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ORIGINAL ARTICLE

Youth with Type 1 Diabetes Had Improvement in Continuous Glucose Monitoring Metrics During the COVID-19 Pandemic

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Abstract

Background: The impact of the coronavirus disease-2019 (COVID-19) pandemic on glycemic metrics in children is uncertain. This study evaluates the effect of the shelter-in-place (SIP) mandate on glycemic metrics in youth with type 1 diabetes (T1D) using continuous glucose monitoring (CGM) in Northern California, United States.
Methods: CGM and insulin pump metrics in youth 3–21 years old with T1D at an academic pediatric diabetes center were analyzed retrospectively. Data 2–4 months before (distant pre-SIP), 1 month before (immediate pre-SIP), 1 month after (immediate post-SIP), and 2–4 months after (distant post-SIP) the SIP mandate were compared using paired *t*-tests, linear regression, and longitudinal analysis using a mixed effects model.
Results: Participants ($n=85$) had reduced mean glucose (-10.3 ± 4.4 mg/dL, $P=0.009$), standard deviation (SD) (-5.0 ± 1.3 mg/dL, $P=0.003$), glucose management indicator ($-0.2\%\pm0.03\%$, $P=0.004$), time above range (TAR) >250 mg/dL ($-3.5\%\pm1.7\%$, $P=0.01$), and increased time in range (TIR) ($+4.7\%\pm1.7\%$, $P=0.0025$) between the distant pre-SIP and distant post-SIP periods. Relationships were maintained using a mixed effects model, when controlling for other demographic variables. There was improvement in SD, TAR 180–250 mg/dL, and TIR for participants with private insurance, but changes in the opposite direction for participants with public insurance.
Conclusions: Improvement in CGM metrics in youth with T1D during the COVID-19 pandemic suggests that diabetes management can be maintained in the face of sudden changes to daily living. Youth with public insurance deserve more attention in research and clinical practice.

Keywords: COVID-19, Continuous glucose monitoring, Type 1 diabetes, Pediatrics, Time in range.

Introduction

THE SEVERE ACUTE RESPIRATORY syndrome coronavirus-2 (SARS-CoV-2) pandemic that emerged in December 2019 led to extreme public health measures worldwide to reduce the viral spread of coronavirus disease-2019 (COVID-19), including a ''Shelter-In-Place'' (SIP) mandate in California on March 19, 2020. California's SIP mandate was one of the earliest and strictest mandates in the United States. The mandate closed in-person schooling, required many companies to shift to remote work, restricted nonessential travel and services, and emphasized masking and social distancing.[1]

As Californians adjusted to the new public health measures, children experienced drastic changes to their daily lives and schedules. Schools quickly shifted to an online format, and extracurricular activities were either canceled or transferred online. The trend of telemedicine rapidly accelerated.[2] Despite the pandemic, endocrinologists have been

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able to continue caring for their patients with diabetes through telemedicine clinics and use of remote continuous glucose monitoring (CGM).[3] These changes for patients and providers have the potential to disrupt or transform health behaviors and diabetes management. Analyzing this unique period of rapid change can shed light on how sudden changes in daily living affect those living with diabetes.

In European countries, the public health lockdowns did not adversely affect glycemic metrics for adults living with type 1 diabetes (T1D). Some studies have shown that adults with T1D on sensors experienced improved glycemic control, both during initial national lockdowns and during subsequent periods of de-escalation of public health restrictions.[4,5] Changes included reductions in average glucose, hemoglobin A1c (A1C), glucose management indicator (GMI), and time above range (TAR), along with an increase in time in range (TIR). However, other studies in the same countries showed that national lockdowns had no impact on glycemic metrics in adults.[6]

