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Improvement in glycaemic control in paediatric and young adult type 1 diabetes patients during COVID-19 pandemic: role of telemedicine and lifestyle changes

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Abstract. *Background and aim:* COVID-19 pandemic determined a profound impact in everyday life and in routine follow-up of patients with type 1 diabetes (T1D). In this context, telemedicine represented an important tool to guarantee a regular care for these patients. Aim of our work was to assess metabolic control before and after lockdown in the cohort of T1D patients followed-up by our Service, to evaluate the impact of restrictive measures and of disease management through telemedicine. *Methods:* This is a retrospective observational study. Subjects were enrolled among children, adolescents and young adults affected by T1D and followed at the Paediatric Diabetology Centre of the University-Hospital of Parma, Italy. We collected data about age, gender, ethnicity, anthropometric measurements, duration of disease, type of blood glucose monitoring used, type of insulin administration, daily insulin requirement (DIR) and metabolic control, assessed using capillary HbA1c. *Results:* We enrolled 139 patients, mean age 13.9 years. During lockdown, we reported significantly more contacts through telemedicine between patients and medical team. Global glyco-metabolic control significantly improved, without differences in DIR. Patients with a previous poor-controlled diabetes showed a greater improvement. Finally, mean weekly hours of physical activity decreased significantly, without worsening in Body Mass Index (BMI) z-score. *Conclusions*: Our results show a significant decrease in mean HbA1c, with a stronger result for patients with a previous non satisfactory control. In our setting, despite regulatory rules and physical and logistic limitations related to pandemic, a global improvement in metabolic control has been shown for patients with type 1 diabetes. (www.actabiomedica.it)

Key words: Type 1 diabetes, telemedicine, COVID-19, HbA1c.

Introduction

On 30 January 2020, the World Health Organization (WHO) officially declared the Severe Acute Respiratory Syndrome-CoronaVirus-2 (SARS-CoV-2) a risk to world public health and on March 11, 2020 declared coronavirus disease 19 (COVID-19) a pandemic health emergency (1,2).

In Italy, starting from the second half of February 2020, in order to prevent the spread of COVID-19, the government was forced to apply strong restrictive measures on people's daily activities and movements leading to an almost complete lockdown of the country: all school levels were closed, and non-essential business, outdoor sports, leisure activities and travels between different cities have been severely limited; only essential services were guaranteed (3). About health care, there was a drastic transfer of resources

with the aim of limiting the impact of the disease, with consequently limitation especially in outpatient activities: routine healthcare activities were deferred, and outpatient services were closed including those for patients with chronic diseases. Only urgent visits were guaranteed.

In this contest, the telemedicine, defined as the use of telecommunication tools with patients, allowed the maintenance of patients' care while ensuring the safety of patients and health care workers during the lockdown, especially for chronic conditions which require regular follow-up (4).

For patients affected by type 1 diabetes (T1D), telemedicine has always represented an effective tool for treatment and control of disease (5). These patients, especially paediatric, can use the most modern technologies for monitoring blood glucose and performing insulin therapy. This allows a significant improvement in metabolic control and quality of life of both children and parents and to share medical information between patients and medical team (6). Many Diabetology Units, even before lockdown, guaranteed a 24-hours remote access to an experienced physician or nurse to help parents or caregivers to deal with diabetes-related health problems, especially in emergency situations (7).

During lockdown the use of telemedicine for T1D patients (such as messages, e-mails, voice and video calls) has been further implemented allowing not only a simpler communication but also remote management of technology (through the downloading and sending of data from glycaemic sensors and insulin pumps), ensuring continuity of care through constant contacts with reference centres (8-10).

Several authors investigated the effects of lifestyle changes on metabolic profile in patients affected by T1D during lockdown, assuming that glycaemic control could be influenced by factors such as physical activity, nutrition and perceived stress. For this reason, an overall worsening of metabolic control could be expected for T1D patients. However, the majority of authors reported an improvement of glycaemic control or at least a stability of metabolic parameters, not associated in most of the studies with an increase in insulin dose, both in adults (11-24) and in paediatric population (14, 23, 25-30).

