sex	26 (46.4)	38 (43.2)	0.70	10 (33.3)	0.24[2]	28 (48.3)	0.84[2]	0.18[2]
Race			0.73[3]		0.28[3]		0.99[3]	0.40[3]
Black	22 (39.3)	27 (30.7)		6 (20.0)		21 (36.2)		
White	12 (21.4)	22 (25.0)		9 (30.0)		13 (22.4)		
Other	17 (30.4)	32 (36.4)		13 (43.3)		19 (32.8)		
Not answered	5 (8.9)	7 (7.9)		2 (6.7)		5 (8.6)		
Ethnicity			0.55[3]		0.44[3]		0.94[3]	0.67[3]
Hispanic	23 (41.1)	41 (46.6)		16 (53.3)		25 (43.1)		
Non-Hispanic	31 (55.4)	46 (52.3)		14 (46.7)		32 (55.2)		
Not answered	2 (3.6)	1 (1.1)		0 (–)		1 (1.7)		
Insurance			1.00[3]		1.00[3]		1.00[3]	1.00[3]
Public	39 (69.6)	62 (70.5)		21 (70.0)		41 (70.7)		
Private	16 (28.6)	24 (27.3)		8 (26.7)		16 (27.6)		
Uninsured	1 (1.8)	2 (2.3)		1 (3.3)		1 (1.7)		
Schooling			<0.001[3]		<0.001[3]		<0.001[3]	0.04[3]
In-person	55 (98.2)	45 (51.1)		11 (36.7)		34 (58.6)		
Full remote	1 (1.8)	40 (45.5)		19 (63.3)		21 (36.2)		
Hybrid	0 (–)	3 (3.4)		0 (–)		3 (5.2)		

Categorical data are shown as *n* (%) and continuous data as indicated. [1]Wilcoxon rank sum. [2]*t* test. [3]Fisher exact test.

(1 January 2017–29 February 2020). The PP was divided into PP1 (1 March 2020–31 December 2020) and PP2 (1 January 2021–31 December 2021).

Inclusion criteria were patients ≤21 years diagnosed clinically with type 2 diabetes at Hasbro Children's Hospital during the study period. Individuals with positive diabetes autoantibodies or prior diagnosis of diabetes were excluded.

Data extracted included date of presentation, age, sex, race and ethnicity, COVID-19 positivity at diagnosis, insurance type, BMI, BMI percentile, blood pressure (BP), BP percentile, hemoglobin A_{1c} (HbA_{1c}), AST, ALT, serum creatinine, diabetic ketoacidosis (DKA), hyperglycemic hyperosmolar syndrome (HHS), or mixed DKA and HHS at presentation, and urine microalbumin.

DKA and HHS were defined according to the International Society for Pediatric and Adolescent Diabetes 2018 guidelines (11). Youth with features of both DKA and HHS were classified as mixed DKA-HHS. Hypertension was defined according to the 2017 American Academy of Pediatrics clinical practice guidelines (12), and microalbuminuria as a urine albumin-to-creatinine ratio (ACR) of >30 μg/mg and <300 μg/mg (13). Estimated glomerular filtration rate (eGFR) was calculated using the Schwartz short formula for patients aged ≤18 years (14) and the 2021 Chronic Kidney Disease Epidemiology Collaboration creatinine equation (15) for patients aged >18 years. Renal injury was defined by an eGFR <60 mL/min/1.73 m^2 (16) or >130 mL/min/1.73 m^2 (17). The Canadian Laboratory Initiative on Pediatric Reference Intervals (CALIPER) database was used to interpret ALT and AST values (18).

Patients with HbA_{1c} ≥8.5% and/or ketonuria and those with severe presentation (DKA, HHS, mixed DKA-HHS) were managed in the inpatient setting during the PrP. As a result of administrative and pandemic-related changes, most patients in the PP were treated as outpatients, except for those with ketonuria or severe presentation.

The primary outcome was the absolute case number of new-onset type 2 diabetes during the PP versus PrP. The secondary outcomes were the percentage of patients with DKA, HHS, or mixed DKA-HHS and metabolic derangements (hypertension, renal injury, microalbuminuria, elevated liver enzymes) during PP versus PrP and between PP1 and PP2.

