Nationwide digital/virtual diabetes care of children, adolescents and young adults with type 1 diabetes during a COVID-19 pandemic in Slovenia

Digitalna/virtualna obravnava otrok, mladostnikov in mladih odraslih s sladkorno boleznijo tipa 1 med pandemijo covida-19 v Sloveniji

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Abstract

Background: During coronavirus pandemic disease 2019 (COVID-19) the Government of the Republic of Slovenia introduced a series of restrictive measures including outpatient clinics closure and a cessation of all elective healthcare visits. To sustain attentiveness to optimal diabetes care, the vast majority of appointments for individuals with type 1 diabetes were transitioned to video digital/virtual visits.

Methods: In this prospective observational study, we compared glycaemic control of children, adolescents and young adults with type 1 diabetes from the Slovenian National Childhood Type 1 Diabetes Registry during the pre-lockdown and lockdown periods. We approached all individuals with type 1 diabetes, who had a visit scheduled between 15th of March and 20th of May 2020.

Results: Out of 326 subjects, 313 (96% response rate) attended a video digital/virtual visit. Glycaemic control was not impaired during the lockdown period in individuals with type 1 diabetes and has even slightly improved. Mean glucose was 9.3 mmol/l (IQR 8.3–10.3) during the lockdown, compared to 9.5 mmol/l (IQR 8.2–10.9), p = 0.001 during the pre-lockdown period.

Conclusion: In a short period of time, we established effective workflows to enable video digital/virtual visits that provided individuals with type 1 diabetes good clinical support and prevented deterioration of this chronic condition and its acute complications during the lockdown due to the COVID-19 pandemic.

Izvleček

Izhodišče: Vlada Republike Slovenije je sprejela vrsto ukrepov za obvladovanje pandemije koronavirusne bolezni 2019 (covid-19), ki so vključevali tudi začasno prenehanje nenujne zdravstvene dejavnosti, kot je redna ambulantna obravnava in elektivni posegi. Da bi ohranili primerno presnovno urejenost oseb s sladkorno boleznijo tipa 1, smo v času karantene osebe s sladkorno boleznijo tipa 1 povabili v digitalno/virtualno obravnavo.

Metode: V tej prospektivni opazovalni raziskavi smo primerjali presnovno urejenost otrok, mladostnikov in mlajših odraslih s sladkorno boleznijo tipa 1 iz slovenskega nacionalnega otroškega registra za bolezen tipa 1 v času pred karanteno in med njo. K sodelovanju smo pov-

abili vse osebe s sladkorno boleznijo tipa 1, ki so imele predvideno redno obravnavo v času karantene med 15. marcem in 20. majem 2020.

Rezultati: 313 od 326 (odziv 96 %) se je udeležilo digitalne/virtualne obravnave preko video stika. Presnovna urejenost oseb s sladkorno boleznijo tipa 1 se času karantene ni poslabšala. Povprečna raven glukoze med karanteno je bila celo nekoliko nižja kot v obdobju pred karanteno: 9,3 mmol/l, tj. IQR 8.3–10.3 med karanteno, v primerjavi z 9,5 mmol/l, tj. IQR 8.2–10.9, p = 0.001 v obdobju pred karanteno.

Zaključek: Podatki naše raziskave kažejo, da smo v kratkem času vzpostavili učinkovite delovne procese digitalno/virtualno obravnavo preko z video stika. S tem smo osebam s sladkorno boleznijo tipa 1 zagotovili ustrezno klinično podporo med karanteno zaradi pandemije covida-19 in preprečili akutne zaplete ali dolgoročno poslabšanje tega kroničnega stanja.

1 Introduction

On 11 March 2020, the World Health Organization declared coronavirus disease 2019 (COVID-19) a pandemic and a day later the Government of the Republic of Slovenia imposed a series of restrictive measures to contain and manage the possible spread, including outpatient clinics closure and a cessation of all elective healthcare visits and procedures.

While diabetes was initially recognized as one of the main risk factors for morbidity and mortality, mainly due to cardiovascular and renal complications (1), it is reassuring to know that young people, with or without diabetes, are at a lower risk with COVID-19 infection (2-4).