Studies reporting this phenomenon indicates several reason to explain this trend: use of technology and telemedicine, more regular lifestyle, less stress related to work, a more strict parental control. However, only few of these studies analyses mean HbA1c pre and post lockdown (24, 28, 29), as most authors reported data regarding metabolic control derived from analysis of GCM/FGM metrics (11-13, 25-27), some of these only for a short period of time, making difficult to draw conclusions about metabolic consequences of lockdown for the entire population of type 1 diabetes patients and during the entire period in which restrictive measures were imposed.

Moreover, also analysis of factors associated with these results are conflicting: some authors reported a better trend mostly in patients treated with CSII or with SAP (17-19, 25), others mostly for patients treated with MDI (13), others reported a better glycaemic control related mostly on improvement in time in hypoglycaemia (16).

In addition, some authors reported a more relevant improvement during lockdown in patients with a previous suboptimal control (19-21, 23, 24, 29) or with low socio-economic status (28).

On the contrary, some publications indicates a worsening of metabolic control during lockdown (31-34). According to the authors, these findings may be due, in some countries, to difficulties in access to telemedicine, lower use of technology, low education level, difficulties in getting the supply for diabetes management appropriately (32-34). A worsening in metabolic control has been also associated to stress due to work instability, social isolation and discomfort related to disease management (14, 24, 31, 35).

The aim of this study was to investigate the effects of unavoidable changes in everyday life, due to the COVID-19 lockdown, on glycaemic control in the entire cohort of children, adolescents and young adults affected by T1D followed-up by paediatric diabetology team of Parma University Hospital, and to assess the impact of telemedicine on disease management. The primary outcome was to compare glycaemic control between the period pre-lockdown and the "stay at home" period to verify the impact of restrictive measures and patient management through telemedicine tools on metabolic control. Secondary endpoints in-

vestigated the effects of restrictive measures on auxological parameters, eating habits and physical activity practice of patients.

Methods

Patients and Study Design

This is a real-life retrospective observational study. Subjects were enrolled among children, adolescents and young adults affected by Type 1 Diabetes (T1D), diagnosed following ISPAD guidelines (36) and followed at the Regional Paediatric Diabetology Centre of the University-Hospital of Parma, Italy.

Inclusion criteria were to have performed at least an outpatient frontal visit with determination of HbA1c in the period of time before lockdown (between the 1st of December 2019 and the 28th of February 2020 - T0), at least an outpatient frontal visit with determination of HbA1c in the period of time after lockdown (between the 1st of June 2020 and the 31st of August 2020 - T1), with no change in type of glycaemic monitoring or of insulin treatment.

During lockdown period, considering the outstanding limitations in outpatient controls, all patients had at least one telemedicine consultation by phone-call, text messaging, e-mail or video-call.

Data collection

All variables were collected from the medical records at the two different observational timepoints (T0 and T1). All data were anonymously recorded in a database using an alphanumeric and progressive identification code.

Anthropometry and general patients' data

For each patient, we collected data about age, gender and ethnicity, Anthropometric measurements (height and weight) were collected (Scale and Stadiometer by Salus, Italy). Body Mass Index (BMI) was calculated from weight and height (kg/m^2) and standardized to standard deviation (SD) score (BMI z-score), according to US CDC 2000 reference (37).

Specific data related to disease control and management

Data regarding age of the patient at onset of diabetes and duration of disease were collected.

For each patient, we reported the type of blood glucose monitoring used: Self-Monitoring of Blood Glucose (SMBG) or subcutaneous glycaemic sensor by Continuous Glucose Monitoring (CGM, Dexcom G6, Theras Lifetech Srl) or Flash Glucose Monitoring (FGM, Freestyle Libre, Abbott Diabetes Care).

Data about the type of insulin administration was collected: insulin delivery method was categorized as Multiple Daily Injection (MDI) or Continuous Subcutaneous Insulin Infusion (CSII). Among patients using CSII we distinguished those with integrated systems (Sensor Augmented Pump – SAP: Minimed 640G and Minimed 670G, Medtronic; Tandem T:slim, Tandem Diabetes Care) compared to other pumps (Omnipod, Theras Lifetech Srl; Accuchek Insight, Roche).