Statistical Analysis

Categorical variables are reported as frequencies and continuous variables with means and SDs. Bivariable comparisons between groups were conducted using the Fisher exact test for categorical variables and the Student *t* test or one-way ANOVA for three or more groups for continuous variables. Pairwise comparisons after ANOVA were performed with the Scheffé test for multiple comparisons. If data were not normally distributed, Wilcoxon rank sum or Kruskal-Wallis for three or more groups was used with the Holm adjustment for multiple comparisons. *P* values <0.05 were considered statistically significant; all tests were two-sided.

RESULTS

Eligibility criteria were met by 144 patients. Demographics (Table 1), metabolic parameters, and complications (Table 2) were compared.

PrP Versus PP

The annualized incidence of new-onset type 2 diabetes cases showed a nearly threefold increase from 17.67 in the PrP to 48 in the PP (Table 1 and Fig. 1).

Table 2—Presentation and complications at diagnosis: PrP vs. PP1/PP2 and PP1 vs. PP2

	PrP (n = 56)	PP1 (n = 30)	P value (PrP vs. PP1)	PP2 (n = 58)	P value (PrP vs. PP2)	P value (PP1 vs. PP2)
Visit location			0.18[3]		0.009[3]	0.38[3]
Inpatient	29 (51.8)	11 (36.7)		16 (27.6)		
Outpatient	27 (48.2)	19 (63.3)		42 (72.4)		
Severe presentation*	2 (3.6)	6 (20.0)	0.03[3]	2 (3.5)	0.97[3]	0.02[3]
BMI (kg/m^2), mean (SD)	(n = 56) 35.8 (7.6)	(n = 30) 36.9 (9.8)	0.27[2]	(n = 57) 39.3 (10.9)	0.09[2]	0.33[2]
BMI % of 95th percentile, mean (SD)	(n = 56) 129.3 (30.3)	(n = 30) 139.4 (47.4)	0.054[2]	(n = 57) 142.6 (40.5)	0.08[2]	0.38[2]
SBP percentile, mean (SD)	(n = 53) 79.6 (21.7)	(n = 30) 86.6 (16.3)	0.13[2]	(n = 52) 84.2 (18.3)	0.19[2]	0.27[2]
DBP percentile, mean (SD)	(n = 53) 69.9 (26.1)	(n = 30) 88.9 (13.0)	<0.001[2]	(n = 52) 80.3 (19.8)	0.03[2]	0.02[2]
HbA_{1c} (%), mean (SD)	9.5 (2.6)	9.1 (2.9)	0.42[2]	8.9 (2.6)	0.32[2]	0.41[2]
AST (IU/L), mean (SD)	(n = 53) 38.7 (50.7)	(n = 24) 25.8 (15.2)	0.53[2]	(n = 52) 29.2 (18.9)	0.27[2]	0.40[2]
ALT (IU/L), mean (SD)	(n = 53) 58.4 (82.1)	(n = 24) 37.7 (38.8)	0.27[2]	(n = 52) 40.3 (27.0)	0.29[2]	0.19[2]
Microalbumin (mcg/mg), mean (SD)	(n = 40) 10.9 (12.8)	(n = 19) 15.9 (21.4)	0.76[2]	(n = 45) 16.7 (34.4)	0.45[2]	0.57[2]
Creatinine (mg/dL), mean (SD)	(n = 42) 0.66 (0.16)	(n = 21) 0.79 (0.42)	0.59[2]	(n = 43) 0.68 (0.18)	0.71[2]	0.48[2]
eGFR (mL/min/1.73 m^2), mean (SD)	(n = 42) 111.6 (21.5)	(n = 21) 97.7 (33.2)	0.19[2]	(n = 42) 108.6 (21.5)	0.24[2]	0.34[2]
HbA_{1c} ≥8.5%	31 (55.4)	12 (40.0)	0.18	22 (37.9)	0.06	0.85
Systolic hypertension	20 (35.7)	16 (53.3)	0.11	16 (27.6)	0.35	0.02
Diastolic hypertension	11 (19.6)	12 (40)	0.04	14 (24.1)	0.56	0.12
Renal injury (eGFR <60 or >130 mL/min/1.73 m^2)	(n = 42) 7 (16.7)	(n = 21) 8 (38.1)	0.07	(n = 42) 11 (26.2)	0.29	0.33
Microalbuminuria	(n = 40) 4 (10.0)	(n = 19) 3 (15.8)	0.52[3]	(n = 45) 6 (13.3)	0.64[3]	0.79[3]
Elevated ALT for age and sex	(n = 53) 30 (56.6)	(n = 24) 12 (50.0)	0.59[3]	(n = 52) 33 (63.5)	0.47[3]	0.27[3]
Elevated AST for age and sex	(n = 53) 15 (28.3)	(n = 24) 8 (33.3)	0.66[3]	(n = 52) 14 (26.9)	0.87[3]	0.57[3]

