Cyber School Is a Marker of Youth with High-Risk Diabetes

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Objective To explore the health characteristics of youth with diabetes in cyber school compared with peers with diabetes in traditional brick-and-mortar schools.

Study design This was a single-center cross-sectional study of youth with type 1 or type 2 diabetes in K-12 education during academic year 2017-2018. Youth enrolled in cyber school were matched with traditional school peers by age, sex, race, diagnosis, and diabetes duration. Comparisons included insurance status, hemoglobin A1c, treatment, coexisting conditions, screening, and healthcare use.

Results Of 1694 participants, 5% (n = 87) were enrolled in cyber school. Youth enrolled in cyber school were predominantly white (89%), female (60%), adolescents (median 15.2 years) with type 1 diabetes (91%). Youth with type 2 diabetes were excluded from analyses owing to the small sample (n = 7). Public insurance was more common among youth enrolled in cyber school (P = .005). Youth in cyber school had higher mean hemoglobin A1c, 9.1 ± 1.8% (76 ± 20 mmol/mol) vs 8.3 ± 1.2% (67 ± 13 mmol/mol) (P = .003), lower insulin pump use (OR, 0.36; 95% CI, 0.18-0.73), and more mental health conditions (OR, 4.48; 95% CI, 1.94-10.35) compared with peers in traditional schools. Youth in cyber school were less likely to have recommended vision (OR, 0.34; 95% CI, 0.15-0.75) and dental (OR, 0.33; 95% CI, 0.15-0.75) evaluations. The relationship between hemoglobin A1c and cyber school persisted after adjusting for insurance status, pump use, and mental health conditions (P = .02). Similar trends were observed for participants with type 2 diabetes.

Conclusions Youth with diabetes in cyber school may be a high-risk population. Understanding the potential impact of cyber school-related factors on health may encourage additional provider/system/school supports for these patients. *(J Pediatr 2021;230:167-73)*.

Cyber school, also known as virtual or online school, relocates K-12 education to either an entirely home-based internet platform or a blended format with in-person schooling.[1] K-12 cyber school first emerged in the 1990s, with enrollment increasing over time to roughly 430 000 students in the US in 2017-2018.[2] Unlike home schooling, another alternative to traditional brick and mortar schools available in the US, classroom activities are led by a trained teacher, rather than the parent, using exclusively online materials. Typically, cyber schools are operated by the state or school district, but can also exist as cyber charters, publicly funded schools that follow state regulations.[1] Classes are typically asynchronous with the usual school day, offering students flexibility with the learning pace.[3]

With the rapid growth of cyber school, concerns have emerged about the inconsistent academic rigor of these programs. The National Education Policy Center reported that less than one-half of full-time virtual schools received an acceptable performance rating.[2] Students in cyber school tend to have lower test scores and reduced graduation rates compared with their peers in traditional schools.[2,4-6] The Center for Research on Education Outcomes estimated that students enrolled in Pennsylvania cyber charter schools lose >100 days of learning in both math and reading annually.[7] As school success relates to health status and professional attainment in adulthood, the variable academic outcomes in the context of cyber school merit closer attention.[8,9]

Students with disabilities requiring an Individualized Education Plan are increasingly enrolling in cyber schools nationally, with the prevalence increasing from 6.8% in 2010-2011 to 15.5% in 2016-2017.[2] Children and adolescents with diabetes, particularly type 1 diabetes, may represent a unique group in this context, because management involves careful meal planning, frequent glucose monitoring, and insulin administration. A significant portion of this care during the week takes place in school under the supervision of a school nurse or other certified staff, and cyber school may not offer the same level of school nursing support. Diabetes care during the school day may also have important implications for learning, as poorer glycemic control is associated with lower scores on standardized testing.[10,11] It is not clear to what extent youth with diabetes are attending cyber school and the effect on their health.[12]

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The objectives of this study were to describe the population of youth with type 1 or 2 diabetes enrolled in cyber school from a large, academic diabetes center and to explore their health-related characteristics compared with their peers with diabetes in traditional schools. Examining the potential relationships between cyber school enrollment and health outcomes for youth with diabetes or other chronic diseases is critical to helping healthcare providers understand the unique medical needs of this population.

