Anthropometric measurements and laboratory investigations in children and youth with type 1 diabetes before and during the COVID-19 pandemic

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Key Messages:

1. An unprecedented shift to telemedicine allowed continued provision of care to children with type I diabetes during the COVID-19 pandemic.
2. This study shows a dramatic drop in growth, blood pressure and A1c measurements one year into the pandemic.
3. There are still many challenges with telemedicine for pediatric diabetes care. Hybrid care models and innovative solutions are needed.

Keywords: type I diabetes, children, COVID-19, telemedicine

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Appendices: 1 table, 1 figure.

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.
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Abstract

Objective: To compare rates of anthropometric, blood pressure (BP) and hemoglobin A1c (A1C) measurements and laboratory screening for hypothyroidism, nephropathy and dyslipidemia in children and youth with type 1 diabetes (T1D), 1-year before and after the onset of COVID-19.

Methods: Clinical data from a voluntary registry of children with T1D followed at BC Children’s Hospital between March 2019 and 2021 were analyzed. Logistic and Poisson mixed effect models were used.

Results: 440 patients, with median (IQR) age and time since diagnosis 12.7 (9.5–15.4) and 4.7 (2.6–7.9) years respectively, were included. Clinic visits were all in-person before March 2020 and 99% telemedicine afterwards. The number of visits per patient was 2 (2–3); with a 6% increase during the pandemic (RR: 1.06, 95%CI: 1.01, 1.10). There was a substantial decrease in height, weight and BP measurements (RR: 0.32, 95%CI: 0.28–0.36; RR: 0.34, 95%CI: 0.31–0.38; RR: 0.005, 95%CI: 0.002–0.014, respectively); only 49% of patients had anthropometric and 1% BP data during the pandemic year, compared to >97% before. A1C measurements dropped from 3 (2–4) to 1 (1–2) per patient per year (RR: 0.53, 95%CI: 0.48–0.57). Rates of screening investigations were suboptimal before the pandemic, and continued to decline.

Discussion: Shifting to telemedicine allowed ongoing care during the pandemic, but the frequency of anthropometric, BP and A1C measurements decreased dramatically. A combined telemedicine/in-person model may be needed to ensure adequate care for this population.

Keywords: type I diabetes, children, COVID-19, telemedicine
Introduction

Delivery of care for patients with different chronic conditions has experienced a dramatic change because of the COVID-19 pandemic [1,2]. Particularly during the early stages of this pandemic, there has been a substantial decrease in the use of in-person outpatient health care services [3,4]. In this setting, telemedicine, defined as the use of electronic information and communication technologies to provide health care when distance separates the participants [5], has been an incredibly valuable tool [6,7].

During this challenging time, the feasibility and effectiveness of telemedicine have been documented in the management of hospitalized patients with type 1 diabetes (T1D) and the provision of diabetes education [8,9]. Furthermore, there is evidence supporting the efficacy of telemedicine interventions for outpatient diabetes care [10–12]. There have been discrepant findings regarding hemoglobin A1C (A1C) trends in children and youth with T1D during lockdown due to the pandemic, with some studies showing increased levels and others reporting no significant changes [13–16]. However, it has been proposed that telemedicine and diabetes technology have been key to maintaining or even improving glycemic control [16]. This model is now standard practice in many centers worldwide, and it seems likely that it will become a permanent component of diabetes care [17,18].

Despite the benefits of telemedicine, some aspects of in-person visits cannot be replaced easily. As per current standards of care, children and youth living with T1D should have regular physical exams, with height, weight and blood pressure (BP) measurements, and laboratory investigations including A1C, albumin-to-creatinine ratio (ACR), thyrotropin (TSH) and lipid profile [19–22]. Adhering to these recommendations may be challenging with telemedicine, especially in the current context of the pandemic [23]. A large national laboratory in the United States reported a marked decline in A1C test volumes during March and April 2020 [24]. Also, a recent study in Latin America showed that children
with T1D had fewer A1C measurements in 2020 compared to 2019 and 2018 [25]. To our knowledge, there are no similar studies among children and youth living with diabetes in North America.

Early in the pandemic, in accordance with provincial recommendations, the diabetes clinic at BC Children’s Hospital (BCCH) experienced a rapid shift of all routine visits from in-person to telemedicine. In this context, we set out to evaluate the comprehensiveness of care of children and youth with T1D, by comparing the rates of measurement of height, weight, BP, A1C and laboratory screening for hypothyroidism, dyslipidemia and nephropathy, 1 year before and after the onset of the COVID-19 pandemic.

