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# Monthly video consultation for children and adolescents with type 1 diabetes mellitus during the COVID-19 pandemic

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ABSTRACT

*Aims:* To explore the impact of primarily telemedical care for children and adolescents with type 1 diabetes by monthly video consultations on metabolic control and parents' treatment satisfaction and disease-specific burden during the COVID-19 pandemic.
*Methods:* In this 12-month multicenter observational follow-up VIDIKI 2.0 study, 100 participants (3–18 years) received monthly video consultations, which partially replaced quarterly outpatient clinic appointments during the pandemic. The children's metabolic parameters as well as the parents' treatment satisfaction and diabetes specific burden were assessed at study entry and 12 months later.
*Results:* During the study, 912 video consultations took place (mean 0.84 ± 0.23 / patient/month). The children's HbA1c remained stable, while mean sensor glucose level and glucose management indicator decreased. Simultaneously, parents' treatment satisfaction significantly increased, and their diabetes-specific burden and distress decreased.
*Conclusions:* Primarily telemedical care of children and adolescents with type 1 diabetes during the COVID-19 pandemic via monthly video consultations resulted in a significant improvement in parents' treatment satisfaction and their diabetes-specific burden and distress. It was associated with a slight improvement in mean sensor glucose and glucose management indicator, while HbA1c remained stable. Thus, video consultations offer great potential to enhance standard care for children and adolescents with diabetes.

## 1. Introduction

Management of diabetes mellitus therapy has always been a tremendous challenge for affected children and adolescents and their parents, requiring close and frequent contact with the diabetes team, especially following disease onset. Quarterly in-person appointments at a specialized diabetes outpatient clinic are the standard for pediatric long-term care in the German health care system. Few efforts were made before the COVID-19 pandemic to use all telemedicine options, and video consultation in particular, to provide more frequent, or any, counseling to children, teenagers, or young adults with type 1 diabetes mellitus [1–5]. However, the pandemic has given a particular push to telemedicine and video consultation as a perceived personal, flexible, and cost-saving consultation alternative [6–10].

In Germany, video consultation was a niche and was only offered for medical care a few years ago. The study "Virtual Outpatient Diabetes

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Clinic for Children and Youth" (VIDIKI 1.0) from April 2017 to April 2020 enrolled 240 children aged 1–16 years with type 1 diabetes mellitus using an insulin pump therapy or multiple daily injection therapy (MDI) in combination with a continuous glucose monitoring system (CGM) and for the first time evaluated the feasibility, acceptance, effects and costs of monthly video consultations for children with type 1 diabetes mellitus as an addition to regular outpatient appointments [11]. The study revealed several technological barriers and challenges during the first months. After overcoming the technical issues, the metabolic control of the children and adolescents finally improved with the additional monthly video consultations after 12 and 15 months [4]. Despite the initial technical problems, the video consultation generated a high level of satisfaction among parents and adolescents by reducing the travel time to the diabetes outpatient clinic, decreasing the general burden on parents, and enabling more frequent and flexible consultations [4,12]. Therapy costs for total diabetes care, including insulin, outpatient and inpatient care, and diabetes supplies, were marginally lower in the telemedicine group, not including the cost of video care [13].

To investigate the long-term effect of video consultation as an add-on service to regular care, the present study VIDIKI 2.0 was initially planned as a one-year extension study with quarterly in-person visits [14]. The start of the study unexpectedly coincided with the first lockdown during the COVID-19 pandemic in Germany, when visits to the outpatient clinic had to be frequently replaced by telemedical consultations. Therefore, the research question of the present study was extended to how primarily telemedical care by monthly video consultations of children and adolescents with type 1 diabetes mellitus affects metabolic control, treatment satisfaction of the family, and the emotional burden and diabetes-related distress of the parents.

## 2. Subjects, materials and methods

### 2.1. Study design, participant recruitment and procedures

The VIDIKI 2.0 study was designed as a multicenter observational trial conducted at four former VIDIKI 1.0 study clinics starting in April 2020 for one year. Study participants had type 1 diabetes mellitus, used a CGM system with MDI or insulin pump therapy, and were regularly treated in the study diabetes clinics. The majority of patients had participated in VIDIKI 1.0 before. The recruitment phase was limited to October 2020 to ensure at least 6 months of continuous video consultations. Detailed characteristics of the study group are presented in Table 1.

The VIDIKI 2.0 study was accepted as an extension to the existing approval for the first VIDIKI study by the Ethics Committee of the University of Lübeck (No. 17-172) and was in compliance with the Declaration of Helsinki. Written informed consent was obtained from parents and children over the age of 12, while younger children gave their oral assent. The existing data protection concept of the VIDIKI 1.0 study was implemented unchanged in VIDIKI 2.0.

The study started during the first lockdown in the COVID-19 pandemic in Germany. Therefore, the enrollment of the participants and data collection were conducted solely by telephone or video contact.

The original plan was to treat the VIDIKI 2.0 study group in the same way as in the VIDIKI 1.0 study for another year; the children had one appointment per quarter in the diabetes outpatient clinic and additionally received structured monthly video consultations as an add-on to regular care. However, due to pandemic conditions, some families postponed or cancelled their in-person appointments at the diabetes outpatient clinic and preferred care via video consultations. Thus, the study continued with regular monthly video consultations and occasional appointments in the diabetes outpatient clinics. The families uploaded the CGM and insulin pump data to a cloud-based software of their choice 1–2 days before the appointment. Subsequently, the study team downloaded the data from the cloud server, evaluated the data, provided comments, and sent the feedback to the families in a PDF file via an encrypted email. The video consultation then took place by means of a certified medical video portal. All demographic and medical information was obtained using questionnaires and medical records.