Methods

This is a retrospective cross-sectional study of youth with diabetes enrolled in cyber school in comparison with peers in traditional schools during academic year 2017-2018 (defined as August 1, 2017, to July 31, 2018). Data were collected from the electronic health record of a large, academic diabetes center (University of Pittsburgh Medical Center Children's Hospital of Pittsburgh). Youth enrolled in cyber school were identified and matched to youth in traditional schools from the remaining clinic population to facilitate comparison of clinical characteristics. This study was approved by the University of Pittsburgh Institutional Review Board (PRO 18100051).

Participants and Procedures

Participants included youth ages 5-19 years with type 1 or 2 diabetes with residence in Pennsylvania, because cyber school eligibility and policies differ by state. The University of Pittsburgh Biomedical Informatics group identified potential participants using type 1 and 2 diabetes-specific diagnosis codes. School type was determined manually by reviewing an internal form completed at all diabetes outpatient encounters that includes a question about school enrollment (traditional school, cyber school, home school, or not available), and subsequently confirmed in the provider note. Youth not enrolled in K-12 during the 2017-2018 academic year or with incorrect or alternative diabetes diagnoses were excluded. Youth with prior cyber school enrollment (transitioned to traditional schools), homeschooling, or homebound schooling were excluded given the differences in these school programs from cyber school.[1] Matched youth in traditional schools were paired to youth enrolled in cyber schools at a 1:1 by age, sex, race, diagnosis, and duration of diabetes. Individuals were paired to the closest control within ±0.2 years of age with a diabetes duration within ±1 year; if none were available, the age difference was extended to ±0.5 years (required for n = 14).

Clinical and Biochemical Data

Demographic and clinical characteristics were extracted from the electronic health record for up to 4 clinic visits during the academic school year. Insurance status (private, public, or both) was obtained as a surrogate marker of socioeconomic status. Glycemic control was measured by calculating a mean value for the year from the point-of-care hemoglobin A1c at each visit. Target hemoglobin A1c was defined as <7% (53 mmol/mol) per the 2020 American Diabetes Association recommendations.[13] Diabetes management regimen and reported use of devices, including continuous glucose monitors and insulin pumps, were obtained. Additional medical conditions and diabetes-related comorbidities included: overweight or obesity (body mass index ≥ 85th percentile), low-density lipoprotein cholesterol of >100 mg/dL (2.59 mmol/L) and/or a prior diagnosis of dyslipidemia, microalbuminuria (2 abnormal urine albumin/creatinine ratios and/or known diagnosis), and any mental health diagnosis (depression, anxiety, attention deficit hyperactivity disorder, or other mood disorder). Annual screenings per American Diabetes Association recommendations included a diabetes-related vision examination (youth ≥11 years), dental examination, and depression screen (Patient Health Questionnaire-9 in youth 12 years).[13] Clinic visits, emergency department visits, hospitalizations, and episodes of diabetic ketoacidosis were collected for the year. Participants were dichotomized by ≥2 missed appointments, ≥2 emergency department visits, ≥1 admission (for any reason), and ≥1 episode of diabetic ketoacidosis. Reasons for cyber school enrollment were noted. Two reviewers conducted all data extraction with a senior investigator available to adjudicate any disagreements.

Statistical Analyses

Descriptive statistics are presented as frequencies with percentages, means with SD, or medians with IQR. Characteristics between youth in cyber school and youth in traditional school were compared with χ^2 or Fisher exact tests for proportions and the t test or Mann-Whitney U test for continuous variables. Multivariable logistic regression was used to calculate ORs for clinical characteristics related to cyber school enrollment, adjusting for matched characteristics. For glycemic control, we assessed for confounding by other clinically relevant variables using multivariable linear regression models with mean hemoglobin A1c as the dependent variable, adjusting for matched characteristics. As the sample of youth with type 2 diabetes in cyber school was small (n = 7) and treatment regimens (eg, oral medications vs intensive insulin therapy) were variable, analyses were conducted for patients with type 1 diabetes only. Findings for the subgroup of youth with type 2 diabetes are presented descriptively. Comparisons for health screenings were conducted for youth meeting American Diabetes Association age criteria where indicated. Analyses were completed in Stata v.15 (StataCorp) with significance determined by a P value of < .05 (2-sided).

