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RESEARCH

Mental health among children with long COVID during the COVID-19 pandemic

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Abstract

A growing number of studies report that persons of all ages, infected with SARS-CoV-2, may experience long-term persistent symptoms, known as long COVID (LC) or post COVID-19 condition. This is one of the first studies examining the consequences of LC on children's mental health. In this case–control study, we compared select mental health aspects of 103 children diagnosed with LC to a control group of 113 children uninfected with SARS-COV-2; all 4–18 years old. Both groups were assessed via parents' questionnaires. In comparison to the control group, children with LC exhibited more memory difficulties. However, no group differences emerged in other functional aspects (connection with friends and engagement in physical activities), problems with concentration, or levels of emotional-behavioral problems (externalizing, internalizing, ADHD, and PTSD symptoms). We also found that children with LC had greater exposure to COVID-19-related stressors. Higher levels of parental worries regarding their children's functioning and economic difficulties at home significantly predicted higher levels of children's emotional-behavioral problems and were better predictors than the child's age, social functioning, or LC diagnosis.

Conclusion: LC was associated with impairments in some aspects of children's memory which may relate to academic functioning, but not with higher rates of emotional-behavioral problems, thus warranting interventional programs addressing school functioning and cognitive abilities in this population. Additionally, parents' economic stress and worries regarding their child's emotional adjustment during the pandemic, are important factors affecting pandemic-related emotional-behavioral problems among children, regardless of COVID-19 infection, that should be addressed.

What is Known:
• *Children may have long COVID (LC) after being infected with SARS-COV-2.*

What is New:
• *LC may be associated to impairments in some aspects of children's memory, as reported by parents.*
• *Parents' economic stress and worries concerning their children's emotional adjustment during the pandemic are associated with more distress in their children.*

Keywords COVID-19 · Long COVID · Post-traumatic stress · Psychosocial adjustment

Abbreviations

ADHD	Attention deficit hyperactivity disorder
CATS	The Child and Adolescent Trauma Screen
LC	Long COVID

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PSC The Pediatric Symptom Checklist
PTSD Posttraumatic stress disorder

Introduction

The COVID-19 outbreak has significantly affected children, adolescents, and adults in many aspects, comprising a serious health threat, financial instability, restrictions of individual freedoms, and causing major routine modifications [1].

Individuals infected with SARS-CoV-2 may experience long-term persistent symptoms, also known as long COVID (LC) or post COVID condition. A meta-analysis of adults followed viral infection with SARS-CoV-2 found that 80% of them developed one or more long-term symptoms within 14–110 days [2]. More than 200 different symptoms were found to be associated with LC [3, 4], the most common being fatigue, headache, attention disorder, hair loss, and dyspnea [3]. Symptoms appearing at or after acute infection were persistent, intermittent, or relapsing in nature [2, 3].

Children may also suffer from long-term symptoms [5–7], the most frequent being fatigue, headache, abdominal pain, muscle and joint pain, post-exertional malaise, and rash, with a significant prevalence of problems with concentration reported [8].

While having been infected with SARS-CoV-2 is considered a risk factor for psychological distress in children [1, 9] the mental health consequences of children having LC remain unknown. Moreover, it is unclear whether the psychological difficulties can be attributed to the illness itself or other related factors (e.g., isolation from friends and family). Thus, environmental, familial, and individual factors affecting children during the pandemic should also be considered.

Among the environmental factors, the interruption of daily routines, such as school activities, social interactions, and physical activity, were identified as related to children and adolescents' mental health problems during the COVID-19 outbreak [10–13]. The amount of time spent in quarantine during the pandemic also related to children's distress [14].

Familial risk factors for children's psychological distress during the pandemic include lower socioeconomic status and parental economic worries [9, 15–19], parental stress and emotional dysregulation [20–22]. Individual factors, such as age and gender, should also be considered, although findings on their contribution to children's distress during the COVID-19 pandemic are inconclusive [10, 13, 23].