Prior studies have shown that children with T1D who used CGM had reduced glucose variability and differences in glycemic metrics based on age group and socioeconomic status. European studies of children with T1D who used CGM showed reduced glucose variability, as measured by standard deviation (SD) and coefficient of variation (CV),[7,8] and an increase in TIR after public health restrictions were enacted.[9] Similarly, an Israeli study showed that, when comparing glycemic data from the immediate pre- and post-lockdown periods, adolescents had decreased glucose variability during the lockdown, although in children <10 years, there were no differences.[10] Younger age and lower socioeconomic status were associated with suboptimal glycemic control during lockdown.[10] A recent large multicenter, U.S.-based study of over 65,000 Dexcom G6 CGM users showed that individuals living in economically wealthier zip codes had higher pre- and intra-pandemic TIR values and a greater improvement in TIR during lockdown. However, this analysis did not specifically evaluate the effects of the pandemic on glycemic metrics in children.[11]

It is important for clinicians to understand the impact of a stay-at-home order on diabetes management in youth living with T1D, as lessons learned during this time may be applicable to future interruptions in daily life. This is especially relevant as telemedicine becomes more routine and as natural disasters and evacuations become seasonal occurrences, as in the case of wildfires in California.[12] No studies have yet specifically explored the impact of the COVID-19 pandemic on glycemic metrics in children with T1D in the United States. In this study, we report our experience of the COVID-19 SIP mandate on CGM metrics in youth with T1D.

Research Design and Methods

Study design and participants

This retrospective cohort study included children, adolescents, and young adults 3–21 years old with T1D, using CGM for ≥1 month, who received care at an academic pediatric diabetes center, which provides multidisciplinary care for children with diabetes in the greater San Francisco Bay Area. The clinic is certified by the American Diabetes Association and is staffed by faculty who are board-certified in pediatric endocrinology, clinical fellows, nurse practitioners, behavioral health providers, Certified Diabetes Care and Education Specialists, dieticians, and support staff. In this clinic, nearly all follow-up diabetes encounters were shifted to telehealth visits within a matter of days following the SIP mandate, at the same quarterly intervals typically used. Routine clinical management was provided to all patients with no specific anticipatory guidance with regard to the SIP mandate.

Youth with T1D were included in this study if they had a scheduled clinic encounter with a diabetes provider in June 2020 and had CGM data for ≥60% of the time over 2-week intervals within four defined study periods: ''distant pre-SIP,'' ''immediate pre-SIP,'' ''immediate post-SIP,'' and ''distant post-SIP.'' The SIP mandate in Northern California was enforced on March 19, 2020, and 2 weeks of glycemic data from each participant were collected from each of the four intervals: (1) 2–4 months before the SIP mandate (November 19, 2019–January 19, 2020, ''distant pre-SIP''), (2) 1 month immediately before the SIP mandate (February 19, 2020–March 18, 2020. ''immediate pre-SIP''), (3) 1 month immediately following the SIP mandate (March 19, 2020–April 19, 2020, ''immediate post-SIP''), and (4) 2–4 months following the SIP mandate (May 19, 2020–July 19, 2020, ''distant post-SIP'') (Fig. 1).

Patients were selected from sequential review of the electronic medical records of patients who were scheduled to be seen in the diabetes clinic either in-person or by telehealth during the month of June 2020 (Fig. 2). Glycemic data for these patients were then manually collected for all time periods. Data were extracted from the electronic medical record and web-based data visualization systems, Tidepool (Palo Alto, CA), and Clarity (Dexcom, Inc., San Diego, CA). The protocol and procedures were approved by the Institutional Review Board at the University of California, San Francisco.

Measurements

Demographic data for participants included age, gender, insurance, primary language, and duration of diabetes as identified in the electronic medical record. CGM glycemic metrics that were obtained from Tidepool or Clarity over a 2-week period included mean glucose, percent TAR (between 180–250 mg/dL and >250 mg/dL), percent TIR 70–180 mg/dL, percent time below range (between 54–70 mg/dL and <54 mg/dL), along with SD and CV to account for changes in glucose variability. GMI, an approximation of the A1C level based on the average glucose readings obtained from CGM, and A1C were also included if available, as markers of glycemic control.[13,14]

''Delta'' variables were defined as the change in glycemic metrics between the distant pre-SIP and post-SIP periods. For example, delta TIR = (post-SIP TIR)–(pre-SIP TIR). For participants using an insulin pump, total daily insulin dose, percent of basal insulin, mean number of boluses per day, and mean number of daily carbohydrates were recorded for each 2-week period. Insulin dosing data for participants using multiple daily injections (MDI) were not collected.