Methods

Setting

BCCH is the only pediatric tertiary care hospital in British Columbia (BC), Canada. The diabetes clinic at BCCH serves approximately 700 (of the over 2000) children and youth living with diabetes from across the province [26]. Before the COVID-19 pandemic, most patients were seen on average 2 times per year, in-person, by a multidisciplinary diabetes team (i.e., a doctor, nurse, dietician, and social worker). During this time, only a small fraction of patients living in rural/remote areas or far away from BCCH had telemedicine visits, in which both local care providers and the BCCH diabetes clinic team participated. In-person visits were scheduled for approximately 90 minutes and included a physical exam, anthropometric and BP measurements, as well as a point-of-care A1C. Families were advised to have A1C measurements in between clinic visits, if these were more than 3 months apart. They also received requisitions for laboratory screening investigations: TSH levels yearly, lipid profile (total cholesterol, LDL, HDL and triglycerides) at age 10 and 18 years or before transition to adult care, and ACR yearly, starting 5 years after the initial diagnosis in youth aged 12 or older. These indications for screening were agreed on by a multidisciplinary team, based on international clinical practice guidelines.
Investigations could be done at the BCCH laboratory immediately after a clinic visit, or later, at a community-based laboratory.

With the onset of the COVID-19 pandemic, all routine diabetes clinic visits were shifted to telemedicine. Visits were conducted using video conferencing platforms (Skype for Business or Zoom), or alternatively, by phone. Patients and caregivers received instructions to perform height and weight measurements at home, and BP measurements were not requested. Orders for laboratory investigations (A1C and other screening tests, when indicated) were sent via postal mail, and families were responsible for booking outpatient appointments at their closest laboratory. To ensure all patients could be seen, telemedicine visits were scheduled for 30 minutes and only with a physician. A nurse educator, social worker and/or dietician would join these visits upon request. In many cases, patients themselves did not participate in the visits, but rather only their parents or caregivers [27]. In-person visits were arranged on a case-by-case basis, when a physical exam was deemed urgent or in-person education was required.

**Study design**

This was a retrospective review of data from the BC Pediatric Diabetes Registry (BC-PDR). The BC-PDR is a voluntary registry, which collects de-identified clinical data of patients with diabetes under the age of 19 years, to support quality improvement research. By January of 2021, 590 out of 682 potential participants at the BCCH Diabetes Clinic (86.5%) had provided consent to be part of this registry [28].

The BC-PDR includes patient-level and visit-level information. Most data are recorded on a paper medical chart by the physician during clinic visits and transcribed into the electronic database by a research assistant. Additionally, results from laboratory tests are extracted from the electronic health records and manually entered into the database. Comprehensive training of research assistants, standardization of data collection, data validation and automatic data checks in the database have been implemented to optimize data quality [28].
Children and youth with T1D followed at BCCH, aged 0-19 years, whose families consented to be part of the BC-PDR and had at least 1 clinic visit between March 19th, 2019 and March 18th, 2021, were included in this study. The following were considered exclusion criteria: (i) having had a telemedicine visit before March 18th, 2020 (ii) having been diagnosed with T1D during the study period; (iii) being ≥18 years old by March 19, 2020 with no clinic visits after this date, indicating transition to adult care before the onset of COVID-19.

**Exposure**

We defined 2 study periods: study period 1 or “Pre-COVID pandemic”, from March 19, 2019 until March 18, 2020, and study period 2 or “During COVID-pandemic”, from March 19, 2020 to March 18, 2021.

**Outcomes**

The following outcomes were considered: height, weight and BP measurements, A1C, TSH, ACR and lipid profile (total cholesterol, HDL and triglycerides) testing. These were analyzed by patient and by visit, as count (number of measurements/tests) or binary variables (performed: yes/no), for each study period.

Indications for screening investigations were defined according to our clinic’s usual procedures, considering the patient’s age at the beginning of each study period ±6 months. It is important to note that heights and weights during the pandemic were predominantly measured at home by a caregiver and self-reported. Because of studies suggesting that A1C levels could be estimated from mean glucose levels from continuous glucose monitoring [29], sensor use at each clinic visit (yes/no) was assessed, and included for adjustment in our models.