Categorical data are shown as n (%) and continuous data as indicated. SBP, systolic blood pressure. *DKA/HHS/mixed pattern. [1]ANOVA with the Scheffé adjustment for pairwise comparisons. [2]Kruskal-Wallis with Holm adjustment for pairwise comparisons. [3]Fisher exact test.

All patients, except for four patients in the PP, were diagnosed due to diabetes symptoms or screening laboratory studies given risk factors for insulin resistance. Seven patients were aged ≤10 years during the PP versus none during the PrP. Information on concurrent COVID-19 infection was available in 34.1% of patients; one was positive during PP1. None of those with a severe presentation had positive COVID-19 status at presentation. The BMI percentiles of the patients steadily increased over time (Fig. 2) and were higher during the PP compared with the PrP (141.5 ± 42.8% of the 95th percentile in the PP vs. 129.3 ± 30.3% in the PrP, P = 0.02). Mean diastolic BP (DBP) percentile was higher during the PP compared with the PrP (83.5 ± 18.1 vs. 69.9 ± 26.1 in PrP, P = 0.001).

PrP Versus PP1 and PP2

The annualized incidence of new onset type 2 diabetes showed a 103.7% increase in PP1 and 228.2% increase in PP2 compared with the PrP (Tables 1 and 2). Compared with the PrP, PP1 was characterized by younger patients (P = 0.001), more severe presentation at diagnosis (P = 0.03), higher mean DBP percentile ($P < 0.001$), and higher proportion of patients with diastolic hypertension (P = 0.04). PP2 had higher mean DBP percentile versus The PrP (P = 0.03).

PP1 Versus PP2

Annualized incidence of new-onset type 2 diabetes continued to rise in PP2 versus PP1 (61% increase) (Tables 1 and 2). Compared with PP2, PP1 was characterized by younger patients ($P < 0.001$), more severe presentations at diagnosis (P = 0.02),