Statistical analysis

Statistical analysis was performed using Stata 16.0 (StataCorp, College Station, TX). Comparisons of paired data for glycemic metrics and insulin pump measurements

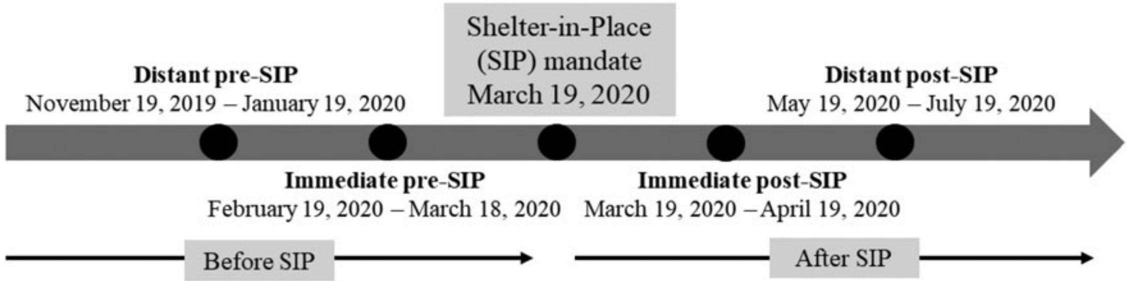

FIG. 1. Timeline of study.

between the immediate pre-SIP and immediate post-SIP time periods and distant pre-SIP and distant post-SIP time periods were performed using two-sided paired *t*-tests.

Linear regression was used to evaluate the association of average differences in glycemic metrics between the distant pre-SIP and distant post-SIP time periods (''delta'' variables) with age group, gender, and insurance. Age groups were categorized as children (3–12 years), adolescents (13–17 years), and young adults (18–21 years). Insurance group was defined as public or private, and gender was defined as male or female. The repeated glycemic measurements for individuals were analyzed using a mixed effects linear model. For modeling purposes, the data were categorized into a ''Before SIP'' time period, representing data in the distant pre-SIP and immediate pre-SIP periods, and an ''After SIP'' time period, representing data in the distant post-SIP and immediate post-SIP periods.

Each participant could contribute up to two data points (one from each of the distant and immediate time periods) to each of the Before SIP and After SIP periods (Fig. 1). For example, a participant who did not have data from all four time periods could still contribute glycemic data in this model, if they had data from at least one of the time periods before the SIP mandate and from at least one of the time