For each patient, daily insulin requirement (DIR) was calculated as international units of insulin used per day divided by the weight of the patient.

Metabolic control was assessed using capillary HbA1c (Immunoassay, DCA2000, Siemens).

Finally, type (outpatient visit or telemedicine) and frequency of contacts with our Centre both before lockdown and during lockdown were reported.

Telemedicine contacts collected in the study included messages, e-mails, voice and video calls.

The operators received special training to manage a conversation effectively according to a previously tested protocol (7). Operators were instructed to make a personal introduction to the caller, record his or her name and telephone number as well as the date and time of the call and to take a detailed history; during the call advices were offered in a confident manner using a clear non-technical language, and instructions were summarized and repeated once or twice, eliciting a repetition from the caller. The operators were also instructed to encourage callers to phone back whenever necessary. Medical team was equipped with software capable of facilitating and standardizing the operators' answers.

Lifestyle habits

During outpatient visit at T1, data about life-

style of patients before and during lockdown were collected, focusing on the change in eating habits (diet modifications and frequency of meals shared with family) and on weekly hours of physical activity. Changes in lifestyle habits were collected by a dedicated interview.

Study Aims

Primary aim of the study was to assess metabolic control before and after lockdown period in the entire cohort of T1D patients followed-up by our Service, to evaluate the impact of restrictive measures and of disease management through telemedicine.

We also analysed impact of lockdown on anthropometry and lifestyle habits.

With the aim of comparing the different age groups, we divided the subjects in preschool age children (< 6 years), school age children (≥ 6 years and < 13 years), adolescents (≥ 13 years and < 17 years) and young adults (≥ 17 years).

With the aim of comparing subjects with a better control of the disease compared to the others, patients were divided into two groups, considering a Hb1Ac pre-lockdown cut off of 64 mmol/mol (8%).

Ethics Statement

This study was approved by local Ethics Committee (EC protocol number 1265). Patients' and/or parental written informed consent were obtained as appropriate before the data collection.

Statistical Analysis

The results regarding continuous variables were expressed as mean ± standard deviation (SD); the results regarding categorial variables were expressed, on the other hand, as absolute frequencies, percentage and valid percentage when some values were missing. For the comparison between continuous variables, the Student's t-test was used to verify the equality of the means and the Levene test was used to verify the equality of variances. Pearson Chi-square test or McNemar test was used for the comparison of discrete variables when appropriate.

Statistical analysis was performed with IBM® SPSS® Statistics software (IBM SPSS Statistics for Windows, Version 26, ITA). A cut-off of *p*-value <0.05 and a 95% confidence interval (CI) were used to define the statistical significance of the analyses.

Results

Patients' characteristics

We enrolled 139 patients; 56% male and 46% female, with a mean age of 13.9 years (± 5,27). Minimum age at enrolment was 2.3 years, maximum age at enrolment was 20.8 years. 6,47% of patients (9/139) were preschool age children, 31,65% (44/139) school age children, 31,65% (44/139) of patients were adolescents, 42/139 (30,22%) were young adults. 97 patients were Italian (69.8%), while 42 were foreign (30.2%), born in Italy by foreign parents or born abroad. Mean age at diabetes diagnosis was 7.05 (± 4,40) years and mean disease duration was 7.21 (± 4,77) years. Mean BMI z-score was 0,30 (± 0,97) .

At the beginning of lockdown period, 86.3% of patients (120/139) were carrying a sensor for glycaemic monitoring (FGM/CGM). About insulin administration, 69.8% of patients (97/139) were performing insulin therapy through multiple daily injections (MDI), while 30.2% of patients (42/139) were using an insulin pump with continuous subcutaneous infusion (CSII); 61.9% of these (26/42) were on an integrated system (SAP) (Table 1).

Patient's follow-up

At T0, for 13.3% of our patients telemedicine represented the main way to get in contact with medical team and for other patients was associated anyway with frontal visits.