**Table 1**
Demographic and clinical characteristics of the participants at baseline.

| **N = 100** | |
|---|---|
| **Demographic characteristics** | |
| Gender Female, N (%) | 39 (39 %) |
| Age, Mean (SD) years | 11.0 ± 4.1 |
| Children not yet of school age, N (%) | 19 (19 %) |
| Country of birth Germany, mother, N (%) | 98 (98 %) |
| Country of birth Germany, father, N (%) | 97 (97 %) |
| Country of birth Germany, child, N (%) | 99 (99 %) |
| **Child lives with** | |
| Both parents, N (%) | 68 (68 %) |
| Mother and new partner, N (%) | 7 (7 %) |
| Father and new partner, N (%) | 3 (3 %) |
| Single Mother, N (%) | 17 (17 %) |
| Single Father, N (%) | 2 (2 %) |
| Foster parents, N (%) | 1 (1 %) |
| Missing, unknown, N (%) | 2 (2 %) |
| Full-time employment father, N (%) | 93 (93%) |
| Full-time employment mother, N (%) | 21 (21%) |
| **Clinical characteristics** | |
| Duration of type 1 diabetes mellitus, Mean (SD) years | 5.6 ± 3.3 |
| Other chronic condition*: yes | 36 (36 %) |
| **Type of insulin therapy** | |
| Insulin pump + CGM | 94 (94 %) |
| Multiple daily injection (MDI) + CGM | 6 (6 %) |

Table note: *Celiac disease, multiple sclerosis, thyroid disease, vitiligo, alopecia, depression, eating disorder, asthma, attention deficit hyperactivity disorder, dyslexia, or anxiety disorder.

### 2.2. Outcomes and measures

#### 2.2.1. Clinical measures

HbA1c determination could not be performed at study enrollment due to the pandemic conditions. Therefore, the last HbA1c in the previous quarter (Q1, 2020) was used as a baseline value and compared with the HbA1c following the end of the study (Q2, 2021). HbA1c values were assessed locally in the outpatient clinics with a point-of-care (POC) analyzer (DCA Vantage® Siemens and Abbott Afinion $^{TM}$). To adjust for different means of the POC analyzers, the multiple of the mean method (MoM) was applied to mathematically standardized HbA1c values to the Diabetes and Complications Trial (DCCT) reference range of 20.7–42.6 mmol/mol (4.05–6.05 %) [15]. Secondary metabolic outcomes included CGM sensor values such as time-in-range (TiR, 70–180 mg/dl / 3.9–10.0 mmol/l), sensor mean glucose, and glucose management indicator (GMI) [16]. In addition, the frequency of any necessary inpatient treatment was analyzed with regard to the reason for the visit and the number of days spent in hospital. Severe adverse events (SAE) were defined as those resulting in death or significant disability, life-threatening, and/or requiring hospitalization. Severe hypoglycemia was defined as an event requiring glucagon, glucose intravenous treatment, or hospitalization.

#### 2.2.2. Psychosocial measures

Psychosocial outcomes were assessed using two validated patient-reported outcome measures (PROMs):

1) Primary caregivers completed the Diabetes Treatment Satisfaction Questionnaire (DTSQs-Parent). This questionnaire is based on the widely used eight-item DTSQ for adults [17,18], which was developed and expanded based on in-depth interviews with parents and teenagers to improve relevance, accessibility, and comprehensibility for teenagers and family members [19]. The DTSQs-Parent is a 14-item measure that enables parents to self-report their satisfaction with the current treatment of their children. Treatment satisfaction is the combined score of

the 10 items (items 1, 5–9, and 11–14) evaluating satisfaction, ease, flexibility, school day, medical support, and continued treatment. The remaining questions relate to perceived frequencies of hyperglycemia or hypoglycemia (items 2–4) and the effects of the current treatment on the parents' lives (item 10). All items are rated from 0 (very unsatisfied) to 6 (very satisfied), and the range of the total score is 0 to 84, with higher scores indicating better satisfaction with diabetes treatment and care.

2) The Problem Areas in Diabetes Questionnaire for parents of children or teens with diabetes mellitus (P-PAID-C and P-PAID-T) captures parental diabetes-specific burden and emotional distress in everyday life. The questionnaire for parents of children under 12 years (P-PAID-C (16 Items)) and the questionnaire for parents of teenagers (P-PAID-T (15 Items)) were used (German language translation) [20,21]. Each item is scored on a six-point Likert scale (1 = Not a problem to 6 = Big/Serious problem). Higher values indicate greater diabetes-specific distress and emotional burden in everyday life. The distress cutoff score on the P-PAID-T was determined to be 54 [21], for P-PAID-C no cutoff was suggested [20]. Good psychometric properties are reported for these assessment instruments [20–22]. Internal consistency of both P-PAID versions was high, and reliability was strong for four factors, e.g., negative emotions, chronic demands, child regimen-specific distress and personal regimen-specific distress.

The families received the questionnaires in paper form by mail at the start and at the end of the study.