However, individuals with chronic conditions, including type 1 diabetes, are at an increased risk for acute complication and chronic condition deterioration during this lockdown period due to limitations in access to outpatient clinics and healthcare services. Therefore, to sustain attentiveness to optimal diabetes care and at the same time to minimize the risk of viral transmission with close proximity and to maintain appropriate social distancing (5,6), the vast majority of appointments for individuals with type 1 diabetes were transitioned to digital/virtual visits. Consequently, in-person diabetes care was restricted only to individuals who were newly started on insulin therapy or had severe acute complications that needed emergency/urgent care visit or hospitalization.

This study aimed to assess glycaemic control in a cohort of individuals with type 1 diabetes who conducted a digital/virtual visit during the lockdown period due to COVID-19 pandemic, compared to the pre-lockdown period.

2 Material and methods

We performed a nationwide prospective observational study of children, adolescents and young adults with type 1 diabetes from the Slovenian National Childhood Type 1 Diabetes Registry (7), who had a scheduled visit at the UMC Ljubljana University Children's Hospital. During the lockdown period between 15th of March and 20th of May 2020, all PWDs were invited to attend a video digital/virtual visit, including a limited video clinical examination when indicated. We compared glycaemic control of eligible persons with diabetes (PWDs) before and during the lockdown period.

Data on the age of the participants at the onset, the treatment modality (multiple daily injections with or without continuous glucose monitoring (CGM), continuous subcutaneous insulin infusion (CSII) with or without CGM, and a hybrid closed-loop) and glycaemic control were collected from the previous in-person visits before the lockdown period. Participants and their families were instructed to share their device reports with the most recent data using e-mail. Video virtual/digital visit was performed using Zoom or with a telephone call if the Internet was not available at participant's home and the scheduled duration of the visit was the same as for the in-person visits (approximately 30 minutes). During the digital-virtual visits, we collected information regarding serious adverse events. Diabetic ketoacidosis (DKA) was defined as an event requiring hospitalization and intravenous therapy (8), and severe hypoglycaemia (SH) was defined as an event with a severe cognitive impairment (including coma and convulsions) requiring external assistance and hospitalization with intramuscular and/or intravenous ther-

apy (9).

We extracted data on glycaemic control during the digital/virtual visits from CareLink™ Personal and Accu-Chek Connect™ portal reports. For the present analysis, we included participants who met the following criteria: type 1 diabetes for at least 6 months, insulin pump use for at least 3 months, age at baseline visit <23 years, availability of glucose control data in electronic format. The primary endpoint was the median difference in individuals' mean glucose concentration between pre-lockdown and lockdown visit.

All statistical analyses were conducted using GraphPad Prism 7 (GraphPad Software, San Diego, CA). Data are presented as median (IQR). Wilcoxon matched-pairs signed-rank test was performed to check the differences of paired data. A P-value <0.05 was considered statistically significant.

The study was conducted in line with the last revision of the Declaration of Helsinki with amendments. Participants/their parents gave their written informed consent for the anonymous reuse of the national registry data for research purposes.

The study was approved by the Medical Ethics Committee of the Republic of Slovenia (Decision No. 0120-328/2020/5).

3 Results

We have contacted 326 PWDs (147 males), mean (SD) age was 13.6 (4.5) years, age at type 1 diabetes onset was 7.3 (4.3) years, and the duration of type 1 diabetes was 6.3 (4.4) years (Figure 1).