**Data analysis**
Descriptive statistics are presented as frequencies and percentages for nominal variables, as well as medians and interquartile ranges (IQR) for continuous variables. Regarding outcomes analyzed per patient, logistic and Poisson mixed effect models were used to evaluate the adjusted associations between study periods and binary and count outcomes, respectively. Results were expressed as odds (OR) and rate ratios (RR) with 95% confidence intervals (CI), and in adjusted figures (conditional rates/possibilities of outcomes at most common covariate values). Patient characteristics (age, sex, time since diagnosis of T1D, last laboratory-measured A1C value before COVID-19 onset, pump use and sensor use) were included in the models for adjustment. Age, time since diagnosis and last A1C value before COVID-19 onset were centred to the means. Patients were categorized as pump and/or sensor users, for each study period, if they reported using these technologies at ≥50% of visits.

For outcomes analyzed by visit, interrupted time series (ITS) logistic mixed effect models were further applied to examine the adjusted associations between study periods and the presence of screening investigations over time. ITS is a quasi-experimental design that quantifies the effect of an exposure or policy change that is implemented at a specific time point [30,31]. We fit a segmented regression model including time (months since the beginning of the study), and interaction between time and period (pre/during pandemic), to assess the possible immediate and lagged effects of the pandemic. Models were further adjusted for patient characteristics. Results were summarized as marginal predicted effects and displayed graphically (i.e. adjusted figures demonstrating conditional possibilities of outcomes over time at most common covariate values). OR for the level-change and during pandemic trend were also estimated.

In addition, a subgroup analysis with logistic mixed effect model was conducted only among data from period 2 to explore if any patient characteristics at the start of this period were associated with per-visit outcomes during the pandemic. For the latter analysis, lipid profile was not included, as patients would be expected to have this laboratory investigation done only once in the whole study period.
A value of $P < 0.05$ was considered statistically significant. Because of the potential for type 1 error due to multiple comparisons, findings should be interpreted as exploratory. Data were analyzed using SAS software, version 9.4 (SAS Institute Inc).

Ethics approval for the BC Pediatric Diabetes Registry was obtained from the Children & Women’s Research Ethics Board at the University of British Columbia.

**Results**

A total of 440 patients were included. Patient characteristics are summarized in table 1. Over the 2 study periods, 1791 clinic visits were analyzed: all visits in period 1 were in-person (n=910), while 874/881 (99%) in period 2 were telemedicine visits.

**Per-patient analysis**

The median (IQR) number of clinic visits per patient was 2 (2–3) in both periods. After adjustment for patient characteristics, there was a 6% increase in the number of visits per patient in period 2, compared to period 1 (RR: 1.06, 95% CI: 1.01–1.10, $p=0.01$).

During period 1, 100% of children and youth included in this study had their height and weight assessed, and 97% had their BP measured at least once. In period 2, the percentage of patients with height and weight data decreased to 53% and 49%, respectively, and only 1% had BP measurements. The median number of measurements per patient in both periods and corresponding RRs are presented in Table 2.

There was also a substantial decrease in the number of A1C measurements, from a median of 3 yearly per patient (IQR 2–4) in period 1, to 1 yearly A1C (IQR 1–2) in period 2. Before March 2020, 26% of patients had quarterly A1C measurements, in line with clinical practice recommendations [19–22], and
this proportion fell to 5% during the pandemic. Also, 22% of patients had no A1C measurements documented in period 2.

Figure 1 represents the probability of patients having laboratory screening investigations in both study periods. Screening rates for hypothyroidism dropped from 52% in period 1, to 13% in period 2 (OR: 0.14, 95% CI: 0.10–0.20, p<0.001). Among patients with indication [19-22], 53% had screening for nephropathy in period 1, compared to 43% in period 2 (OR: 0.66, 95% CI: 0.40–1.01, p=0.10). For dyslipidemia, screening rates slightly declined from 33% to 29% of eligible patients over the 2 periods (OR: 0.87, 95% CI: 0.40–1.91, p=0.72).