### 2.3. Data and statistical analyses

Descriptive statistics are presented as means (M) and standard deviations (SD), or absolute numbers and percentages. Paired samples t-tests or non-parametric tests (Wilcoxon signed-rank test) were used to analyze differences longitudinally. Differences between subgroups were analyzed with t-tests or non-parametric tests (Mann-Whitney-*U* test). To test whether the variables distribution departs significantly from normality, the Shapiro-Wilk-test was performed. Three separate multiple linear regression analyses were used to estimate the influence of age, diabetes duration, sex (female/male), comorbidity (yes, no), and child living arrangements (with both parents/other), on HbA1c and GMI as well as on diabetes treatment satisfaction. Independent variables were entered simultaneously to the model using an enter method. Spearman-Rho was used to examine the associations between non-normally distributed parameters and the quality of metabolic control. Missing variables were handled by using the pairwise deletion method for analyses, when possible, to maximize all data available. The statistical significance was set at $p < 0.05$ (two-tailed) for all analyses. Data analyses were conducted using the statistical software package IBM SPSS Version 27.0 (SPSS Inc., Chicago, Illinois).

## 3. Results

In the four study centers, 100 eligible families decided to participate in the present study. None of the invited and eligible families refused to participate in the study. One family dropped out right after enrollment. Thus, 99 of 100 families completed the study. Depending on the date of enrollment, the median duration of study participation of the families was 10.8 ± 1.6 months (7–12 months). During the study, 912 video consultations were conducted, of which 848 (93%) were regular appointments, 64 (7%) were extra appointments due to more frequent contact needs. The number of video consultations and outpatient clinic visits were on average 0.84 ± 0.23 per month (min 0.17, max 1.42) and 3.48 ± 0.98 per year (min 0, max 6), respectively.

### 3.1. Severe adverse events, adverse events, and hospital treatments

During the study period, a total of 14 inpatient treatments took place among the 99 participants: five regular stays due to pump or sensor training, three planned group training sessions, two due to oncological disease, and one non-diabetes-related surgery. Only three inpatient stays due to acute diabetes-specific complications (two metabolic imbalances without diabetic ketoacidosis (DKA) and one with DKA) were necessary. Emergency room visits by the study participants without subsequent inpatient treatment did not take place.

### 3.2. Metabolic outcome

#### 3.2.1. Primary metabolic outcome HbA1c

The HbA1c remained stable during the study year. The mean baseline HbA1c in the quarter before study entry (Q 1.2020) was 7.8% ± 1.0% (62 ± 10 mmol/mol) and after one year (Q 2.2021) 7.8% ± 0.8% (62 ± 9 mmol/mol) (N = 99) (p = 0.719). Multiple linear regression analyses were run to predict HbA1c from diabetes duration, age, sex, child comorbidity, and living arrangements at baseline and at study end. There was no significant association of HbA1c with diabetes duration, age, sex, and child comorbidity at either time point. Only child living arrangements significantly predicted HbA1c at study entry and end (each p = 0.001): when both parents jointly cared for their children, the children had lower HbA1c levels. Similarly, no significant association was identified between the change in HbA1c level during the study and the number of telemedicine and outpatient consultations (rho = 0.061; p = 0.55).

#### 3.2.2. Secondary metabolic outcome parameter

For every video consultation, the CGM parameters of the previous 14 days were evaluated, including the GMI, TiR, TbR and mean sensor glucose value. Whereas TiR and TbR of the patients remained stable during the study period, the mean sensor glucose value as well as the GMI slightly, but significantly, improved (Table 2). As for HbA1c values, multiple linear regression showed no evidence that GMI was significantly predicted by diabetes duration, age, sex, and child comorbidity at baseline or end of study. Only child living arrangements were associated with GMI at study entry in such a way that children who were cared for

**Table 2**
Clinical and patient reported outcomes at study entry versus end of study.

| | study entry | end of study | *p* |
|---|---|---|---|
| **Metabolic measures M (SD) (n = 99)** | | | |
| HbA1c (%) | 7.8 (1.0) | 7.8 (0.8) | 0.719[b] |
| HbA1c (mmol/mol) | 62 (10) | 62 (9) | |
| Time in Range (%) | 56.4 (14.7) | 58.0 (12.7) | 0.090[b] |
| Time below Range (%) | 2.06 (1.70) | 2.37 (1.99) | 0.203[b] |
| Mean sensor glucose mg/dl | 179.8 (27.7) | 174.5 (22.9) | 0.002[b] |
| Glucose management indicator GMI (%) | 7.61 (0.66) | 7.49 (0.55) | 0.003[b] |
| BMI SDS | 0.55 (0.91) | 0.58 (0.87) | 0.801[b] |
| **Parental reported outcome measures (n = 87)** | | | |
| **DTSQs parents: diabetes treatment satisfaction – total score** (min-max 0-84) | 57.08 (9.61) | 60.36 (9.79) | <0.001[a] |
| Parents' overall treatment satisfaction (10 Items) (min-max 0-60) | 43.57 (7.35) | 45.64 (7.06) | 0.001[a] |
| Parents' satisfaction with perceived hypoglycemia (min-max 0-6) | 3.66 (0.99) | 3.93 (1.02) | 0.035[b] |
| Parents' satisfaction with perceived glycemic control (min-max 0-12) | 6.46 (2.13) | 6.97 (2.14) | 0.021[a] |
| Parents' satisfaction with perceived effect of treatment on their life (min-max 0-6) | 3.51 (1.39) | 3.82 (1.44) | 0.026[b] |
| **P-PAID diabetes burden and distress** | | | |
| P-PAID-C summed total score (min- max 16-96) parents of children | 47.48 (12.81) | 44.28 (14.23) | 0.042[a] |
| P-PAID-T summed total score (min- max 15-90) parents of teens | 50.63 (15.25) | 45.08 (13.53) | 0.003[a] |

Table note: [a]According to paired samples t-Test pre-post or [b]Wilcoxon test pre-post.

by both parents had lower GMI (p = 0.001).