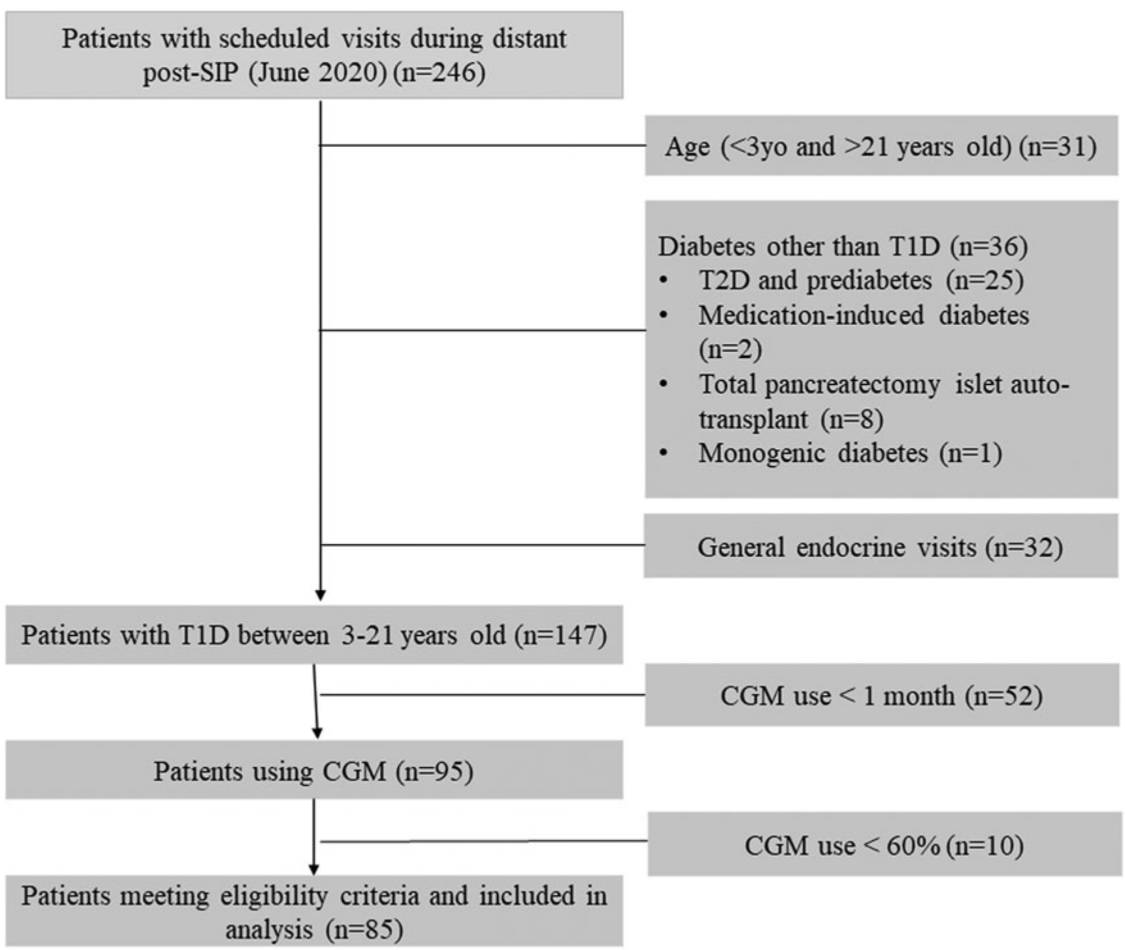

FIG. 2. Flowchart depicting the selection of individuals for inclusion in the study.

periods after the SIP mandate, which allowed comparison within individuals. The mixed effects model included a fixed effect for time period (Before SIP vs. After SIP) and a random effect for participant to account for the intrasubject correlation of the repeated measurements.

In the multivariate mixed effect model, when accounting for gender, age, diabetes duration, language, and medical insurance, the fixed effect parameter for time period is interpreted as an average difference in glycemic metrics in the Before SIP versus After SIP periods but accommodates uneven numbers of measurements across patients and time periods. A *P*-value <0.05 was considered statistically significant.

Results

Of the 246 patients scheduled for visits (either in person or by telehealth) in the diabetes clinic in the distant post-SIP period (June 2020), 85 patients with T1D who were between 3 and 21 years old (mean age 13.6 ± 4.6 years) and had CGM data for ≥60% of the time over 2 weeks were included in the analysis (Fig. 2). The majority of included participants had private insurance, and the primary language spoken was English (Table 1). Median duration of diabetes was 5.5 (2.5–9.5) years (Table 1). Seventy-six percent of participants were using insulin pumps.

Participants had statistically significant reductions in mean glucose (−10.3 ± 4.4 mg/dL), SD (−5.0 ± 1.3 mg/dL), GMI (–0.2% ± 0.03%), TAR >250 mg/dL (–3.5% ± 1.7%), and TBR <54 mg/dL (0.23% ± 0.5%), along with an increase in TIR (4.7% ± 1.7%) in the distant post-SIP period compared to the distant pre-SIP period (Table 2). Similar analysis was also performed for the immediate pre-SIP and post-SIP periods, but no significant changes were found (data not shown). In participants using insulin pumps, there was no significant difference in total daily dose, percent basal insulin, mean number of boluses per day or mean number of daily carbohydrates between the distant pre-SIP and post-SIP time periods (Table 2) or between the immediate pre-SIP and post-SIP time periods (data not shown).