Results

The Figure outlines participant identification. For academic year 2017-2018, 1694 children with diabetes met inclusion criteria with 87 (5%) enrolled in cyber school. The majority of youth with diabetes in cyber school were white (n = 77

[89%]), female (n = 52 [60%]), adolescents (median, 15.2 years; range, 5.9-18.9 years) with type 1 diabetes (n = 79 [91%]). Those in cyber school tended to be older and more often female compared with all participants meeting inclusion criteria (median age, 13.9 years; 46% female), but other baseline characteristics were similar. Six in the cyber school group could not be matched because race was not documented or no traditional school participant with the same race existed. There were no differences between matched and unmatched youth in cyber school in terms of age, sex, diagnosis, duration of diabetes, body mass index percentile, or hemoglobin A1c. Background characteristics of cyber school and traditional school groups by diagnosis are displayed in Table I. There were no differences between cyber school and tradition school groups on matched characteristics; more youth with type 1 diabetes in cyber school were on public insurance alone.

Youth with Type 1 Diabetes

Additional medical conditions were identified in 53 youth (72%) in cyber school and 42 youth (57%) in traditional school, most commonly atopy (allergic rhinitis, asthma, and/or eczema), headaches, or other autoimmune conditions (eg, hypothyroidism, celiac disease). Four youth in cyber school had a documented history of autism spectrum disorder or a learning disability compared with no youth in traditional school; excluding these 4 youth revealed no significant changes to our findings, and thus they were included in our final analysis.

Clinical characteristics between youth in cyber school and youth in traditional school with type 1 diabetes are presented in Table II. The mean hemoglobin A1c was nearly 1 percentage point higher among youth in cyber school compared with youth in traditional school: 9.1 ± 1.8% (76 ± 20 mmol/mol) vs 8.3 ± 1.2% (67 ± 13 mmol/mol) (P = .003). This difference remained significant when adjusting for insurance status (P = .003). There was no difference in the proportion of youth achieving a target hemoglobin A1c of <7% (53 mmol/mol) (P = .29), but youth in cyber school were more likely to have a hemoglobin A1c of ≥10% (86 mmol/mol), indicating poor glycemic control (P = .003). The difference in mean hemoglobin A1c was most notable in youth 12 years of age or older, measured at 9.4 ± 1.8% (79 ± 20 mmol/mol) in adolescents in cyber school compared with 8.4 ± 1.2% (68 ± 13 mmol/mol) in adolescents in traditional school (P = .0008). In contrast, the mean hemoglobin A1c among younger children was similar between those in cyber school (7.7 ± 0.7%, 61 ± 7 mmol/mol) and traditional school (7.7 ± 1.2%, 61 ± 13 mmol/mol) (P = .84).

Logistic regression showed that enrollment in cyber school was most strongly associated with a hemoglobin A1c of ≥10% (P = .006), lack of an insulin pump for management (P = .004), mental health conditions (P < .001), and reduced dental (P = .008) and vision (P = .007) screening. These relationships persisted when adjusting for insurance status in addition to matched characteristics. Because pump use and coexisting mental health issues may affect glycemic control, we used multivariable linear regression to examine the relationship between school type and mean hemoglobin A1c adjusting for these 2 variables in addition to matched characteristics and insurance status. Enrollment in cyber school remained significant among all ages (P = .02) and among those ≥12 years of age only (P = .01).

Between youth in cyber school and youth in traditional school with type 1 diabetes, there were no differences in continuous glucose monito use, body mass index, or abnormal low-density lipoprotein cholesterol. A diagnosis of microalbuminuria was documented in only 6 participants, although it was more commonly noted in youth in cyber school (n = 5 [7%] vs n = 1 [1%], respectively). Unlike other screenings, Patient Health Questionnaire-9 completion rates were similar. Median scores were statistically different (P = .0006), and youth in cyber school were more likely to have a Patient Health Questionnaire-9 score of ≥10 (16% vs 2%, respectively) (P = .02), indicative of a positive screen; however, scores were missing for 10 youth in cyber school and 9 youth in traditional school, limiting our interpretation.[14] Although youth in cyber school had more missed appointments, emergency department visits, admissions, and episodes of diabetic ketoacidosis, only admissions was statistically significant (22% vs 8%, respectively) (P = .02).