### 3.3. Parents' reported outcomes

At study entry, 91 of 99 families with a child participating in VIDIKI 2.0 completed the DTSQs-Parents and P-PAID questionnaires and sent them to the study center. At the end of the study, a total of 95 families completed the questionnaires. The questionnaires were mainly completed by the mothers (71% at both time points). The data from the 87 families submitting questionnaires at both time points were compared longitudinally (Table 2).

#### 3.3.1. Satisfaction with diabetes treatment

Overall treatment satisfaction among parents increased significantly, although the initial level of satisfaction was already high. Similarly, satisfaction with the frequency of hypoglycemia and with the perceived quality of metabolic control improved significantly, but to a lesser extent, as well as the effect of diabetes therapy on parents' lives (Table 2).

Two items of the DTSQs were of particular interest for the acceptance of telemedicine care. 1) The question as to whether the parents were satisfied with the support of the diabetes team was answered with an average of 5.49 ± 0.66 points initially and 5.48 ± 0.97 points at the end of the study (range 0 – 6). 2) When asked if they wanted to continue current treatment, parents answered very positively with 5.22 ± 1.02 points initially and 5.55 ± 0.97 points at the end of the study (p = 0.003). Linear regression pointed only to a significant association between overall treatment satisfaction and age of the child with diabetes mellitus (study entry p = 0.025, study end p = 0.012) with slightly lower satisfaction among parents of younger children. As expected, HbA1c and GMI were significantly associated with the combined two DTSQ items on satisfaction with metabolic control (study entry rho = -0.417 / rho = -0.272 / and study end rho = -0.266 / rho = -0.268, each p < 0.01) but not with DTSQ sum scores.

#### 3.3.2. Diabetes-specific burden (P-PAID Questionnaire)

From the parents' perspective, their diabetes-specific burden and emotional distress in everyday life decreased significantly during participation in VIDIKI 2.0. This was evident for parents of children as well as of teenagers (Table 2). Initially, 39 % of the parents of teenagers exceeded the cutoff value of 54 (high burden). At the end of the study, only 19 % did so. While there was no significant association between emotional distress and child HbA1c for parents of children, the relationship between emotional distress and adolescent HbA1c was significant at both time points (study entry Spearman rho = 0.392, p = 0.018; study end Spearman rho = 0.426, p = 0.025).

## 4. Discussion

Our study shows that additional telemedical care for children and adolescents with type 1 diabetes mellitus during the COVID-19 pandemic consisting of structured monthly video consultations for 12 months resulted in a significant improvement in parents' treatment satisfaction and their diabetes-specific burden and distress and was associated with a slight improvement in mean sensor glucose value and glucose management indicator, while HbA1c remained stable.

Monthly video consultations with children and adolescents with type 1 diabetes mellitus during the COVID-19 pandemic, which partially replaced outpatient clinic appointments, were not associated with a deterioration in metabolic control in the present study. Contrary to the tendency for the HbA1c value to increase with longer diabetes duration [23], the HbA1c value remained stable in our study, and the mean sensor glucose value and glucose management indicator even slightly decreased. This is of special note, considering the profound changes in the children's and adolescents' everyday lives during the COVID-19 pandemic and the lockdown, which included temporary closure of daycare institutions, schools and team sports activities, home-schooling, and social distancing and isolation. In adolescents, the COVID-19 pandemic was shown to be associated with a lack of physical activity, different eating habits, increased screen time, modified sleep-wake rhythm, and a higher rate of social withdrawal, depression, and anxiety disorders, all of which might have had a negative effect on diabetes management and metabolic control [24,25]. Furthermore, during the COVID-19 pandemic in Germany, visits to the diabetes outpatient clinic were often postponed or cancelled due to the risk or fear of infection or various other reasons. However, the lower frequency of in-person visits and primarily telemedical care via video consultations in our study did not have any negative effect on glycemic control. Our findings are consistent with recent studies investigating the effect of COVID-19-associated lockdowns on glycemic control in children and adolescents, which revealed stable metabolic control or even an improvement [26–31]. Some studies suggest that spending more time at home with parental supervision and diabetes management and a slowdown in daily activities might have beneficial effects on metabolic control, especially in younger children [28,32]. Furthermore, our study indicates that telemedicine via structured video consultations by diabetes healthcare professionals may be as therapeutically effective as in-person visits at outpatient clinics. Since the vast majority of study participants had taken part in the previous study VIDIKI 1.0, the only slight improvement in glycemic parameters might partially be due to an already reached plateau of patient's glycemic control.