During lockdown, we reported significantly more contacts between patients and medical team than in the previous period: before the start of lockdown started, 66.2% of patients (88/133) was visited less than 1 time for month, whereas during lockdown only 36.8% (49/133) had contacts with the Centre less than 1 time for month (*p: <0.001*): these contacts were almost completely realised through telemedicine, as only two

Table 1. Patients' characteristics at T0 (before the start of lockdown)

Categorical Variables		Continuous Variables	
Gender			
Males (%)	64/139 (46.0)	Mean age, years	13.9 ± 5.27
Females (%)	75/139 (54.0)		
Ethnicity			
Italian (%)	97/139 (69.8)	Age at diagnosis, years	7.05 ± 4.40
Foreign (%)	42/139 (30.2)		
Glycaemic monitoring			
CGM or FGM (%)	120/139 (86.3)	Diabetes duration, years	7.21 ± 4.77
SMBG (%)	19/139 (13.7)		
Insulin administration			
MDI (%)	97/139 (69.8)	BMI, z-score	0.30 ± 0.97
CSII (%)	42/139 (30.2)		
SAP (%)	26/42 (18.7)		
Age groups		HbA1c, mmol/mol	64.36 ± 15.59
Preschool age (0-6 y.) (%)	9/139 (6.47)		
School age [6-13 y.) (%)	44/139 (31.65)	DIR, IU/kg/die	0.74 ± 0.20
Adolescents [13-17 y.) (%)	44/139 (31.65)		
Young adults ≥ 17 y. (%)	42/139 (30.22)		
HbA1c < 64 mmol/mol (%)	87/139 (62.6)		

Categorical data are reported as absolute frequencies (percent values); continuous data as mean ± SD. CGM, continuous glucose monitoring; FGM, flash glucose monitoring; SMBG, self-monitoring of blood glucose; MDI, multiple daily injection; CSII, continuous subcutaneous insulin infusion; SAP, sensor augmented pump; HbA1c, glycated haemoglobin; BMI, body mass index; DIR, daily insulin requirement.

patients needed urgent frontal visit during this period. Patients and caregivers did not report particular issues in communication with medical team *via* telemedicine.

Glycaemic control before the start of lockdown

Mean HbA1c of the entire cohort of patients was 64.36 mmol/mol ± 15.59. 63.0% of patients (87/139) had a HbA1c value less than 64 mmol/mol before the start of lockdown. In the period before lockdown, patients with an integrated system (SAP) had a better glycaemic control compared to others, with a mean HbA1c of 58.54 ± 8.32 mmol/mol *versus* a mean HbA1c of 65.71 ± 16.57 mmol/mol of others (patients on MDI or carrying an insulin pump without an integrated system) (*p: 0.034*).

Children performing insulin therapy via insulin pump had a mean HbA1c of 61.29 ± 9.57 mmol/mol *versus* 65.70 ± 17.46 mmol/mol of those on multiple daily injections but this difference is not statistically significant (*p: 0.13*). Patients using a sensor for glycaemic monitoring had a mean HbA1c of 63.69 ± 15.18 mmol/mol *versus* 68.53 ± 17.80 mmol/mol in patients without a sensor, but this difference is not statistically significant (*p: 0.27*).

There were no significant differences in metabolic control (in terms of mean HbA1c) before the lockdown period considering sex (mean HbA1c 62.48 ± 13.64 mmol/mol in male *versus* 65.93 ± 16.98 mmol/mol in female; *p: 0.19*) and ethnicity (mean HbA1c 63.06 ± 15.61 mmol/mol in Italian patients *versus* 67.41 ± 15.30 mmol/mol in foreign patients; *p: 0.13*) and among different age groups (Table 2). Similarly, there are no differences between these groups regarding daily insulin requirement before the lockdown period.

Comparing patients with HbA1c values lower or higher than 64 mmol/mol before the start of lockdown, no statistically significant differences were found in gender, ethnicity, age at diagnosis, diabetes duration, BMI (Table 3).