Youth with Type 2 Diabetes

Descriptive clinical characteristics of youth in cyber school and youth in traditional school with type 2 diabetes are presented in Table III. A history of other conditions associated with metabolic syndrome, including dyslipidemia, fatty liver disease, polycystic ovary syndrome, and/or hypertension, were documented in 5 youth in cyber school and 4 youth in

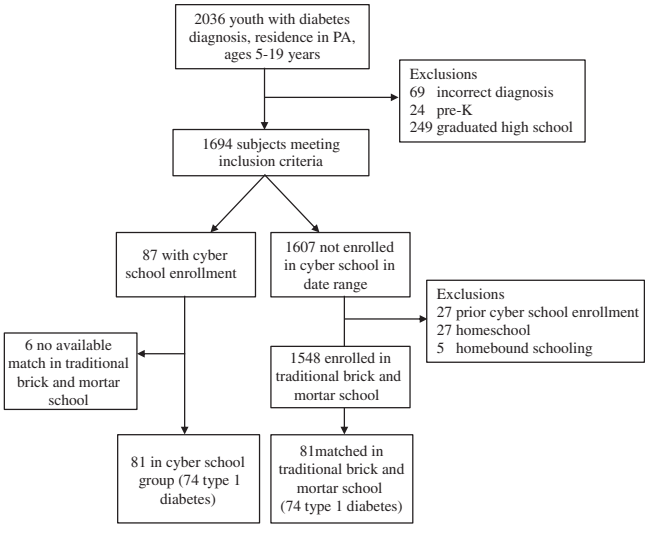

Figure. Flow diagram for determination of included participants in the cyber school and traditional brick and mortar school comparison groups.

Table I. Background characteristics of included participants by diagnosis

Characteristics	Type 1 diabetes		Type 2 diabetes	
	Cyber school (n = 74)	Traditional brick and mortar school (n = 74)	Cyber school (n = 7)	Traditional brick and mortar school (n = 7)
Age, y	15.2 [5.9-18.9]	15.2 [6.0-18.6]	15.4 [11.1-18.0]	15.5 [10.6-17.8]
Sex				
Male	28 (38)	28 (38)	4 (57)	4 (57)
Female	46 (62)	46 (62)	3 (43)	3 (43)
Race				
White	71 (96)	71 (96)	6 (86)	6 (86)
Black	3 (4)	3 (4)	1 (14)	1 (14)
Diabetes duration, y	5.9 [0.2-16.5]	6.0 [0.3-15.6]	2.3 [0.6-3.3]	2.0 [0-2.8]
Insurance status*				
Private	11 (15)	11 (15)	0	0
Private and public	19 (26)	37 (50)	2 (29)	1 (14)
Public	44 (59)	26 (35)	5 (71)	6 (86)

Data are median [range] or number (%).
*Insurance status was statistically significant between youth in cyber school and traditional brick and mortar school youth for participants with type 1 diabetes only ($P = .005$).

traditional school. The median hemoglobin A1c was 8.7% (72 mmol/mol) among youth in cyber school and 6.2% (44 mmol/mol) among youth in traditional school. More youth with type 2 diabetes in cyber school required multiple daily injections rather than metformin alone. Similar trends were observed in comorbidities, screening, and care use to participants with type 1 diabetes.

Cyber School Enrollment Reasons

Among all youth with diabetes enrolled in cyber school, a reason for this school choice was available for 72 (83%) cases; of those, 27 (38%) were for medical concerns, 12 (17%) academic issues, 9 (13%) peer/safety concerns (eg, bullying), and 24 (33%) parent preference with no additional rationale provided.

Table II. Clinical characteristics of youth in cyber school and traditional brick and mortar school youth with type 1 diabetes