Additionally, our study showed that monthly video consultations for 12 months resulted in a significant improvement in parents' treatment satisfaction and their diabetes-specific burden and distress. Parental stress decreased during the study, especially among parents of adolescents. In addition, parents were more satisfied with the impact of diabetes treatment on their lives. The COVID-19 pandemic represented an additional stressor for parents of children and adolescents as they were being asked to combine multiple roles (e.g., professional role, teaching role and parenting role) [33]. Parents of children with chronic disease reported higher levels of anxiety than parents of healthy children during the COVID-19 pandemic [33]. Given this, the significant decrease in parental diabetes-specific burden and distress in our study despite the pandemic situation is remarkable. As in VIDIKI 1.0, parents were very satisfied with the video consultations and appreciated the time savings and the higher frequency of medical appointments [12]. The structured data analysis and discussion as an essential part of the counseling appointment enabled an increasingly improved understanding of how treatment changes can be derived from the CGM data analyses. Furthermore, adolescents were able to be much more active in treatment discussions about their own data compared to the outpatient clinic.

Major advantages of video consultations for families with children or adolescents with type 1 diabetes mellitus, compared to standard in-person visits, comprise saving travel time or waiting time, flexibility in appointments in terms of time and place, a higher frequency of contact leading to short-term therapy adjustments, and an increase in the ability to adjust therapy independently [12]. Patients and families missed significantly less school and work time to attend appointments [34]. Troncone et al. revealed a higher level of patient-doctor agreement on explicit goals of treatment in video consultations compared to in-person visits and no differences in terms of the doctor-patient relationship [35]. Especially in rural areas with limited access to specialty care, telemedicine care offers great potential to increase adherence and improve diabetes care [34].

However, the introduction of telemedicine, and specifically video consultation, initially requires thorough preparation: the necessary hardware and software must be installed and tested by the diabetes healthcare team. Reliable internet access and a technical device suitable for the performance of video consultation are necessary at the family's site. Both the diabetes healthcare team and the parents need to learn how to use the virtual consultation portal and to deal with minor technical errors. Consultation time slots, billing options, and the

organization of prescriptions for the families need to be differently coordinated. Lack of reliable internet or hardware access may hamper telemedicine care, especially for families with lower socioeconomic status. Some families with lower technical abilities may feel overburdened with the technical requirements when starting telemedicine [4].

The main limitation of video consultation is the lack of physical examination. Parents must be instructed to evaluate the injection sites themselves. Measurement of weight and blood pressure need to be delegated to the families. For children and adolescents with suspected hypertension, measurements with an appropriate home blood pressure monitor or annual 24-hour blood pressure measurement should be arranged with local health care facilities.

Furthermore, the quarterly HbA1c is not always adequately reflected by software GMI, mean sensor glucose, TiR, and TbR, and so cannot be simply replaced by software measures in all patients [36]. For this reason, from our perspective, before starting primarily video consultation-based care, it is advisable to compare an HbA1c value from the outpatient clinic with the corresponding GMI from a 4-week evaluation and check whether the GMI deviates clinically significantly, i.e., more than 0.5%, in case of incorrectly low calibrated sensors, for example. In cases with significant deviation, the use of a home test HbA1c meter may provide the necessary parameter.

Our findings are consistent with studies before and during the COVID-19 pandemic, which also found high acceptance and satisfaction with video consultation in other countries [3,10,35,37]. However, this drastic change in on-site care concepts through the introduction of video consultation also requires appropriate reimbursement. Moreover, the use of diabetes technologies and diabetes software must become part of the training concepts for both patients and diabetes healthcare professionals. A European group of authors also addressed the legal and strategic requirements necessary to make telemedicine available to broad patient groups while ensuring data protection, patient privacy and cyber security [10].

However, some limitations of the study should be noted. VIDIKI 2.0 was designed as a follow-up observational study with mainly former VIDIKI 1.0 participants, who were already familiar with telemedicine. The positive previous experience and the existence of the technical hardware and software for telemedicine thus reflects a selected, well-trained group of participants. Families without telemedicine experience were not equally represented in the study. Therefore, a selection bias is likely with respect to satisfaction with telemedicine. Furthermore, families with migration background were underrepresented in our study.

In contrast, the length of the study is a particular strength, since - to our knowledge - no long-term studies on telemedicine in pediatric diabetology exist. The VIDIKI 1.0 study and the present follow-up VIDIKI 2.0 study investigate for the first time the metabolic parameters as well as parents' treatment satisfaction and diabetes-specific burden of a cohort of children and adolescents who received monthly video consultations for a minimum of 7 months and a maximum of 3.5 years over the two directly consecutive studies.

In conclusion, this study shows that telemedicine conducted via monthly video consultations as an addition to, or replacement for, quarterly outpatient clinic visits is equivalent to in-person visits in terms of maintaining metabolic control in children and adolescents with type 1 diabetes, and improves parents' treatment satisfaction and their diabetes-specific burden and distress under pandemic conditions. Thus, innovative treatment modalities such as video consultations offer an enormous potential to extend and improve standard care for children and adolescents with diabetes mellitus in the future. Provided that there is access to the internet, a legal framework, regulated reimbursement as well as acceptance by the diabetes healthcare teams, video consultation could soon be integrated into national diabetes care models.

**Author contributions**

FF, KL, SVS and OH designed the research study. JS, JB, BB, NS and SVS performed monthly video consultations, and contributed to manuscript revisions. KL analyzed the data. KL, SVS and JS wrote the manuscript. All co-authors helped to interpret the data and contributed to manuscript revisions.

## Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: SVS reports being a consultant for Abbott, Dexcom, Lilly, Novo Nordisk and Medtronic and having received lecture fees from Abbott, Berlin-Chemie, Hexal, Infectopharm, Lilly, NovoNordisk, Merck, Medtronic, and Sanofi, with no potential conflicts of interest relevant to this article. JB received lecture fees from Mediq Direkt, Lilly, Pfizer, Merck Serono and Dampsoft AG (Germany), with no potential conflicts of interest relevant to this article. OH received consulting fees from Novo Nordisk and lecture fees from Novo Nordisk, Infectopharm, and Kyowa Kirin, with no potential conflicts of interest relevant to this article. KL received lecture fees from Astra Zeneca, BDI, BioMarin, Chiesi, Lilly, Medtronic, Menarini Berlin Chemie, MSD SHARP & DOHME, neubourg skin care, Novo Nordisk, Roche Diabetes Care, and Sanofi Aventis, with no potential conflicts of interest relevant to this article. All other authors declare no potential conflicts of interest relevant to this manuscript.

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## References

[1] Crossen SS, Marcin JP, Qi L, Sauers-Ford HS, Reggiardo AM, Chen ST, et al. Home Visits for Children and Adolescents with Uncontrolled Type 1 Diabetes. Diabetes Technol Ther 2020 Jan;22(1):34–41. doi: 10.1089/dia.2019.0214. Epub 2019 Sep 18. PMID: 31448952; PMCID: PMC6945797.

[2] Reid MW, Krishnan S, Berget C, Cain C, Thomas JF, Klingensmith GJ, et al. CoYoT1 Clinic: Home Telemedicine Increases Young Adult Engagement in Diabetes Care. Diabetes Technol Ther 2018 May;20(5):370–9. https://doi.org/10.1089/dia.2017.0450. Epub 2018 Apr 19 PMID: 29672162.

[3] Raymond JK, Berget CL, Driscoll KA, Ketchum K, Cain C, Fred Thomas JF. CoYoT1 Clinic: Innovative Telemedicine Care Model for Young Adults with Type 1 Diabetes. Diabetes Technol Ther 2016 Jun;18(6):385–90. doi: 10.1089/dia.2015.0425. Epub 2016 May 19. PMID: 27196443; PMCID: PMC5583551.

[4] von Sengbusch S, Eisemann N, Mueller-Godeffroy E, Lange K, Doerdelmann J, Erdem A, et al. Outcomes of monthly video consultations as an add-on to regular care for children with type 1 diabetes: A 6-month quasi-randomized clinical trial followed by an extension phase. Pediatr Diabetes 2020 Dec;21(8):1502–15. https://doi.org/10.1111/pedi.13133. Epub 2020 Oct 15 PMID: 33009690.

[5] Tchero H, Kangambega P, Briatte C, Brunet-Houdard S, Retali GR, Rusch E. Clinical Effectiveness of Telemedicine in Diabetes Mellitus: A Meta-Analysis of 42 Randomized Controlled Trials. Telemed J E Health 2019 Jul;25(7):569–83. https://doi.org/10.1089/tmj.2018.0128. Epub 2018 Aug 20 PMID: 30124394.

[6] Tornese G, Schiaffini R, Mozzillo E, Franceschi R, Frongia AP, Scaramuzza A; Diabetes Study Group of the Italian Society for Pediatric Endocrinology and Diabetes. The effect of the COVID-19 pandemic on telemedicine in pediatric diabetes centers in Italy: Results from a longitudinal survey. Diabetes Res Clin Pract 2021 Sep;179:109030. doi: 10.1016/j.diabres.2021.109030. Epub 2021 Aug 28. PMID: 34461140; PMCID: PMC8438313.

[7] March CA, Flint A, DeArment D, Gilliland A, Kelly K, Rizzitano E, et al. Paediatric diabetes care during the COVID-19 pandemic: Lessons learned in scaling up telemedicine services. Endocrinol Diabetes Metab 2020 Nov 21;4(1):e00202. doi: 10.1002/edm2.202. Epub ahead of print. PMID: 33349799; PMCID: PMC7744857.

[8] Braune K, Boss K, Schmidt-Herzel J, Gajewska KA, Thieffry A, Schulze L, et al. Shaping Workflows in Digital and Remote Diabetes Care During the COVID-19 Pandemic via Service Design: Prospective, Longitudinal, Open-label Feasibility Trial. JMIR Mhealth Uhealth 2021 Apr 5;9(4):e24374. https://doi.org/10.2196/24374. PMID: 33571104; PMCID: PMC8023381.

[9] Lee JM, Carlson E, Albanese-O'Neill A, Demeterco-Berggren C, Corathers SD, Vendrame F, et al. Adoption of Telemedicine for Type 1 Diabetes Care During the COVID-19 Pandemic. Diabetes Technol Ther 2021 Sep;23(9):642–651. doi: 10.1089/dia.2021.0080. Epub 2021 May 21. PMID: 33851873; PMCID: PMC8501471.

[10] Choudhary P, Bellido V, Graner M, Altpeter B, Cicchetti A, Durand-Zaleski I, et al. The Challenge of Sustainable Access to Telemonitoring Tools for People with Diabetes in Europe: Lessons from COVID-19 and Beyond. Diabetes Ther 2021 Sep; 12(9):2311–2327. doi: 10.1007/s13300-021-01132-9. Epub 2021 Aug 14. PMID: 34390477; PMCID: PMC8363869.