Table 1. Participant Characteristics

	n = *85*
Mean age (years)	13.6 ± 4.6
Child age (%)	
3–12 years	43
13–17 years	28
18–21 years	28
Gender (%)	
Female	47
Male	53
Median duration of diabetes (years)	5.5 (2.5–9.5)
Primary language (%)	
English	95
Spanish	5
Insurance status (%)	
Private	78
Public	22

Data are means ± SD, medians (interquartile range), or frequencies, as indicated.

SD, standard deviation.

To determine the association between demographic variables and changes in glycemic metrics during the distant pre-SIP and post-SIP periods, linear regression was performed. Multivariate linear regression showed statistically significant associations of private insurance status with an increase in TIR (6.5% ± 13.1%), reduced TAR 180–250 mg/dL (–3.0% ± 9.4%), and reduced SD (–6.6 ± 10.7 mg/dL), whereas public insurance was associated with decreased TIR (–0.9% ± 11.9%), increased TAR 180–250 mg/dL (6.9% ± 14.5%), and increased SD (2 ± 16.1 mg/dL) between the distant pre-SIP and post-SIP periods after adjusting for age and gender (Table 3).

Analysis by age group revealed that children (mean difference –6.7 ± 10.7 mg/dL) and adolescents (mean difference –7.7 ± 10.3 mg/dL) had reductions in SD, compared to young adults who showed increases in SD (mean difference 1.6 ± 15.2 mg/dL), which neared statistical significance ($P = 0.06$) between the distant pre-SIP and post-SIP periods. Other changes in glycemic metrics were not significantly associated with age group. Gender was not associated with any significant changes in glycemic metrics between the distant pre-SIP and post-SIP periods.

Multivariate mixed effect modeling to look for associations of glycemic metrics in the Before SIP and After SIP time periods, when adjusting for gender, age, diabetes duration, language, and insurance status, showed a statistically significant decrease in mean glucose (–5.2 [–9.0 to −1.4] mg/dL), SD (–3.5 [–5.5 to −1.4] mg/dL), TAR >250 mg/dL (−1.8 [–3.4 to –0.2] %), and an increase in TIR (2.8 [0.7–4.8] %). There was also a significant increase in TBR 54–70 mg/dL, but a decrease in TBR <54 mg/dL (Table 4). No significant differences were found with insulin pump metrics.

Discussion

The COVID-19 pandemic disrupted the daily lives of individuals and families living with T1D, presenting a challenge to glycemic management.[15] Sudden changes included many parents shifting to work from home, unemployment, school closures, interruption of usual diet and physical activity, and increased psychosocial stressors.[15] Given the potentially negative effects that the pandemic could have on children and their health, we aimed to understand if the stay-at-home mandate during the COVID-19 pandemic had any effect on CGM glycemic metrics in youth living with T1D. The results suggest that many families of youth with T1D who use CGM can effectively manage diabetes, despite the limitations presented by the pandemic.

Similar to adult and pediatric Italian studies,[4,9] our results showed improvement in CGM metrics in the distant time periods surrounding the SIP mandate. However, our study did not show any significant changes in glycemic metrics when comparing the time periods immediately before and after the SIP mandate, unlike other studies which reported improvement in glycemic metrics 2–4 weeks immediately following their mandates.[4,5,7,8,10] CGM metrics in our study may be comparable in the periods immediately surrounding the SIP mandate because behaviors may have changed weeks before the formal government SIP order was in place. Since the first case of COVID-19 in Northern California was reported in February 2020, parents might have voluntarily kept their children home from school ahead of the formal mandate,[16] and schools in some Northern California counties closed

TABLE 2. COMPARISON OF CONTINUOUS GLUCOSE MONITORING AND INSULIN PUMP METRICS BETWEEN DISTANT PRE-SHELTER-IN-PLACE (SIP) AND POST-SIP TIME PERIODS