Characteristics	Youth in cyber school (n = 74)	Youth in traditional brick and mortar school (n = 74)	*P* value	aOR (95% CI)
Glycemic control				
Hemoglobin A1c, %	9.1 ± 1.8	8.3 ± 1.2	.003	-
<7%	6 (8)	10 (14)	.29	0.54 (0.18-1.63)
≥10%	21 (28)	8 (11)	.007	3.77 (1.45-9.79)
Device use				
Pump use	27 (36)	44 (60)	.005	0.36 (0.18-0.73)
CGM use	21 (28)	31 (42)	.09	0.54 (0.27-1.08)
Comorbidities				
BMI percentile	80.1 [54.3-90.9]	80.0 [63.0-93.0]	.36	-
BMI ≥85th percentile	30 (41)	30 (41)	>.99	1.00 (0.50-1.98)
LDL, mg/dL	96 [78-122]	87 [75-100]	.14	-
≥100 mg/dL or dyslipidemia	35 (47)	24 (32)	.07	1.92 (0.97-3.82)
Mental health diagnosis*	32 (43)	13 (18)	.001	4.48 (1.94-10.35)
Healthcare screening				
Depression screen	n = 61 57 (93)	n = 62 59 (95)	.68	0.71 (0.15-3.48)
PHQ-9 score	n = 51 2 [0-8]	n = 53 0 [0-3]	.0006	-
Annual vision examination	n = 63 36 (57)	n = 64 51 (80)	.006	0.34 (0.15-0.75)
Annual dental examination	49 (66)	63 (85)	.007	0.33 (0.15-0.75)
Healthcare use				
Annual diabetes visits	3 [2-4]	4 [3-4]	.02	-
≥2 missed visits/y	21 (28)	12 (16)	.08	2.10 (0.93-4.75)
≥2 ED visits/y	11 (15)	4 (5)	.06	3.26 (0.95-11.25)
≥1 Admission/y	16 (22)	6 (8)	.02	3.24 (1.17-8.97)
≥1 DKA/y	10 (14)	4 (5)	.09	2.78 (0.83-9.52)

BMI, body mass index; *CGM*, continuous glucose monitor; *DKA*, diabetic ketoacidosis; *ED*, emergency department; *LDL*, low-density lipoprotein; *PHQ-9*, Patient Health Questionnaire-9.
Data are number (%), mean ± SD, or median [IQR]. *P* values reported for χ^2 or Fisher exact or *t* test/Mann-Whitney *U* test. ORs are calculated for effect of school type on each clinical characteristic, adjusting for matched characteristics.
Conversion to SI units: hemoglobin A1c (%) to mmol/mol, multiple by 10.93 and subtract 23.5; LDL cholesterol (mg/dL) to mmol/L, divide by 38.67.
*Mental health diagnosis includes depression, anxiety, attention deficit hyperactivity disorder, or other mood disorder.

Table III. Descriptive clinical characteristics of youth in cyber school and traditional brick and mortar school with type 2 diabetes

Characteristics	Youth in cyber school (n = 7)	Youth in traditional brick and mortar school (n = 7)
Glycemic control		
Hemoglobin A1c, %	8.7 [5.2-11.4]	6.2 [5.8 to 14]
Management regimen		
Metformin alone	1 (14)	3 (43)
Basal insulin and metformin	1 (14)	1 (14)
Multiple daily injections ± metformin	5 (71)	3 (43)
Comorbidities		
BMI percentile	99.1 [80.9-99.8]	99.3 [97.1 to 99.5]
LDL, mg/dL	102 [71-147]	118 [70-168]
LDL ≥100 mg/dL or dyslipidemia	4 (57)	4 (57)
Mental health diagnosis*	5 (71)	3 (43)
Healthcare screening		
Depression screen, n = 6 each group	3 (50)	3 (50)
Annual vision examination	3 (43)	5 (71)
Annual dental examination	2 (29)	5 (71)
Healthcare use		
Annual diabetes visits	1 [1-3]	3 [1-4]
≥2 missed visits/y	5 (71)	2 (29)
≥2 ED visits/y	2 (29)	0
≥1 Admission/y	3 (43)	1 (14)

Data presented as number (%) or median [range].
Conversion to SI units: Hemoglobin A1c (%) to mmol/mol, multiple by 10.93 and subtract 23.5; LDL cholesterol (mg/dL) to mmol/L, divide by 38.67.
*Mental health diagnosis includes depression, anxiety, attention deficit hyperactivity disorder, or other mood disorder.

Discussion

We found that approximately 5% of youth with diabetes were enrolled in cyber school. According to publicly available data from the Pennsylvania Department of Education, approximately 2% of the general state population is enrolled in cyber school, suggesting that youth with diabetes may participate in cyber school at a higher rate.[15] Within both the state and our clinic populations, cyber school enrollment seemed to be more common among females and older teens, consistent with national trends.[2] The identified youth enrolled in cyber school had features of high-risk diabetes, most notably with glycemic control. Cyber school enrollment may be an indicator of underlying, complicating factors that contribute to poor diabetes and related-health outcomes.