Per-visit analysis

When outcomes were analyzed per visit, there was a similar drop in anthropometric, BP and A1C measurements. The proportion of clinic visits with height and weight data fell from 99% in study period 1 to 31% and 33%, respectively, in period 2. A BP measurement was documented in 93% of clinic visits in period 1, and less than 1% (4/881) in period 2. An A1C result was recorded in 99% of visits in period 1, compared to 30% in period 2. Across all visits in period 2, 34% did not have a laboratory-measured A1C or documented use of a continuous glucose monitor.

Figure 2 illustrates the change in the probability of having anthropometric measurements, A1C and screening investigations over time during the 2 study periods. The ITS models for weight, height and BP measurements were unable to be fit due to the complete or quasi-complete separation issue. However, as shown in the unadjusted figures, there was a drastic drop in measurements in period 2. After fitting the ITS logistic mixed effect model, we observed an immediate level drop in period 2 for both A1C (OR:0.04, 95% CI: 0.02–0.06, p<0.0001) and TSH measurements (OR:0.10, 95% CI:0.05–0.18, p<0.0001).
Assessing the data during period 2 only, when other variables were held constant, later visit dates during the pandemic were associated with higher odds of having self-reported growth measurements (OR: 1.28; 95% CI: 1.22–1.33, p<0.0001 and OR: 1.27, 95% CI: 1.20–1.34, p<0.0001 for height and weight, respectively, per 1-month increase in visit date). Likewise, later visits during the pandemic were associated with higher odds of having an A1C measurement (OR: 1.08, 95% CI: 1.05–1.12, p<0.0001, per month). There was a similar trend over time for hypothyroidism and nephropathy screening, although estimates had higher uncertainty (OR: 1.08, 95% CI 1.00–1.17, p=0.06 for TSH measurements, and OR: 0.67, 95% CI 0.32–1.39, p=0.28 for ACR).

Finally, in terms of the relationship between patient characteristics and outcomes during the pandemic, the likelihood of having height measurements was higher for boys (OR: 1.64, 95% CI 1.12–2.39, p=0.01), and younger children (OR: 0.93, 95% CI 0.88–0.98, p=0.01, per 1-year increase in age). The proportion of patients using continuous glucose monitoring increased to 57% during this period (from 46% pre-pandemic). There was no association between the use of continuous glucose monitoring and the likelihood of having laboratory A1C measurements. None of the patient characteristics included in our models were associated with the likelihood of having weight, A1C, TSH or ACR measurements (Table A1). BP measurements were not included in the analysis because of the small number available in period 2.

**Discussion**

As a result of the COVID-19 pandemic, routine diabetes care has been transformed to be predominantly delivered via telemedicine [32-34]. In March of 2020, the diabetes clinic at BCCH saw an unprecedented shift to telemedicine [27], as has been the case in many centres worldwide. Our study evaluated the comprehensiveness of care provided to children and youth with T1D in the only tertiary care centre in the Canadian province of BC, 1 year before and after the onset of the pandemic. We found
a dramatic decline in the frequency of anthropometric, BP and A1C measurements as well as laboratory screening tests for diabetes-related comorbidities and complications during the pandemic.

Having continued to provide ambulatory care during the pandemic by telemedicine is undoubtedly positive. A recent study in children with T1D from 4 Latin American countries (n=227) showed that those with access to telemedicine had more medical visits in 2020 compared to those without access [25]. Our study showed a slight increase in the number of clinic visits per patient during the pandemic, compared to the pre-pandemic year. This may be related to the advantages of telemedicine eliminating barriers to accessing care, such as cost, time required for travel, time off work, or need for childcare [35, 36]. However, there was a proportion of patients in our study who did not have visits during the pandemic, and it is possible that some of them were lost to follow-up due to difficulties accessing or engaging with telemedicine. Unfortunately, our registry does not include data on cancelled or missed appointments, so the frequency of these events during the 2 study periods could not be compared. Also, there is no information on relocation or transfer to other healthcare teams, which could explain this apparent loss to follow-up.

During the early stages of the pandemic, certain medical exams and interventions were safely deferred based on individual patient characteristics and risks. However, prolonged postponement of necessary evaluations could carry long-term detrimental implications for patients’ health and well-being, as shown in other populations [37]. Considering this, as the pandemic continues, the definition and frequency of “essential” medical exams will certainly need consideration.