[11] Frielitz FS, Müller-Godeffroy E, Hübner J, Eisemann N, Dördelmann J, Menrath I, et al. Monthly Video-Consultation for Children With Type 1 Diabetes Using a Continuous Glucose Monitoring System: Design of ViDiKi, a Multimethod Intervention Study to Evaluate the Benefit of Telemedicine. J Diabetes Sci Technol 2020 Jan;14(1):105–111. doi: 10.1177/1932296819861991. Epub 2019 Jul 17. PMID: 31315446; PMCID: PMC7189148.

[12] von Sengbusch S, Doerdelmann J, Lemke S, Lange K, Hiort O, Katalinic A, et al. Parental expectations before and after 12-month experience with video consultations combined with regular outpatient care for children with type 1 diabetes: a qualitative study. Diabet Med 2021 Jun;38(6):e14410. https://doi.org/10.1111/dme.14410. Epub 2020 Oct 4. PMID: 32969088.

[13] Frielitz FS, Eisemann N, Werner K, Hiort O, Katalinic A, Lange K, et al. Direct Costs of Healthcare for Children with Type 1 Diabetes Using a CGM System: A Health Economic Analysis of the VIDIKI Telemedicine Study in a German Setting. Exp Clin Endocrinol Diabetes 2022 Jan 3. https://doi.org/10.1055/a-1708-3134. Epub ahead of print. PMID: 34979571.

[14] Schleswig-Holstein Ministry of Health funds to save health care in rural regions [Versorgungssicherungsfonds des Landes Schleswig-Holstein] [accessed 24 Feb 2022].

[15] Diabetes Control and Complications Trial Research Group, Nathan DM, Genuth S, Lachin J, Cleary P, Crofford O, et al. The effect of intensive treatment of diabetes on the development and progression of long-term complications in insulin-dependent diabetes mellitus. N Engl J Med 1993 Sep 30;329(14):977–86. https://doi.org/10.1056/NEJM199309303291401. PMID: 8366922.

[16] Bergenstal RM, Beck RW, Close KL, Grunberger G, Sacks DB, Kowalski A, et al. Glucose Management Indicator (GMI): A New Term for Estimating A1C From Continuous Glucose Monitoring. Diabetes Care 2018 Nov;41(11):2275–2280. doi: 10.2337/dc18-1581. Epub 2018 Sep 17. PMID: 30224348; PMCID: PMC6196826.

[17] Bradley C, Lewis KS. Measures of psychological well-being and treatment satisfaction developed from the responses of people with tablet-treated diabetes. Diabet Med 1990 Jun;7(5):445–51. https://doi.org/10.1111/j.1464-5491.1990.tb01421.x. PMID: 2142043.

[18] Bradley C. The Diabetes Treatment Satisfaction Questionnaire: DTSQ. Handbook of Psychology and Diabetes: a guide to psychological measurement in diabetes research and practice. First ed. Chur, Switzerland: Harwood Academic Publishers; 1994.

[19] Bradley C, Loewenthal K, Woodcok A, McMillan C. Development of the diabetes treatment satisfaction questionnaire (DTSQ) for teenagers and parents: the DTSQ-Teen and the DTSQ-Parent (Abstract). Diabetologia 2009;52(Suppl.):S397, Abstract 1013.

[20] Weissberg-Benchell J, Antisdel-Lomaglio J. Diabetes-specific emotional distress among adolescents: feasibility, reliability, and validity of the problem areas in diabetes-teen version. Pediatr Diabetes 2011 Jun;12(4 Pt 1):341–4. https://doi.org/10.1111/j.1399-5448.2010.00720.x. Epub 2011 Mar 28 PMID: 21443583.

[21] Shapiro JB, Vesco AT, Weil LEG, Evans MA, Hood KK, Weissberg-Benchell J. Psychometric Properties of the Problem Areas in Diabetes: Teen and Parent of Teen Versions. J Pediatr Psychol 2018 Jun 1;43(5):561–71. https://doi.org/10.1093/jpepsy/jsx146. PMID: 29267939; PMCID: PMC6454555.

[22] Evans MA, Weil LEG, Shapiro JB, Anderson LM, Vesco AT, Rychlik K, et al. Psychometric Properties of the Parent and Child Problem Areas in Diabetes Measures. J Pediatr Psychol 2019 Jul 1;44(6):703–13. https://doi.org/10.1093/jpepsy/jsz018. PMID: 30920628; PMCID: PMC6573474.

[23] Schwandt A, Hermann JM, Rosenbauer J, Boettcher C, Dunstheimer D, Grulich-Henn J, et al. Longitudinal Trajectories of Metabolic Control From Childhood to Young Adulthood in Type 1 Diabetes From a Large German/Austrian Registry: A Group-Based Modeling Approach. Diabetes Care 2017 Mar;40(3):309–16. https://doi.org/10.2337/dc16-1625. Epub 2016 Dec 22. PMID: 28007778.

[24] Di Renzo L, Gualtieri P, Pivari F, Soldati L, Attinà A, Cinelli G, et al. Eating habits and lifestyle changes during COVID-19 lockdown: an Italian survey. J Transl Med 2020 Jun 8;18(1):229. https://doi.org/10.1186/s12967-020-02399-5. PMID: 32513197; PMCID: PMC7278251.