There are several possible contributing explanations for the observed difference in mean hemoglobin A1c between youth in cyber school and their peers in traditional school with type 1 diabetes. Coexisting mental health conditions and insulin pump use can each impact self-management practices and glycemic control; however, adjusting for these variables did not change the effect of school type on hemoglobin A1c.[16-19] This finding suggests that other internal (child) or external (family/school/environment) factors may be influencing diabetes care. Some of these factors may be specific to cyber school. First, the asynchronous learning environment can disrupt daily routines, which are important for management habits.[20] Second, although publicly funded cyber schools must employ a school nurse to ensure children meet routine health requirements, students in cyber school may not receive daily school nursing support.[21] School nurses can serve an essential role for vulnerable students; indeed, for youth with poorly controlled diabetes, transitioning some aspects of diabetes care to the school nurse, such as basal insulin delivery, can help lower hemoglobin A1c.[22,23] A potential intervention could use school nurses to engage with children in cyber school who struggle with diabetes management at home through virtual visits. Last, parental supervision at home may vary; we found no difference in hemoglobin A1c between younger children by school type, who are less likely to be independent in their diabetes management or schoolwork at home.

Other family and environmental factors may contribute to both diabetes management practices and school choice. Disparities in glycemic control, treatment, and screening have been identified by socioeconomic status and race/ethnicity in youth with type 1 diabetes, yet our findings may not represent similar disparities.[24-27] In our study, the racial/ethnic composition of youth in cyber school was similar to that of our general clinic population. Although insurance status differed between those in cyber school and traditional school, with more youth in cyber school publicly insured, this marker did not affect the relationship between school type and hemoglobin A1c or other variables. Overall, cyber schools enroll substantially fewer racial/ethnic minorities or students living in poverty compared with public school.[2,7] Cyber school requires stable housing, adequate technology (eg, computers, tablets), and high-speed Internet capability, which may be less accessible in disadvantaged populations. Inequities in diabetes-related measures require further study to elucidate the causal contributing factors and potential challenges to healthcare access. Examining child executive functioning skills, family support, parental diabetes knowledge, and perceived diabetes burden in the cyber school population should be considered.[28,29]

Although it did not account for the relationship between cyber school attendance and glycemic control in participants with type 1 diabetes, the higher report of mental health conditions among those in cyber school was striking. Co-occurrence of depression and other mental health conditions are common among children with chronic illness and specifically those with diabetes, but how school setting factors into mental health is less clear.[30-32] The quandary is whether cyber school may contribute to a higher risk of mental health outcomes, or if enrollment is more common among those with preexisting mental health issues. The school environment can contribute to students' mental health through the degree of connectedness to the school and staff, peer relationships, and academic stress.[33] Some youth with diabetes may participate in cyber school to avoid triggers for their depression and anxiety.[34] At the same time, cyber school could exacerbate a sense of social isolation. The nature of the relationship between cyber school attendance and psychosocial health

merits further evaluation to clarify mental healthcare needs and identify approaches to address gaps in care.

School choice remains a personal decision for parents based on their child's unique medical, social, and academic needs. Difficult-to-manage diabetes and mental health conditions may factor into parents' decision making to enroll their child in cyber school. We found that medical concerns were the most frequently documented reason for cyber school enrollment when available. The healthcare provider may have a role in understanding and helping to address concerns about diabetes management in a brick and mortar school.[12] Providers should be aware of the legal protections to support the safety of children and adolescents with diabetes in school, as well as educational tools to help train and educate school staff.[35-37] Providers may be able to appropriately target resources to help children remain in a traditional school environment if that is desired by the parents and child.

A primary limitation of this study was the small sample of youth with type 2 diabetes in cyber school. Although this factor limited our analyses, similar trends were observed with glycemic control, coexisting mental health conditions, annual screening, appointment attendance, and healthcare use (emergency department visits, admissions). Notably, youth with type 2 diabetes in cyber school were more often treated with intensive insulin therapy, which may account for the difference observed in hemoglobin A1c. Additionally, it is possible we did not identify all youth enrolled in cyber school if the requisite form was not completed in clinic, although this situation is unlikely because we reviewed the forms and provider notes for every clinical encounter during that academic year. A clearly documented rationale for cyber school enrollment was not available for all participants, and we were unable to retrospectively examine indicators of academic achievement. Last, we cannot generalize our findings to other states, where there may be differences in cyber school offerings. Importantly, we can only detect associations and cannot infer that cyber school enrollment specifically is causative of poorer outcomes. Indeed, poor diabetes control and associated factors may increase the likelihood of enrollment in cyber school, or other unmeasured factors may be influencing both diabetes care and cyber school participation.