Comparison of T0 and T1 data

On comparison of pre- and post-lockdown data, global glyco-metabolic control significantly improved (mean HbA1c pre-lockdown 64.4 ± 15.61 mmol/mol *versus* 60.7 ± 11.54 mmol/mol post lockdown, *p:*

Table 2. Glycaemic control values compared for types of glycaemic monitors and insulin administrations, group of ages, sex and ethnicity

	HbA1c (mean ± SD)	*p-value*
CGM or FGM	63.69 ± 15.18	*0.27*
No CGM or FGM	68.53 ± 17.80	
CSII	61.29 ± 9.57	*0.13*
MDI	65.70 ± 17.46	
SAP	58.54 ± 8.32	*0.034**
No SAP	65.71 ± 16.57	
Male	62.48 ± 13.64	*0.19*
Female	65.93 ± 16.98	
Italians	63.06 ± 15.61	*0.13*
Foreign	67.41 ± 15.30	

Data are reported as mean ± SD. CGM, continuous glucose monitoring; FGM, flash glucose monitoring; MDI, multiple daily injection; CSII, continuous subcutaneous insulin infusion; SAP, sensor augmented pump.

0.002). The mean daily insulin requirement increased slightly during the lockdown (0.74 ± 0.198 IU/kg/day *vs* 0.76 ± 0.215 IU/kg/day, *p: 0.19*), but this is not statistically significant (Table 4). There are also no significant differences regarding the variation in metabolic control during lockdown, considering sex or ethnicity.

In children with a previous poor-controlled diabetes (HbA1c > 64 mmol/mol), HbA1c post lockdown improved significantly more than the other group (mean HbA1c reduction of 9.41 mmol/mol vs 0.45 mmol/mol, *p: <0.001)*; their mean daily insulin requirement increased not significantly more than in those with a well-controlled diabetes (*p: 0.07*) (Table 3).

Comparing blood glucose monitoring methods (SBGM vs FGM/CGM), no statistically significant differences were found regarding variation on HbA1c and daily insulin requirement before and after lockdown period (Table 5).

HbA1c post lockdown improved significantly more in patients on MDI or with an insulin pump without an integrated system compared to patients on SAP (mean HbA1c reduction 4.62 ± 14.81 mmol/mol *vs* 0.04 ± 8.05 mmol/mol, *p: 0.035*), without statistically significant difference in mean daily insulin requirement between these two groups (*p: 0.76*). Children on MDI therapy reduced HbA1c values more than those with CSII therapy (with or without SAP), but this result was not statistically significant (mean HbA1c reduction of 4.91 ± 15.64 mmol/mol *versus* 1.17 ± 8.19 mmol/mol, *p: 0.07)*.

Assessing mean variation of HbA1c pre and post lockdown in different age groups, in preschool children we observed an opposite trend compared to others, with a mild worsening of metabolic control; in particular, preschool age children showed a mean HbA1c increase post lockdown of 2.89 ± 6.29 mmol/

Table 3. Comparison of patients with HbA1c values lower or higher than 64 mmol/mol before the start of lockdown and evaluation of HbA1c variantion pre and post lockdown

	HbA1c < 64 mmol/mol	HbA1c > 64 mmol/mol	*p-value*
Gender			
Males %	51.7	35.3	*0.06*
Females %	48.3	64.7	
Ethnicity			
Italian %	74.7	62.7	*0.14*
Foreign %	25.3	37.3	
Age at diagnosis, years	7.45 ± 4.57	6.39 ± 3.52	*0.16*
Diabetes duration, years	7.31 ± 5.02	7.17 ± 4.30	*0.86*
BMI, z-score	0.19 ± 1.03	0.49 ± 0.82	*0.07*
Variation on HbA1c, mmol/mol	-0.45 ± 7.50	-9.41 ± 19.48	*<0.001**
Variation on DIR IU/kg/die	-0.01 ± 0.15	+0.05 ± 0.13	*0.07*

Categorical data are reported as absolute frequencies (percent values); continuous data as mean ± SD. CGM, continuous glucose monitoring; FGM, flash glucose monitoring; SMBG, self-monitoring of blood glucose; MDI, multiple daily injection; CSII, continuous subcutaneous insulin infusion; AP, artificial pancreas; BMI, body mass index; HbA1c, glycated haemoglobin; DIR, daily insulin requirement.