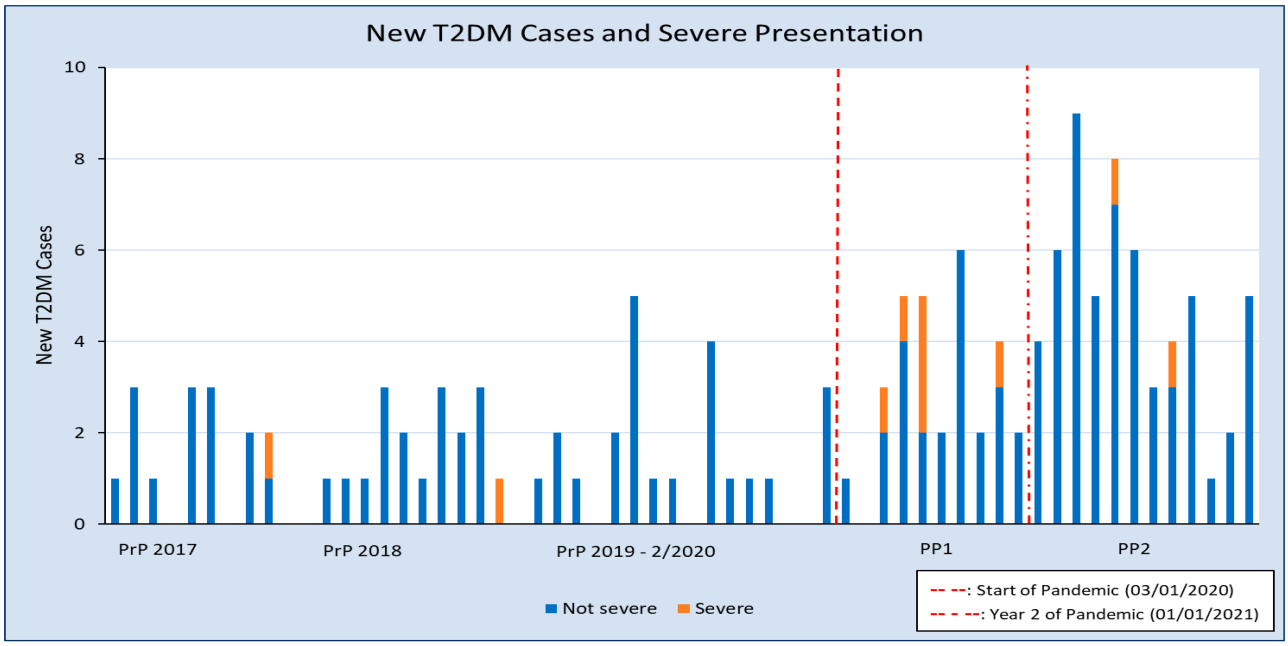

Figure 1—Monthly type 2 diabetes cases and severe presentation before and during the COVID-19 pandemic. T2DM, type 2 diabetes mellitus.

higher mean DBP percentile ($P = 0.02$), and higher proportion of patients with systolic hypertension ($P = 0.02$).

CONCLUSIONS

Our results demonstrate an alarming increase in youth-onset type 2 diabetes during the first 2 years of the COVID-19 pandemic compared with the 3 years prior, with a parallel increase in BMI percentile. The incidence continued to rise in PP2 compared with PP1. To our knowledge, this is the first study to analyze the incidence and metabolic parameters of youth-onset type 2 diabetes into the 2nd year of the pandemic.

The finding of significantly increasing BMI during the pandemic aligns with the observation of a multicenter study from the U.S. on youth-onset type 2 diabetes (10), while other studies reported no differences in BMI percentiles (1,2,4–6). The rising BMI percentile reported in youth with new-onset type 2 diabetes is not surprising and likely reflects pandemic-related obesogenic factors, including decreased physical activity, poor sleep hygiene, increased screen time, and energy-dense food consumption.

We observed an increased incidence of severe presentations (DKA/HHS, mixed DKA-HHS) during PP1 compared with the PrP, which aligns with prior studies