Our study is strengthened by being situated in an academic diabetes center with a large enough patient sample to provide matched controls. Although academic concerns related to cyber school have been noted in prior reports, our study suggests that youth with diabetes who are enrolled in cyber school may also have health challenges, which may extrapolate to youth with other chronic health conditions. Future research is needed to examine the associations between cyber school enrollment and health prospectively in a larger population. Qualitative research could explore parents' motivations to choose cyber school, including if and when school districts encourage cyber school enrollment, potential barriers to care, and students' experiences with managing diabetes in cyber school. Furthermore, our findings are salient given the current novel coronavirus disease-2019 pandemic, which has caused children and adolescents to engage in distance learning on an unprecedented scale.[3] Additional studies are needed to understand how distance learning owing to novel coronavirus disease-2019 may impact diabetes management and determine whether more families will chose cyber school options in the future.

In our sample, cyber school enrollment could be considered a marker of youth with high-risk type 1 diabetes given the correlations with worrisome health metrics. Cyber school is a growing phenomenon in the US, which may accelerate in response to the novel coronavirus disease-2019 pandemic. Providers and school nurses may play a role in identifying potential supports needed among their pediatric patients who are in cyber school to ensure access to behavioral and health services to support their well-being. ■

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References

1. Waters LH, Barobour MK, Menchaca MP. The nature of online charter schools: evolution and emerging concerns. Educ technol soc 2013;17:379-89.
2. Molnar A, Miron G, Elgeberi N, Barbour MK, Huerta L, Shafer SR, et al. Virtual Schools in the U.S. 2019. National Education Policy Center; 2019. p. 125.
3. Black E, Ferdig R, Thompson LA. K-12 virtual schooling, COVID-19, and student success. JAMA Pediatr 2020 [Epub ahead of print].
4. Buddin R, Zimmer R. Student achievement in charter school: a complex picture. J Policy Anal Manag 2005;24:351-71.
5. Zimmer R, Gill B, Booker K, Lavertu S, Sass T, Witte J. Charter schools in eight states: effects on achievement, attainment, integration, and competition. RAND Corporation; 2009. p. 162.
6. Woodworth JL, Raymond ME, Chirbas K, Gonzalez M, Negassi Y, Snow W, et al. Online charter school study 2015. Center for Research on Education Outcomes, Stanford University; 2015. p. 114.
7. Center for Research on Education Outcomes. Charter school performance in Pennsylvania 2019. Stanford University; 2019. p. 61.
8. Ross CE, Wui C. The links between education and health. Am Sociol Rev 1995;60:719-45.
9. Rogers RG, Hummer RA, Everett BG. Educational differentials in US adult mortality: an examination of mediating factors. Soc Sci Res 2013;42:465-81.
10. Skipper N, Gaulke A, Sildorf SM, Eriksen TM, Nielsen NF, Svensson J. Association of type 1 diabetes with standardized test scores of Danish school children. JAMA 2019;321:484-92.
11. Fleming M, Fitton CA, Steiner MFC, McLay JS, Clark D, King A, et al. Educational and health outcomes of children treated for type 1 diabetes: Scotland-wide record linkage study of 766,047 children. Diabetes Care 2019;42:1700-7.
12. Smith LB, Terry A, Bollepalli S, Rechenberg K. School-based management of pediatric type 1 diabetes: recommendations, advances, and gaps in knowledge. Curr Diab Rep 2019;19:37.