Evaluating the height and weight of children and youth with T1D is key to providing optimal care [19-23]. Inadequate growth can indicate suboptimal glycemic control [38, 39] or comorbid conditions such as hypothyroidism or celiac disease. Obesity and overweight are highly prevalent among children and youth with T1D [40], and these conditions are associated with increased risk of complications [41]. Our study showed that there was not enough information to assess the growth trajectory or body mass index
of most patients during the pandemic, and a substantial proportion did not have any anthropometric data during the whole year. Also, even when home-measured heights and weights were performed, they can be significantly less accurate than those measured by a healthcare provider in a clinic visit [42]. A lack of growth data may have led to missed opportunities to identify patients with poor glycemic control, diagnose comorbid conditions or counsel on healthy lifestyle.

Similarly, hypertension is more prevalent in children and youth with T1D than in the general population [43]. Early identification and appropriate treatment are critical to prevent the development of micro and macrovascular complications. [44, 45]. Nevertheless, families in our diabetes clinic were not routinely advised to have BP measurements in preparation for their telemedicine visits. Not surprisingly, only a handful of patients had documented BP levels during the pandemic year.

Laboratory investigations are also a crucial component of diabetes care [19-23]. A1C levels are a strong predictor of the risk of complications, and could serve as a tool to optimize management [46]. Studies have shown beneficial effects of rapidly available A1C results (obtained by point-of-care testing) on glycemic control and patient satisfaction [46, 47]. Also, infrequent A1C monitoring is associated with worse glycemic outcomes [48, 49]. Moreover, while A1C could be estimated based on continuous glucose monitoring data [29], there may be significant discordance in a real-world setting, reinforcing the value of laboratory-measured A1C [50]. In our clinic, we found a dramatic decline in the frequency of A1C testing during the pandemic, as reported in other studies [24,25]. Only a small fraction of patients had recent A1C results to review at their telemedicine visits, and a substantial proportion was not wearing a continuous glucose monitor. Further, the likelihood of having an A1C measurement at a clinic visit was not affected by the use of a sensor. This would certainly make it challenging to assess long-term glycemic trends and provide appropriate treatment.

Clinical practice guidelines provide evidence-based recommendations to guide appropriate timing and testing for diabetes-related complications and comorbidities, aiming to standardize and improve
delivery of care [51]. Among adults with diabetes, adherence to these screening recommendations is associated with lower morbidity and mortality rates [52]. In keeping with previous findings [53], the frequency of laboratory screening in our study population was already suboptimal pre-pandemic, when visits were in-person. With the onset of the COVID-19 pandemic, laboratory testing was deferred, and not surprisingly, rates of screening continued to decline.

Our study supports consideration of a hybrid model of in-person and telemedicine visits to ensure appropriate anthropometric, BP and A1c measurements are completed. Early in the pandemic, families followed in our diabetes clinic had expressed their desire to continue having telemedicine visits in the future [27]. Still, based on our results, it appears that the current model of almost all visits being done by telemedicine might not be appropriate, as standards of care have not been met [19-22]. Redesigning our model of pediatric diabetes care will require attention to raising awareness among patients, families and clinicians of the importance of a proportion of clinic visits being in-person so that evidence-based, high-quality care can be achieved. Although we did not find specific patient characteristics that would predict the likelihood of having measurements and investigations during the pandemic, future research can help identify characteristics of families who would most benefit from continuing telemedicine exclusively versus those who will need an element of in-person care when this becomes possible.

Interestingly, children and youth with T1D in our study were more likely to have growth and A1C measurements available at telemedicine clinic visits that occurred later during the pandemic, which is not in concordance with the provincial trend in COVID-19 cases and restrictions [54]. The reasons for this may include evolving views on the risk associated with attending healthcare, as well as changes in the perceived need for these evaluations by families and their providers, as time went by since the last in-person visit. Further studies assessing families’ perspectives on barriers to completing measurements and laboratory testing will be essential to create innovative, patient-centered solutions.

Future quality improvement initiatives should aim to address gaps in care found in this study. Seeking
support from local primary care providers to perform in-person measurements and exams could be an effective solution. Continuous glucose monitoring systems may also be an option to improve the availability of information on glycemic trends during clinic visits; however, this may not completely replace the need for laboratory-measured A1C [29, 52]. Furthermore, current pediatric diabetes guidelines are based on the best available evidence before the onset of the pandemic [19-23]. Updated guidelines might consider including recommendations on the need for physical exams and investigations for children and youth with T1D in this rapidly evolving context.