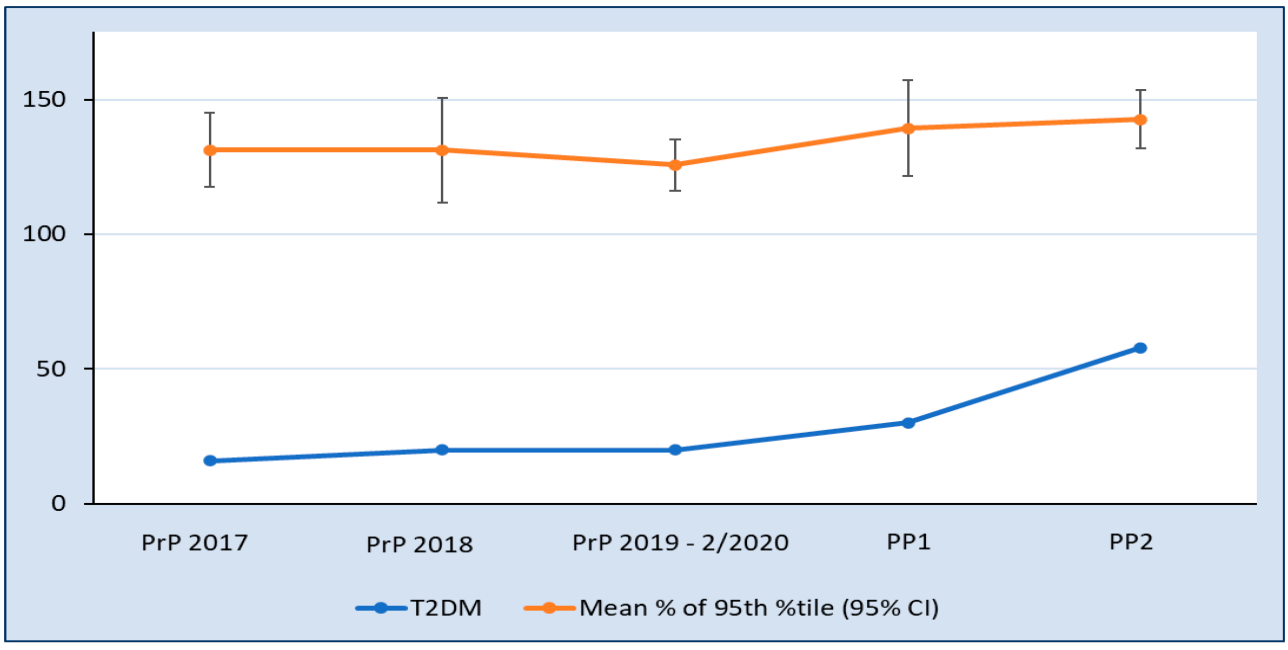

Figure 2—Rate of changes of type 2 diabetes incidence and of BMI percentile during the study period. T2DM, type 2 diabetes mellitus.

(2–10). The incidence of severe presentations decreased to PrP values in PP2 despite a continued rise in type 2 diabetes incidence. Return to in-person medical care likely resulted in earlier diagnosis and treatment in PP2, preventing severe presentations.

The mean age of patients at presentation was younger in PP1, with more children aged ≤10 years compared with the PrP and PP2. The etiology of the increased incidence among younger children during PP1 compared with the PrP or PP2 is unclear and has not been previously reported. Prior studies revealed similar age at presentation during the PP and PrP (2,3,5,6). It is possible that the multifactorial influences on weight and the severity of the stress impact during the pandemic period affected younger children more during PP1.

We observed a higher mean DBP percentile in the study population during PP1 and PP2 compared with the PrP and higher in PP1 compared with PP2. The proportion of subjects with diastolic hypertension was higher in PP1 compared with the PrP. The rise in the mean DBP percentile is concerning, as mild increases in DBP, even though in the normal range, may increase the risk for diabetic kidney disease (19).

We found a persistent female predominance in our study group prior to and during the pandemic in contrast to other studies that reported a change in sex predilection from female to male (4,6,7,10) or an increase in the proportion of male patients during the pandemic (5). It is unclear why we did not observe a change as noted in other studies, but this may be region specific.

COVID-19 status was available in a third of the study subjects in the current study. Only one patient showed COVID-19 positivity and none with severe presentation had COVID-19 infection at diagnosis; hence, the rising incidence observed in our study was not due to concurrent COVID-19 infection, although no data were available about prior infection. Similar observations were made by other studies (2,4,6), while another study observed higher COVID-19 positivity among youth with type 2 diabetes compared with those with type 1 diabetes (8).

Limitations of our study include the retrospective nature of the data collection at a single institution and the lack of information about current or prior COVID-19 infection or immunization status. As the only dedicated pediatric hospital in Rhode Island, our institution serves the entire state, and our catchment area remained stable during the study period. Trends seen in this study likely reflect the changes in type 2 diabetes in youth in our state but should not be generalized.

Conclusion

The incidence of youth-onset type 2 diabetes rose during the COVID-19 pandemic compared with the 3 years prior, with a parallel increase in the BMI percentile. The incidence continued to rise in the second pandemic year despite lifting of quarantine measures, vaccination availability, and return to in-person learning. Awareness of the escalating incidence of youth-onset type 2 diabetes is essential to avoid delays in diagnosis and to inform educational programs aimed to combat the continued impact of the pandemic on health outcomes. Future scientific investigation is needed to better understand the relationship between COVID-19 and diabetes onset in youth.

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Author Contributions. S.S.P. conceptualized the study, drafted the study protocol, performed data collection and interpretation, performed the literature review, and wrote the initial draft of the manuscript. P.H. performed descriptive statistics and critically reviewed and edited the manuscript. J.B.Q., M.S.G., V.L.K., and L.S.T. critically reviewed and edited the manuscript. M.E.F. helped to conceptualize the study, critically revised the study protocol, oversaw data collection, and reviewed and edited the manuscript. All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work. M.E.F. is the guarantor of the work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.
Prior Presentation. Parts of this study were presented as a poster at the Department of Pediatrics Celebration of Scholarship at Hasbro Children's Hospital, Providence, RI, 24 October 2022. The authors contributed data to the multicenter report on the incidence and presentation of type 2 diabetes among youth during the COVID-19 pandemic (10).

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