13. American Diabetes Association. Children and adolescents: standards of medical care in diabetes-2020. Diabetes Care 2020;43:S163-82.
14. Fisher L, Hessler DM, Polonsky WH, Masharani U, Peters AL, Blumer I, et al. Prevalence of depression in type 1 diabetes and the problem of overdiagnosis. Diabet Med 2016;33:1590-7.
15. Public school enrollments 2017-2018. 2018. Pennsylvania Department of Education, https://www.education.pa.gov/DataAndReporting/Enrollment/Pages/PublicSchEnrReports.aspx. Accessed September 25, 2018.
16. McGrady ME, Laffel L, Drotar D, Repaske D, Hood KK. Depressive symptoms and glycemic control in adolescents with type 1 diabetes: mediational role of blood glucose monitoring. Diabetes Care 2009;32:804-6.
17. Picozzi A, DeLuca F. Depression and glycemic control in adolescent diabetics: evaluating possible association between depression and hemoglobin A1c. Public Health 2019;170:32-7.
18. Plener PL, Molz E, Berger G, Schober E, Monkemoller K, Denzer C, et al. Depression, metabolic control, and antidepressant medication in young patients with type 1 diabetes. Pediatr Diabetes 2015;16:58-66.
19. 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.
20. Fritz H. The influence of daily routines on engaging in diabetes self-management. Scand J Occup Ther 2014;21:232-40.
21. Title 28 PA Code Section 23. http://www.pacodeandbulletin.gov/. Accessed September 1, 2020.
22. Council On School Health. Role of the school nurse in providing school health services. Pediatrics 2016;137:e20160852.
23. Nguyen TM, Mason KJ, Sanders CG, Yazdani P, Heptulla RA. Targeting blood glucose management in school improves glycemic control in children with poorly controlled type 1 diabetes mellitus. J Pediatr 2008;153:575-8.
24. Gulliford MC, Dodhia H, Chamley M, McCormick K, Mohamed M, Naithani S, et al. Socio-economic and ethnic inequalities in diabetes retinal screening. Diabet Med 2010;27:282-8.
25. Commissariat PV, Boyle CT, Miller KM, Mantravadi MG, DeSalvo DJ, Tamborlane WV, et al. Insulin pump use in young children with type 1 diabetes: sociodemographic factors and parent-reported barriers. Diabetes Technol Ther 2017;19:363-9.
26. Sheikh K, Bartz SK, Lyons SK, DeSalvo DJ. Diabetes device use and glycemic control among youth with type 1 diabetes: a single-center, cross-sectional study. J Diabetes Res 2018;2018:5162162.
27. Kahkoska AR, Shay CM, Crandell J, Dabelea D, Imperatore G, Lawrence JM, et al. Association of race and ethnicity with glycemic control and hemoglobin A1c levels in youth with type 1d. JAMA Netw Open 2018;1:e181851.
28. Butler DA, Zuehlke JB, Tovar A, Volkening LK, Anderson BJ, Laffel LM. The impact of modifiable family factors on glycemic control among youth with type 1 diabetes. Pediatr Diabetes 2008;9:373-81.
29. Vloemans AF, Eilander MMA, Rotteveel J, Bakker-van Waarde WM, Houdijk E, Nuboer R, et al. Youth with type 1 diabetes taking responsibility for self-management: the importance of executive functioning in achieving glycemic control: results from the Longitudinal DINO Study. Diabetes Care 2019;42:225-31.
30. Adams JS, Chien AT, Wisk LE. Mental illness among youth with chronic physical conditions. Pediatrics 2019;144:e20181819.
31. Robinson ME, Simard M, Larocque I, Shah J, Nakhla M, Rahme E. Risk of psychiatric disorders and suicide attempts in emerging adults with diabetes. Diabetes Care 2019;43:484-6.
32. Lawrence JM, Standiford DA, Loots B, Klingensmith GJ, Williams DE, Ruggiero A, et al. Prevalence and correlates of depressed mood among youth with diabetes: the SEARCH for Diabetes in Youth study. Pediatrics 2006;117:1348-58.
33. Briere FN, Pascal S, Dupere V, Janosz M. School environment and adolescent depressive symptoms: a multilevel longitudinal study. Pediatrics 2013;131:e702-8.
34. Anderson B. Psychosocial care for young people with diabetes. Pediatr Diabetes 2009;10(Suppl 13):3-8.
35. U.S. Department of Education, Office for Civil Rights. Free Appropriate Public Education for Students With Disabilities: Requirements Under Section 504 of the Rehabilitation Act of 1973, Washington, D.C. 2010. https://www2.ed.gov/about/offices/list/ocr/docs/edlite-FAPE504.html. Accessed January, 2020.
36. Individuals with Disabilities Education Act, 20 U.S.C. § 1400; 2004.
37. American Diabetes Association. Safe at school. http://www.diabetes.org/living-with-diabetes/parents-and-kids/diabetes-care-at-school/school-staff-trainings/. Accessed January, 2020.