	Distant pre-SIP	*Distant post-SIP*	P
CGM metrics ($n=75$)[a]			
Mean glucose (mg/dL)	193.5 ± 39.2	183.2 ± 43.6	**0.0009**
SD (mg/dL)	68.0 ± 14.5	63.0 ± 15.8	**0.003**
CV (%)	36.3 ± 5.8	35.4 ± 6	0.30
GMI (%)	7.6 ± 0.8	7.4 ± 0.8	**0.004**
TAR >250 mg/dL (%)	23.5 ± 17.7	20.0 ± 19.4	**0.01**
TAR 180–250 mg/dL (%)	27.4 ± 9.8	26.7 ± 12.2	0.65
TIR 70–180 mg/dL (%)	48.2 ± 19.7	52.9 ± 21.4	**0.0025**
TBR 54–70 mg/dL (%)	1.49 ± 2.2	1.50 ± 2.0	0.97
TBR <54 mg/dL (%)	0.20 ± 0.3	0.43 ± 0.8	**0.01**
Insulin pump metrics ($n=46$)[b]			
Total daily dose (units)	44.8 ± 25.0	47.1 ± 22.6	0.22
Percent basal insulin (%)	47.3 ± 12.6	46.5 ± 13.6	0.67
Mean no. of boluses/day	6.6 ± 2.8	8.9 ± 12.2	0.19
Mean carbohydrates/day (g)	166.0 ± 111.8	157.3 ± 88.3	0.49

P-values were obtained from paired *t*-tests. *P*-values < 0.05 are shown in bold. Data are means ± SD.
[a]With the exception of $n=69$ for mean glucose, $n=58$ for SD, $n=57$ for CV, and $n=40$ for GMI.
[b]With the exception of $n=43$ for mean carbohydrates/day.
CGM, continuous glucose monitoring; CV, coefficient of variation; GMI, glucose management indicator; SIP, shelter-in-place; TAR, time above range; TBR, time below range; TIR, time in range.

before the statewide orders on March 19, 2020.[1] Numerous employers encouraged their employees to work from home for weeks before this date,[17] which could have potentially led to increased adult supervision at home before the formal mandate. Due to concerns that suboptimal diabetes control was a risk factor for worse COVID-19 outcomes, families may have been more motivated to optimize glycemic management in the weeks leading up to the public health order.

Multiple factors and behavioral changes may have contributed to the improvement in glycemic metrics in the distant time periods surrounding the public health mandate. Prior studies have shown that adults and children had increased sensor usage and glucose scans during lockdown periods,[5] suggesting that increased CGM use may be related to optimal glycemic metrics. In other studies, children using either MDI or insulin pump therapy had no changes in total daily dose of insulin in the immediate[7] or distant time periods (3 months)[9] surrounding the SIP mandate, which was confirmed in our study.

We also saw no significant change in the recorded number of carbohydrates, suggesting that change in carbohydrate intake was not a major contributor to improved glycemic metrics. Other studies found that children ate breakfast and dinner later in the day and were less physically active during

TABLE 3. ASSOCIATION OF INSURANCE STATUS WITH CHANGES IN CONTINUOUS GLUCOSE MONITORING METRICS AND INSULIN PUMP METRICS BETWEEN DISTANT PRE-SHELTER-IN-PLACE (SIP) AND DISTANT POST-SIP TIME PERIODS