Table 4. Glyco-metabolic control and lyfestyle comparing pre- and post-lockdown

	T0	T1	*p-value*
Mean HbA1c, mmol/mol	64.44 ± 15.61	60.66 ± 11.54	*0.002**
Mean DIR, IU/kg/day	0.743 ± 0.198	0.759 ± 0.215	*0.19*
Mean BMI, z-score	0.30 ± 0.97	0.35 ± 1.05	*0.55*
Mean weekly hours of physical activity, h/week	3.91 ± 3.56	2.13 ± 3.33	*< 0.001**

Data are reported as mean ± SD. HbA1c, glycated haemoglobin; DIR, daily insulin requirement; BMI, body mass index.

Table 5. Variation on HbA1c from T0 to T1 stratyfied for types of glycaemic monitoring, type of insulin treatment and age groups.

Variation on HbA1c, mmol/mol	Mean ± SD	*p-value*
CGM or FGM	-3.56 ± 13.21	*0.70*
SMBG	-5.21 ± 18.06	
MDI	-4.91 ± 15.64	*0.07*
CSII	-1.17 ± 8.19	
SAP	-0.04 ± 8.05	*0.035**
no SAP	-4.62 ± 14.81	
Preschool age	2.89 ± 6.29	*0.011**
Others	-4.26 ± 14.19	
School age	-3.77 ± 19.51	*0.99*
Others	-3.80 ± 10.55	
Adolescent	-5.28 ± 12.46	*0.37*
Others	-3.11 ± 14.54	
Young adults	-3.71 ± 8.57	*0.96*
Others	-3.82 ± 15.75	

Data are reported as mean ± SD. CGM, continuous glucose monitoring; FGM, flash glucose monitoring; SMBG, self-monitoring of blood glucose; MDI, multiple daily injection; CSII, continuous subcutaneous insulin infusion; SAP, sensor augmented pump; HbA1c, glycated haemoglobin.

mol *versus* a mean HbA1c decrease of 4.26 ± 14.19 mmol/mol for the rest of patients (*p: 0.011*). Adolescents' HbA1c improved more than the others (mean HbA1c reduction of 5.28 ± 12.46 mmol/mol vs 3.11 ± 14.54 mmol/mol; *p: 0.37*), but this result is not statistically significant (Table 5).

We did not observe any significant difference in variation of mean daily insulin requirement among age groups.

BMI, physical activity and lifestyle during lockdown

Post-lockdown BMI of our patients worsened, but not statistically significant (mean BMI z-score at T0 of 0.30 ± 0.97 *versus* mean BMI z-score at T1 of 0.35 ± 1.05, *p: 0.55*). Mean weekly hours of physical activity decreased significantly during the lockdown (3.91 ± 3.56 hours before lockdown *versus* 2.13 ± 3.33 hours during lockdown; *p: <0.001*) (Table 4). Nevertheless, a small group of patients (8.9%) reported an increase in physical activity during this period, with a more relevant increase in those with more frequent contacts with our Centre during lockdown: 15% of patients with frequent visits by telemedicine during lockdown increase the time of physical activity *versus* 5% of others (*p: 0.06*).

The majority of our patients (58,2%) declared to have changed their diet habits during lockdown: in particular, 64.1% of these children changed the meal times, 39.7% reported a tendency of eating more snacks between meal times and 28.2% skipped one or more meals (especially breakfast). Moreover, patients reported a tendency towards a more frequent sharing of meals with other family members (46.7%).

No statistically significant differences were found in mean HbA1c and daily insulin requirement variations considering diet and physical activity changes during lockdown.

Conclusions

Considering the profound impact of pandemic and regulatory rules adopted to control Sars-Cov2 infection during lockdown, it was reasonable to presume a global worsening in metabolic control secondary to a reduction in access to medical service for routine follow-up visits and a forced decrease in physical activity.

However, report from the literature that examined type 1 diabetic patients' performance during pandemic showed controversial results.

Most of authors, at least from developed countries, reported an improvement in metabolic control, although the majority of studies analysed CGM/FGM report of limited periods or selected groups of patients (11-30).

On the contrary, some publications, mostly from developing countries, indicate a worsening of metabolic control during lockdown and highlighted difficulties in access to telemedicine, lower use of technology, low education level, difficulties in getting the supply for diabetes management and a global increase in stress, social isolation and discomfort related to disease management (31-35).