During the lockdown period, we have completed 313 digital/virtual visits (96% response rate). The mean age of the 13 non-responders was 15.9 years and
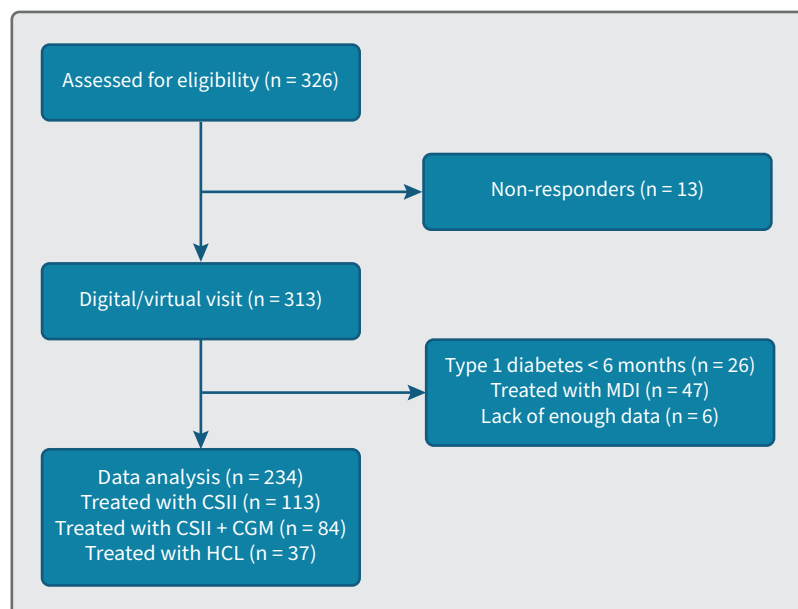
Figure 1: Study flowchars.
Data are median (IQR). CGM – continuous glucose sensor, CSII – Continuous subcutaneous insulin infusion, HCL – Hybrid closed-loop, MDI – Multiple daily injections.

HbA1c 8.1% (65 mmol/mol).

Twenty-six children have been diagnosed with type 1 diabetes within the six months prior to the lockdown and were invited to their first/second follow-up as a virtual visit (age 10.8 years and HbA1c 9.0% (74.9 mmol/mol). We included 234 individuals who provided glucose data reports for both periods, excluding children with a recent diagnosis of type 1 diabetes, individuals treated with multiple daily injections and individuals that did not provide a sufficient amount of data for the analysis (Figure 1). Their last measured median HbA1c prior to lockdown period was 7.5% (IQR 7–8.1) (58.5 mmol/mol (53.0–65). There were on average 3.8 months between the visits.

Data on glycaemic control between the two periods are presented in Table 1. During the lockdown period, the median glucose concentration of 9.3 mmol/l (IQR 8.3–10.3) was slightly lower compared to the pre-lockdown period glucose concentration of 9.5 mmol/l ((IQR 8.2–10.9), p = 0.001) (Figure 2). Similarly, there was a slight improvement among CSII users (p<0.001), while there was no change in glycaemic control between the two periods among HCL users and CSII users with CGM (Figure 3).

There was no significant difference in a median change of glucose concentration towards baseline between visits conducted in the first part of the lockdown, compared to the second part (p = 0.195). There was no difference in coefficient of variation (CV) of mean glucose, while there was a modest increase in total daily insulin dose and in the amount of carbohydrates consumed, and a decrease in the number of glucose measurements performed between the two periods (Table 1).

There were no severe hypoglycaemic events, DKA, SARS-CoV-2 infections or any other severe adverse events requiring hospitalization during the whole observational period among our study participants.

Table 1: Metrics of glycaemic control.

	Pre-lockdown period	Lockdown period	P value
Mean glucose (mmol/l)	9.5 (8.2–10.9)	9.3 (8.3–10.3)	0.001
CV of mean glucose (%)	41 (36–50)	41 (35–51)	0.348
SD of mean glucose (mmol/l)	4.1 (3.5–5.3)	4.0 (3.3–5.0)	0.046
TDD (units/day)	30.7 (16.1–46.7)	34.5 (17.8–48.0)	<0.001
Number of glucose measurements	6.8 (5.3–8.0)	6.4 (4.7–8.0)	0.011
Amount of CH consumed (g/day)	173 (113–216)	179 (130–225)	0.039