Delta variables (post-SIP–pre-SIP)	*Private insurance*	*Public insurance*	P
CGM metrics	$n=57$[a]	$n=18$[b]	
ΔMean glucose (mg/dL)	−12.8 ± 23.4	−2.1 ± 28.1	0.130
ΔSD (mg/dL)	−6.6 ± 10.7	+2.0 ± 16.1	**0.037**
ΔCV (%)	−1.2 ± 5.4	+0.9 ± 7.8	0.314
ΔGMI (%)	−0.3 ± 0.5	−0.2 ± 0.8	0.154
ΔTAR >250 mg/dL (%)	−4.2 ± 10.0	−1.1 ± 15.3	0.331
ΔTAR 180–250 mg/dL (%)	−3.0 ± 9.4	+6.9 ± 14.5	**0.002**
ΔTIR 70–180 mg/dL (%)	+6.5 ± 13.1	−0.9 ± 11.9	**0.046**
ΔTBR 54–70 mg/dL (%)	+1.4 ± 1.8	+1.0 ± 2.3	0.449
ΔTBR <54 mg/dL (%)	+1.3 ± 2.1	−0.4 ± 0.7	0.116
Insulin pump metrics	$n=37$[c]	$n=10$[d]	
ΔTotal daily dose (units)	+2.1 ± 13.0	+3.09 ± 11.9	0.832
ΔPercent basal insulin (%)	−0.4 ± 12.1	−2.0 ± 9.6	0.702
ΔMean no. of boluses/day	+2.89 ± 13.2	0 ± 2.7	0.553
ΔMean carbohydrates/day (g)	−1.2 ± 51.1	−37.1 ± 155.3	0.239

P-values were obtained from multivariate linear regression. *P*-values < 0.05 are shown in bold. Data are means ± SD.
[a]With the exception of $n=53$ for mean glucose, $n=46$ for SD, $n=47$ for CV, $n=37$ for GMI.
[b]With the exception of $n=16$ for mean glucose, $n=11$ for SD and CV, $n=3$ for GMI.
[c]With the exception of $n=36$ for total daily dose, $n=34$ mean carbohydrates/day.
[d]With the exception of $n=9$ for mean no. of boluses/day and mean carbohydrates/day.

Table 4. Multivariate Comparison of Continuous Glucose Monitoring and Insulin Pump Metrics Between Before Shelter-In-Place (SIP) and After SIP Time Periods

	Before SIP	*After SIP*	P
CGM glycemic metrics ($n=85$)[a]			
Mean glucose (mg/dL)	190.5 (182.0–198.9)	185.3 (176.9–193.7)	**0.008**
SD (mg/dL)	67.4 (63.9–70.9)	63.9 (60.5–57.4)	**0.001**
CV (%)	36.3 (35.0–37.6)	35.3 (34.0–36.5)	**0.029**
GMI (%)	7.7 (7.5–7.9)	7.6 (7.4–7.9)	0.165
TAR >250 mg/dL (%)	22.2 (18.6–25.7)	20.3 (16.8–23.8)	**0.031**
TAR 180–250 mg/dL (%)	26.4 (24.3–28.4)	26.5 (24.4–28.5)	0.906
TIR 70–180 mg/dL (%)	49.7 (45.7–53.8)	52.5 (48.5–56.6)	**0.009**
TBR 54–70 mg/dL (%)	0.3 (0.06–0.58)	1.4 (1.18–1.68)	**<0.0001**
TBR <54 mg/dL (%)	1.5 (1.3–1.8)	0.36 (0.09–0.64)	**<0.0001**
A1c (%)	8.1 (7.8–8.4)	8.0 (7.6–8.5)	0.811
Insulin pump metrics ($n=78$)[b]			
Total daily dose (units)	41.3 (36.8–45.8)	42.3 (37.8–46.8)	0.590
Percent basal insulin (%)	46.7 (44.2–49.1)	46.9 (44.4–49.3)	0.855
Mean no. of boluses/day	6.8 (5.3–8.4)	8.3 (6.8–9.9)	0.135
Mean carbohydrates/day (g)	156.9 (135.0–178.9)	144.9 (123.1–166.7)	0.189

P-values were obtained from multivariate mixed effect model analysis. *P*-values <0.05 are shown in bold. Data are means (95% confidence interval).

[a]With the exception of $n=72$ for SD and A1c, $n=76$ for CV, $n=84$ for GMI.