Strengths of this study include the high number of patients and clinic visits, which represent the vast majority of children and youth followed in the only pediatric tertiary care centre in the province of BC. There are several limitations. First, despite the high proportion of patients enrolled in the BC-PDR, it is still possible that the use of data from a voluntary registry could introduce selection bias. Also, the relative impact of this unprecedented shift to telemedicine care cannot be differentiated from the effects of the pandemic. Thus, findings may be difficult to generalize and integrate into planning future care. Moreover, investigations for other diabetes-related comorbidities and complications (celiac disease, retinopathy and neuropathy) were not considered. This was due to variable recommendations in terms of frequency of screening, as well as the lack of good quality data for retinopathy and neuropathy screening in our registry [19-22]. Also, because of the low rates of laboratory testing during the pandemic, it was not possible to assess the change in A1C levels. Finally, this study did not evaluate the change in endpoints such as rates of hospitalization, emergency department visits, severe hypoglycemia and diabetic ketoacidosis or incidence of diabetes-related complications. Nevertheless, we believe that it provides useful information, by showing the decrease in recommended anthropometric measurements and laboratory investigations, which are intended to prevent such complications among patients with T1D. Longer-term studies evaluating the impact of these changes on patient outcomes are needed.

Conclusion
The rapid and unprecedented shift from in-person to telemedicine allowed for ongoing delivery of care during the COVID pandemic. However, the care provided to children and youth in our diabetes clinic has not been in keeping with current recommendations regarding anthropometric measurements and laboratory investigations. The number of height, weight, BP and A1C measurements experienced a dramatic decline during the pandemic year, and screening for important diabetes-related comorbidities and complications also showed a downward trend. This has likely led to missed opportunities for early intervention and may result in negative long-term health outcomes in this population. We noted a positive trend over time during the pandemic, with increased frequency of height, weight and A1C measurements at later visits during this period. Still, as it is, the current model of primarily telemedicine care does not appear to be suitable for most children and youth with T1D. Being currently 2 years into the global COVID-19 pandemic, it is essential that we engage in health system redesign that includes novel technology, leverages primary care and combines in-person and telemedicine modalities so that children and youth living with T1D receive comprehensive, high-quality care.

Acknowledgements

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Author contributions

C.S. and S.A. contributed to the conception and study design, interpretation of data and analysis, and writing the manuscript. Q.Z and J.F contributed to the statistical analysis, interpretation of data, and assisted with drafting the manuscript. All authors reviewed and revised the manuscript and provided approval of the final version.

Author Disclosures

The authors declare that they have no known competing financial interests or personal relationships that
could have appeared to influence the work reported in this paper.

References


42. Esteban-Vasallo MD, Galán I, Ortiz-Pinto MA, Astray San Martín A, Cabrero López EM, Morales San José MT, et al. Accuracy of anthropometric measurements and weight status


Table 1. Baseline patient characteristics (n=440) †

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender, male, n (%)</td>
<td>236 (54)</td>
</tr>
<tr>
<td>Age, median (IQR)</td>
<td>12.7 (9.47 - 15.42)</td>
</tr>
<tr>
<td>Time since diagnosis,</td>
<td></td>
</tr>
<tr>
<td>median (IQR)</td>
<td>4.7 (2.55 - 7.88)</td>
</tr>
<tr>
<td>A1C, median of patient</td>
<td></td>
</tr>
<tr>
<td>medians‡ (IQR)</td>
<td>7.9 (7.2 – 8.7)</td>
</tr>
<tr>
<td>Pump use‡, n (%)</td>
<td>200 (46)</td>
</tr>
<tr>
<td>Sensor use‡, n (%)</td>
<td>196 (45)</td>
</tr>
</tbody>
</table>

†Total=393 patients with visits in both study periods, 41 and 6 patients seen only in period 1 and period 2, respectively.
‡during study period 1
Table 2. Anthropometric, BP and A1C measurements, per patient