Data are median (IQR), CH – Carbohydrates, CV – Coefficient of variation, SD – Standard deviation, TDD – Total daily dose of insulin.
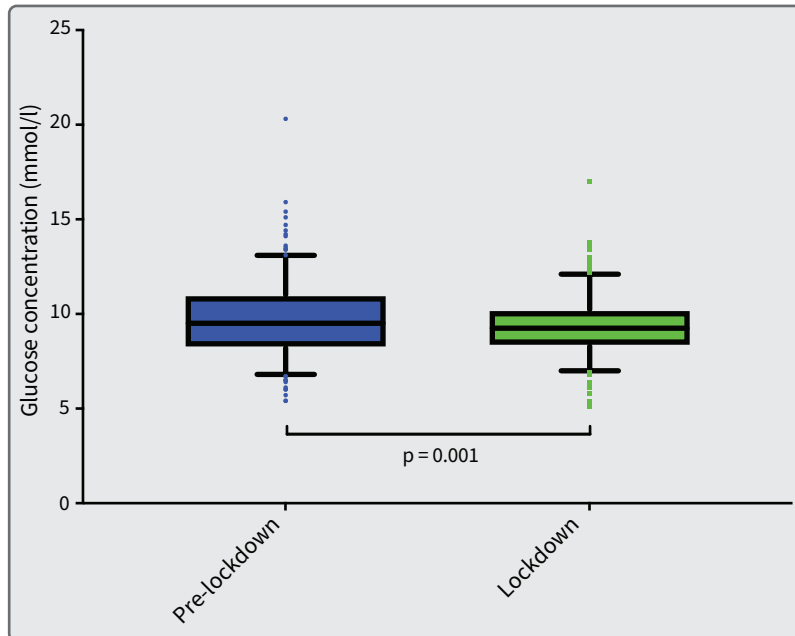
Figure 2: Median of participant's mean glucose concentration during the pre-lockdown (blue) and lockdown (green) periods.
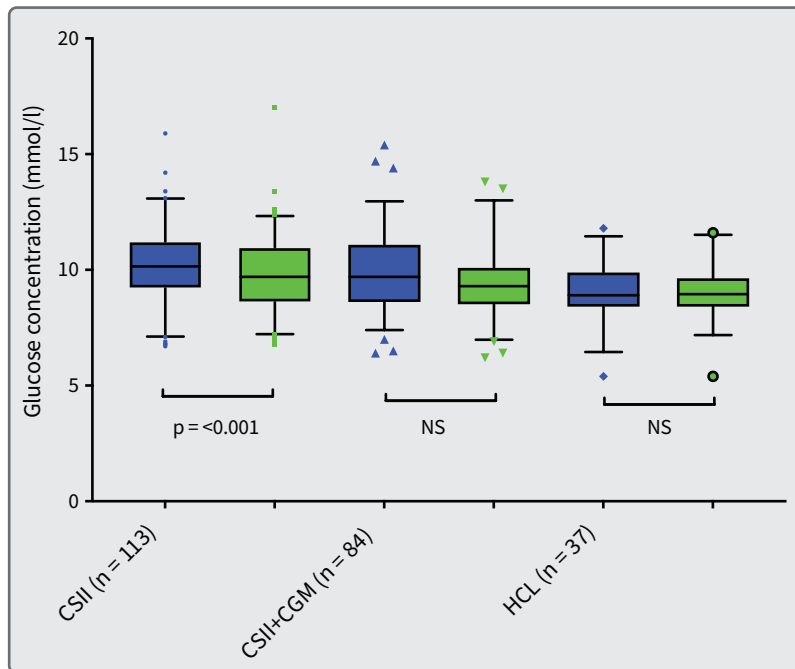Data are median (IQR).

Figure 3: Median of participant's mean glucose concentration during the pre-lockdown (blue) and lockdown (green) periods for different treatment modalities.
Data are median (IQR). CGM – continuous glucose sensor, CSII – Continuous subcutaneous insulin infusion, HCL – Hybrid closed-loop, MDI – Multiple daily injections.