[b]With the exception of $n=77$ for mean carbohydrates/day.

the pandemic,[7] likely due to a discontinuation of extracurricular activities. Further, an international multicenter study suggested that home confinement during the pandemic led to increased sedentary time and increased unhealthy food choices in the general population.[18] Despite these potentially detrimental lifestyle changes, children had improvement in their glycemic metrics without a change in their total daily insulin requirements.[7,9]

Notably, patients with private insurance had improved glycemic metrics, with increased TIR and reduced hyperglycemia and glucose variability (SD), whereas those with public insurance had changes in these metrics in the opposite directions. This corroborates a growing body of evidence demonstrating disparities in diabetes outcomes across different demographic and socioeconomic factors during the COVID-19 pandemic.[11] It is known that ethnic minority and socioeconomically disadvantaged children carry the highest burden of COVID-19 infection,[19] and that children from ethnic minority groups with T1D and COVID-19 have had higher median A1C values and presented in diabetic ketoacidosis more frequently.[20] Our findings highlight the need to devote efforts to families who may be suffering from multiple challenges during the pandemic, such as those with public insurance, to ensure that they have the resources and support to achieve optimal diabetes management.

Glycemic metrics were comparable across age groups, but there was an age-specific change in glycemic variability that approached significance. Children and adolescents had reduced glycemic variability (SD), whereas young adults had increased glycemic variability in the distant post-SIP compared to the distant pre-SIP time period. It is possible that children experienced more changes in their daily lives, which had a positive impact on diabetes care, such as increased parental supervision or increased attention to diabetes self-management while home from school, with caregivers who were also spending more time at home.

In contrast, the SIP mandate may have had a different impact on diabetes self-care in young adults, who are likely more independent in their T1D management and may have less input from their family in daily management. In addition, the young adult population may have experienced more instability in their employment, education, and living situations, which could have led to less attention to their diabetes management.

Our study has some limitations. Because participants were selected from those who attended scheduled clinic visits in June 2020, there may have been a selection bias toward patients and families who were more likely or able to attend visits and be engaged in their diabetes care. Similarly, a Saudi Arabian study showed that patients with T1D who attended telemedicine visits during the pandemic had improved glycemic metrics compared to those who did not.[21]

Our study was limited to those who used CGM during the study period and who had the capability and resources to upload their diabetes data remotely to a web-based system, which suggests the need for a relatively high level of technological literacy. The study population may have also been practicing close to optimal diabetes self-management at baseline, suggested by a baseline GMI of 7.6%, which approaches the A1C target for glycemic control for youth.[22] It is unclear if youth with A1C or GMI levels above target would have similar results. Data on the type of insulin delivery system used by our study population, such as automated insulin delivery systems, which could impact glycemic control, were not collected, which is also a limitation of our study.

Conflicting results were noted for time spent in hypoglycemia, which was already small at baseline, making the hypoglycemia data inconclusive. Our population was mostly English-speaking and had private insurance, making it difficult to generalize our findings to more diverse populations.

Future studies are needed to better understand how COVID-19 has influenced diabetes management, CGM metrics, and glycemic control. Studies of more diverse populations, and quantitative and qualitative analysis of race and ethnicity, hospitalizations, socioeconomic factors, lifestyle changes, psychosocial stressors, along with detailed knowledge about the type of insulin pump therapy used, including automated insulin delivery systems, are needed to more completely understand the impact of the pandemic on all youth with T1D.

Finally, studies that identify the specific aspects of the global pandemic and SIP restrictions, which had a positive impact on glycemic metrics, may be helpful in optimizing glycemic management in youth with diabetes even in a more routine clinical setting.

Conclusion

Youth with near-optimal baseline management of T1D using CGM showed statistically significant improvement in glycemic metrics during the SIP mandate in Northern California, United States. These results suggest that youth living with T1D who use CGM can effectively manage their diabetes remotely, despite the limitations of the public health measures. Disparities in glycemic outcomes were noted, with publicly insured youth experiencing a decline in the same metrics, in which those with private insurance showed improvement, highlighting the need to devote further studies and resources to more diverse populations.

Authors' Contributions

F.S.A. and H.C. performed data collection, data analysis, and article preparation. W.J.B. assisted with data analysis and article preparation. J.C.W. conceived of the study idea and she and S.E.G. provided input on study design and article preparation.

Author Disclosure Statement

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