To the best of our knowledge, there is only one study, to date, regarding paediatric population, in which the authors presented data regarding both HbA1c values pre and post lockdown and data from glycaemic sensors in a developed country setting and results of this study showed an improvement in metabolic control. However, the authors did not report any information on physical activity or nutritional habits (29).

Our results show a global improvement in mean HbA1c value, without any difference in BMI z-score and insulin dose and despite a significant reduction in time spent in physical activities. Moreover, we observed an increase in contacts through telemedicine facilities between patients and diabetology team during the lockdown period. Stratifying patients according to metabolic control and treatment pre lockdown, we observed a stronger improvement for patients with a previous non satisfactory HbA1c and in patients without an integrated system.

Our data are consistent with previous report from studies from developed countries (11-30).

In our setting, despite regulatory rules and physical and logistic limitations related to pandemic, no worsening of metabolic control has been shown for paediatric and young adult patients with type 1 diabetes and on the contrary patients with a lower performance pre lockdown demonstrated a significant improvement in management of the disease whereas patients with a good control maintained a stable HbA1c.

Milestones of type 1 diabetes therapy include appropriate insulin treatment, adequate nutritional habits and regular physical activity. Treatment is successful if patients and caregivers actively manage their condition on a day to day basis.

Data demonstrates that sustained and positive parental involvement, in the context of a model of parent-child coordination in disease management, has a profound impact in improving health outcome of patients with type 1 diabetes (38-40).

Moreover, recent literature underlines how telehealth system promotes a better self-care and adherence to treatment, especially in patients with suboptimal control, and this improvement appears to be secondary to an increase in frequency of counselling by diabetes team (41, 42).

Considering data regarding number of contacts with medical team and changes in lifestyle during lockdown and keeping in account the above mentioned considerations regarding improvement of metabolic control in patients with a positive parental involvement and with frequent counselling with medical team, it is possible to hypothesise that these results depend on the efficacy of telemedicine approach in the management of type 1 diabetes during pandemic and on the role of a stricter parental control in the supervision of both insulin treatment (regular and correct administration) and diet.

The only countertrend data we observed concern preschool age children who showed a mild but statistically significant worsening in metabolic control; it is likely that in this specific age group reduction in recreational activity may have played a critical role, as nutritional habits are driven anyway by the household.

In addition, analysing data regarding metabolic control among different age groups, it's important to notice that adolescents, category of patients who changed dramatically lifestyle habits during pandemic, showed a greater improvement than others, although this result is not statistically significant, probably for the limited number of subjects analysed and for the great dispersion of data observed among patients in different age groups.

Opposite results come from developing countries, and it is reasonable to assume that this discrepancy depends, at least in part, on a lower availability of telemedicine facilities in some areas (32-34).

Our data highlight the importance of telemedicine in disease management during pandemic and suggest the possibility to reinforce this instrument, as a support for traditional frontal clinic, in the management of paediatric type 1 diabetes also for routine follow-up (7), especially for patients with lower compliance or with a poor metabolic control, who require a strict follow-up with frequent and regular contacts with medical team.

Strength of our study consist in the analysis of the entire cohort of patients followed-up in our clinic, regardless type of treatment, quality of metabolic control and use of technology for management of diabetes, assessing performances of patients pre and post lockdown with a uniform approach (HbA1c). Moreover, this is the first study, to the best of our knowledge, in which data on physical activity, nutritional habits and contacts with medical team has been also collected.

There are also several limitations in our work. Firstly, we don't have included in the analysis reports from FGM/CGM; secondary, data regarding nutritional habits are self-reported by patients and only qualitative and have therefore to be interpreted with caution. Finally, we assessed only the HbA1c value at

first outpatient clinic after lockdown, and therefore we can't draw any conclusion regarding long term metabolic control during the second wave of pandemic.

In conclusion, our study shows an overall better glycaemic control in paediatric and young adult type 1 diabetes patients during lockdown likely secondary to an extensive use of telemedicine during pandemic and to a stringent parental control.

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article

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