4 Discussion

Diabetes care witnessed a dramatic change during the COVID-19 pandemic. Before the COVID-19 pandemic, it was thought that digital/virtual diabetes care approaches would become available only if it was possible to demonstrate their long-term safety, efficacy and cost-effectiveness (10). In reality, many institutions had to adopt digital/virtual care in a matter of days, have successfully done so, and it has become the forefront of diabetes care in these challenging times (11-15). Our observation that glycaemic control in individuals with type 1 diabetes has not worsened during the lockdown period, and has even slightly improved, is reassuring. Similarly, a small study including 22 school and preschool children reported improved glycaemic control among CGM users (16). One possible explanation could be that temporary slowing down and omitting routine obligations could have favourable effects on glucose control in the short term (12,15). A recent report demonstrated that individuals with type 1 diabetes who stayed at home during the lockdown period improved their glycaemic control, while the latter remained unchanged in individuals who continued to work (15).

We report a nationwide glycaemic control data of children, adolescents and young adults with type 1 diabetes during a COVID-19 pandemic as accessed with digital/virtual diabetes care. In a relatively short period of time, despite many challenges, we had to establish effective workflows, including communication with PWDs and their families, and adjusting the time of their appointment with a transition to digital/virtual environment. In this period, we have ap-

proached all individuals included in the Slovenian National Childhood Type 1 Diabetes Registry (7) with a scheduled visit during the lockdown, and have demonstrated this approach feasible and yielding a high response rate (96%). To do so, families needed access to appropriate technologies, such as a smart phone, tablet or a computer, an internet connection, and access to online device portals. PWDs and their families, however, still had to download data from their devices and share only their report forms with a summarized glycaemic control data. This highlights the need for the policymakers and device manufacturers to enable safe, convenient and reliable data sharing with their healthcare providers, other family members or caregivers through open-source platforms (17).

During the whole observational period, there were no severe acute complications of type 1 diabetes requiring hospitalization or an urgent care visit, and no other severe adverse events; none had COVID-19. Two children out of seven diagnosed with type 1 diabetes in this lockdown period had DKA at admission, which is a comparable to recently reported prevalence in this region (18). As there have been reports of several cases of newly diagnosed type 1 diabetes or DKA in children with known type 1 diabetes with delayed admission to hospital due to the closed service for non-COVID-19 care, it is of utmost importance to adequately recognize early clinical signs of hyperglycaemia and prevent DKA (5). In our country, support and consultations are offered via an emergency 24/7 telephone line for all children with type 1 diabetes, their families, caregivers, and primary healthcare providers, regardless of the treatment modality. We offered additional digital/virtual visits to all PWD in need, especially where there was a deterioration of glycaemic control, a major change in insulin dosing recommended, or a need for psychological support. As acute hyperglycaemia also causes cognitive impairment (19), we kept our focus on Time in Range within the recommended targets (20). In addition to physicians, we also provided contacts with a dietician and a psychologist.

Limitations of this analysis include the observational design and retrospective analysis. Glycaemic control evaluation was possible only for PWDs who provided an electronic format of their data. A possible solution for glucose control evaluation when reliable electronic data are not available could be an at-home HbA1c testing (21). Glycaemic control metrics were extracted from device report files without an access to raw data files. Consequently, we were not able to calculate recommended CGM metrics (including time in ranges) that were not presented in software-generated device reports. Additionally, in this pilot study we were unable to evaluate the impact of digital/virtual care on glycaemic control. We plan to evaluate this, together with additional factors, including quality of life, attitude towards digital/virtual care, socioeconomic status and physical activity, in a follow-up study in the near future. While there are possible benefits of digital/virtual care, including lower costs, less travel-related hurdle, especially when consulting families from remote areas, and allowing for easier social distancing (14,22), there are larger future studies needed to evaluate to what extend digital/virtual care could complement face-to-face approach in the future.

5 Conclusion

In summary, for individuals with type 1 diabetes and their families, it is essential to have necessary team support including physicians, dieticians and psychologist, especially during these unprecedented times. In this study, we demonstrated that a digital/virtual visit is a feasible alternative in specific clinical circumstances, such as COVID -19 pandemic. The future will show to what extent this modality of diabetes care will be utilized in routine clinical practice.

6 Funding

7 Author contributions

KD, TB and NB contributed to conception and design of the study, data acquisition, analysis, and interpretation, and drafting of the manuscript and gave final approval for submission.

SRO and DSS contributed to data acquisition, made critical revisions for important intellectual content, and gave final approval for submission. NB is the guarantor of this 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.

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