This study aimed to identify consequences of LC on children's mental health, by assessing selected emotional symptoms and routine functioning among children with LC and healthy controls. The study rationale is to assess and to delineate specific features associated with LC in children and adolescents, in order to adapt treatments for this age group. We hypothesized that while a status of LC would relate to greater impairment in children's mental health, other environmental, familial, and individual factors will also predict different aspects of children's emotional well-being during the pandemic.

Materials and methods

Study design and participants

The institutional review boards of Schneider Children's Medical Center of Israel (RMC-20–0885) and Ruppin Academic Center (2021-77L /cp) approved the research. This case–control study compared the mental health of children with LC to healthy controls, both recruited from November 2020 to August 2021.

The LC group included children who presented to a designated multidisciplinary clinic for LC, at a tertiary pediatric center. Inclusion criteria for the LC group included the following: (a) children > 4 and ≤ 18 years of age and (b) SARS-CoV-2 infection microbiologically confirmed by PCR during acute infection or by subsequent serology, and (c) symptoms suggestive of LC > 4 weeks from acute illness that cannot be explained by an alternative diagnosis. Time from confirmed illness to the study's assessment ranged between 5 and 41 weeks.

The control group consisted of COVID-19 negative children who responded to an online survey, distributed through diverse online platforms across Israel. Inclusion criteria for the control group included (a) children > 4 and ≤ 18 years of age, and (b) parental report of no past SARS-CoV-2 infection. The rationale of examining the control group was to evaluate factors that affected children's mental health during the pandemic, regardless of being infected with COVID-19. In order to address potential bias, systematic differences between baseline characteristics of the groups compared were accounted for through the use of covariance in the statistical analysis.

Of the LC group, 15.5% were called to a medical procedure before completing the PSC questionnaire and 49.5% did not complete the CATS questionnaire, added to the research at a later time. While all control participants received the full battery of questionnaires, 10.6% did not complete the PSC and 18.5% did not complete the CATS, for unknown reasons.

Procedures

A parent or legal guardian provided written informed consent for children participating in the study. LC group children were recruited upon their visit to the LC multidisciplinary clinic, where they underwent an assessment of symptoms using a structured interview conducted by a senior pediatrician, a physical examination, and additional diagnostic testing [5]. In addition, parents or legal guardians completed mental health questionnaires. In the control group, parents

or legal guardians completed all questionnaires online, using the Research Electronic Data Capture (REDcap, Nashville, USA) software. The number of LC cases in the clinic during the study period determined the sample size. The control group size was matched accordingly.

Measures

Demographic variables This included child's age, sex, and parents' report of economic difficulties.

Exposure to COVID-19-related stressful events A scale was constructed for this study, comprised of four yes/no items concerning possible COVID-19-related stressful events (the child was quarantined, a family member had COVID-19, was hospitalized because of COVID-19, died of COVID-19) and the number of days the child was isolated. Days of isolation were divided into four categories by the variables' quartiles. These five items were summed; thus, a higher rating indicated a higher level of exposure to COVID-19-related stress. This scale contains items of discrete incremental events, which do not necessarily correlate with one another. Thus, there is no rationale for evaluating correlation between them.

Functional impairment due to COVID-19 Four variables, comprised specifically for this study, evaluated functional impairment in different domains.

Memory problems Parents were asked to report whether their child experienced memory problems on a 0–4 scale, with higher ratings reflecting greater impairment.

Concentration problems Parents were asked to report whether their child experienced concentration problems on a 0–4 scale, with higher ratings reflecting greater impairment.

Social engagement Parents were asked to report their child's willingness to socially engage with peers, on a 0–2 scale, with higher ratings reflecting greater social impairment.

Physical activity engagement Parents were asked to report how physically engaged their child is, on a 0–2 scale, with higher ratings reflecting greater physical impairment.

Parental worries regarding their child A 3-item scale, constructed for this study, assessed parents' concerns regarding their child's social status, school functioning, and mental state. Each item was rated on a 5-point scale and the three items were averaged for the total score, such that higher scores indicate greater parental worries. Cronbach's alpha value was 0.77.