<table>
<thead>
<tr>
<th>Number of measurements, median (IQR)</th>
<th>Pre-COVID onset</th>
<th>During pandemic</th>
<th>Unadjusted RR (95% CI), P value</th>
<th>Adjusted RR (95% CI), P value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>2 (2-3)</td>
<td>1 (0-1)</td>
<td>0.32 (0.29–0.36), p&lt;0.0001</td>
<td>0.32 (0.28–0.36), p&lt;0.0001</td>
</tr>
<tr>
<td>Weight</td>
<td>2 (2-3)</td>
<td>1 (0-1)</td>
<td>0.35 (0.32–0.39), p&lt;0.0001</td>
<td>0.34 (0.31–0.38), p&lt;0.0001</td>
</tr>
<tr>
<td>BP</td>
<td>2 (2-2)</td>
<td>0 (0-0)</td>
<td>0.005 (0.002–0.013), p&lt;0.0001</td>
<td>0.005 (0.002–0.014), p&lt;0.0001</td>
</tr>
<tr>
<td>A1C</td>
<td>3 (2-4)</td>
<td>1 (1-2)</td>
<td>0.52 (0.48–0.57), p&lt;0.0001</td>
<td>0.52 (0.48–0.57), p&lt;0.0001</td>
</tr>
</tbody>
</table>

†Estimated RR from Poisson model, after adjustment for age, sex, time since diagnosis, A1C before COVID onset, pump use and continuous glucose monitor use
Table A.1. Association between patient characteristics and probability of having anthropometric measurements and laboratory investigations during the pandemic (period 2)

<table>
<thead>
<tr>
<th></th>
<th>Height</th>
<th>Weight</th>
<th>A1C</th>
<th>ACR</th>
<th>TSH</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR (95% CI), P</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>OR (95% CI)</td>
<td>P value</td>
<td>OR (95% CI)</td>
<td>P value</td>
<td>OR (95% CI)</td>
</tr>
<tr>
<td>Age† (years)</td>
<td>0.93 (0.88–0.98), 0.01*</td>
<td>0.96 (0.92–1.01)</td>
<td>0.14</td>
<td>1.02 (0.98–1.05)</td>
<td>0.34</td>
</tr>
<tr>
<td>Sex (male)</td>
<td>1.64 (1.12–2.39)</td>
<td>0.01*</td>
<td>1.35 (0.96–1.91)</td>
<td>0.09</td>
<td>1.05 (0.83–1.32)</td>
</tr>
</tbody>
</table>

Time since diagnosis (years) ‡ 1.00 (0.97–1.09) 0.39 | 0.97 (0.96–1.07) | 0.71 | 1.00 (0.96–1.04) | 0.96 | 0.99 (0.93–1.06) | 0.83 | 1.04 (0.95–1.15) | 0.39 |

A1C‡ (%) 0.98 (0.88–1.08) 0.66 | 0.99 (0.90–1.09) | 0.89 | 1.02 (0.96–1.09) | 0.52 | 0.93 (0.82–1.06) | 0.28 | 1.03 (0.85–1.26) | 0.77 |

Pump use† 0.73 (0.49–1.10) 0.14 | 0.77 (0.53–1.12) | 0.17 | 1.05 (0.82–1.35) | 0.68 | 0.85 (0.54–1.35) | 0.48 | 0.94 (0.50–1.77) | 0.84 |

CGM use† 1.00 (0.67–1.49) 0.98 | 0.99 (0.68–1.44) | 0.94 | 0.88 (0.68–1.14) | 0.33 | 1.13 (0.71–1.80) | 0.60 | 0.56 (0.30–1.03) | 0.06 |

Estimated OR, adjusted by the remainder of patient variables listed and visit date. ACR measurements were only considered among patients with indication for screening.

†At the beginning of study period 2
‡Last A1C measured before March 2020
*P<0.05
Figure 1. Laboratory screening for diabetes-related complications

Estimated rates and 95% CI, adjusted for age, sex, time since diagnosis, A1C before COVID-onset, pump and sensor use. ACR and lipid profile measurements were only considered among patients with indication for screening.

*indicates $P<0.05$
Figure 2. Anthropometric, BP and A1C measurements and screening investigations over time

Estimated rates and 95% CI, adjusted for age, sex, time since diagnosis, A1C before COVID-onset, pump and sensor use (for A1C, TSH and ACR measurements). For weight, height and BP measurements, unadjusted data is plotted due to complete or quasi-complete separation between the 2 periods.
Figure A1. A1C measurements and screening investigations over time

Estimated rates and 95% CI, from unadjusted models.
Estimated probabilities and 95% CI, at cohort’s average age, time since diagnosis and last A1C before COVID, Sex=F, Pump and CGM use
*indicates p<0.05