[25] Guessoum SB, Lachal J, Radjack R, Carretier E, Minassian S, Benoit L, et al. Adolescent psychiatric disorders during the COVID-19 pandemic and lockdown. Psychiatry Res 2020 Sep;291:113264. https://doi.org/10.1016/j.psychres.2020.113264. Epub 2020 Jun 29. PMID: 32622172; PMCID: PMC7323662.

[26] Hammersen J, Reschke F, Tittel SR, Pappa A, Dost A, Köstner K, et al. Metabolic control during the SARS-CoV-2 lockdown in a large German cohort of pediatric patients with type 1 diabetes: Results from the DPV initiative. Pediatr Diabetes 2022 May;23(3):351–61. https://doi.org/10.1111/pedi.13319. Epub 2022 Feb 14 PMID: 35084805.

[27] Christoforidis A, Kavoura E, Nemtsa A, Pappa K, Dimitriadou M. Coronavirus lockdown effect on type 1 diabetes management on children wearing insulin pump equipped with continuous glucose monitoring system. Diabetes Res Clin Pract 2020 Aug;166:108307. doi: 10.1016/j.diabres.2020.108307. Epub 2020 Jul 8. PMID: 32650036; PMCID: PMC7340587.

[28] Schiaffini R, Barbetti F, Rapini N, Inzaghi E, Deodati A, Patera IP, et al. School and pre-school children with type 1 diabetes during Covid-19 quarantine: The synergic effect of parental care and technology. Diabetes Res Clin Pract 2020 Aug;166: 108302. doi: 10.1016/j.diabres.2020.108302. Epub 2020 Jul 3. PMID: 32623034; PMCID: PMC7332425.

[29] Di Dalmazi G, Maltoni G, Bongiorno C, Tucci L, Di Natale V, Moscatiello S, et al. Comparison of the effects of lockdown due to COVID-19 on glucose patterns among children, adolescents, and adults with type 1 diabetes: CGM study. BMJ Open Diabetes Res Care 2020 Oct;8(2):e001664. https://doi.org/10.1136/bmjdrc-2020-001664. PMID: 33115820; PMCID: PMC7594202.

[30] Brener A, Mazor-Aronovitch K, Rachmiel M, Levek N, Barash G, Pinhas-Hamiel O, et al. Lessons learned from the continuous glucose monitoring metrics in pediatric patients with type 1 diabetes under COVID-19 lockdown. Acta Diabetol 2020 Dec; 57(12):1511–7. https://doi.org/10.1007/s00592-020-01596-4. Epub 2020 Oct 7. PMID: 33026497; PMCID: PMC7538839.

[31] Predieri B, Leo F, Candia F, Lucaccioni L, Madeo SF, Pugliese M, et al. Glycemic Control Improvement in Italian Children and Adolescents With Type 1 Diabetes Followed Through Telemedicine During Lockdown Due to the COVID-19 Pandemic. Front Endocrinol (Lausanne) 2020 Dec;7(11):595735. https://doi.org/10.3389/fendo.2020.595735. PMID: 33424771; PMCID: PMC7793913.

[32] Kofoed PE, Timm S. The impact of COVID-19 lockdown on glycaemic control and use of health services among children followed at a Danish diabetes clinic. Acta Paediatr 2022 Feb;111(2):368–375. doi: 10.1111/apa.16128. Epub 2021 Oct 5. PMID: 34586678; PMCID: PMC8653272.

[33] Wauters A, Vervoort T, Dhondt K, Soenens B, Vansteenkiste M, Morbée S, et al. Mental Health Outcomes Among Parents of Children With a Chronic Disease During the COVID-19 Pandemic: The Role of Parental Burn-Out. J Pediatr Psychol 2022 Apr 8;47(4):420–31. https://doi.org/10.1093/jpepsy/jsab129. PMID: 34915562; PMCID: PMC8754736.

[34] Wood CL, Clements SA, McFann K, Slover R, Thomas JF, Wadwa RP. Use of Telemedicine to Improve Adherence to American Diabetes Association Standards in Pediatric Type 1 Diabetes. Diabetes Technol Ther 2016 Jan;18(1):7–14. https://doi.org/10.1089/dia.2015.0123. Epub 2015 Aug 21 PMID: 26295939.

[35] Troncone A, Cascella C, Chianese A, Zanfardino A, Casaburo F, Piscopo A, et al. Doctor-Patient Relationship in Synchronous/Real-time Video-Consultations and In-Person Visits: An Investigation of the Perceptions of Young People with Type 1 Diabetes and Their Parents During the COVID-19 Pandemic. Int J Behav Med 2022 Jan 25:1–10. doi: 10.1007/s12529-021-10047-5. Epub ahead of print. PMID: 35076861; PMCID: PMC8788397.

[36] Piona C, Marigliano M, Mozzillo E, Di Candia F, Zanfardino A, Iafusco D, et al. Evaluation of HbA1c and glucose management indicator discordance in a population of children and adolescents with type 1 diabetes. Pediatr Diabetes 2022 Feb;23(1):84–9. https://doi.org/10.1111/pedi.13299. Epub 2021 Dec 15 PMID: 34888998.

[37] Fung A, Irvine M, Ayub A, Ziabakhsh S, Amed S, Hursh BE. Evaluation of telephone and virtual visits for routine pediatric diabetes care during the COVID-19 pandemic. J Clin Transl Endocrinol. 2020 Dec;22:100238. doi: 10.1016/j.jcte.2020.100238. Epub 2020 Oct 12. PMID: 33072519; PMCID: PMC7548628.