Parent's COVID-19-related distress This 6-item scale, constructed for this study, assessed the degree to which parents felt negative emotions (e.g., fear, anger) concerning the pandemic. Each item was rated on a 1–5 scale. The items were averaged for the total score. Cronbach's alpha value was 0.78.

The Pediatric Symptom Checklist (PSC) is a screening tool for cognitive, emotional, and behavioral problems in children aged 4–18 years. The PSC includes 35 items, assessing the frequency of attention problems, and internalizing (i.e., anxiety and depression) and externalizing (i.e., conduct) symptoms. Each item is rated on a 0–2 scale with the scores on all 35 items summed for the total score. Cutoff scores of PSC > 24 for children under 6 years, and PSC > 28 for children over 6 years, suggest clinical dysfunction and the need for further evaluation. The PSC has good validity and reliability [24, 25]. In our study, Cronbach's alpha values for the general score, attention problems, and internalizing and externalizing subscales were 0.92, 0.79, 0.84, and 0.83, respectively.

The Child and Adolescent Trauma Screen (CATS) is a short questionnaire screening for exposure to potentially traumatic events, posttraumatic stress disorder (PTSD) symptoms, and psychosocial functioning. In the current study, we slightly adapted the instructions; participants were asked to report the frequency of experiencing different PTSD symptoms related to the COVID-19 pandemic, during the past 2 weeks. The PTSD scale includes 20 items based on the DSM-5 criteria for PTSD, mapping symptoms of hyperarousal, re-experiencing, avoidance, and negative alterations in cognitions and mood. The items are rated on a 0–3 scale. International validation of the CATS has proven good psychometric properties [26]. In the current study, Cronbach's alpha values for the general score and the hyperarousal, re-experiencing, avoidance, and negative alternation subscales were 0.71, 0.88, 0.84, 0.91, and 0.86, respectively.

Statistical methods

Data were analyzed using SPSS, version 23.0 (Armonk, NY: IBM Corp). Differences between the LC and the control group were examined using independent samples *t*-tests and χ^2, with Bonferroni corrections to adjust the *p*-values. Bivariate Pearson correlation tests (for interval variables) or Spearman correlation tests (for ordinal variables) were used to explore relationships among the study's variables. Two multiple regression analyses examined the variables contributing to children's PSC and CATS levels. The assumptions of multiple linear regressions were all met: no univariate outliers were identified (z score ± 3.29 standard deviations from the mean) [27] and the data did not violate assumptions of homoscedasticity of

Table 1 Demographic characteristics of the LC and control groups

	LC ($n=103$)	Control ($n=113$)	T/chi^2	Sig. (p)	Effect size
Age (M, SD)	13.50 (4.01)	10.14 (2.80)	$T=-7.19$*	0.000	Cohen's $d=-0.98$
Sex (% females)	54.4% ($n=56$)	48.7% ($n=55$)	$chi^2=0.70$	0.403	Cramer's $V=0.06$
Economic difficulties	2.15 (1.36)	1.88 (0.97)	$T=-1.63$	0.104	Cohen's $d=-0.22$

*$p<0.01$

residuals and independence of errors, linearity, or normality. There was no evidence of multicollinearity: (i) tolerance and VIF were within accepted limits ($1<\text{VIF}>1.4$; $0.79<\text{tolerance}>0.99$), and (ii) no correlation was found between independent variables above the 0.80 threshold [28].

The rates of missing data in the different measures ranged between 4 and 10%. These responses were judged to be missing completely at random (MCAR; Little's MCAR $p>0.05$); therefore, listwise deletion was performed.

Results

Of 216 parents participating in this study, 103 had children diagnosed with LC and 113 children in the control group. The mean age of children in the total sample was 11.7 years (SD = 3.8). Table 1 presents demographic characteristics of the LC and control groups. Median time from SARS-CoV-2 PCR testing to first visit at the clinic was 16.5 weeks (IQR = 11.64).

Comparison between the LC and control group characteristics

The LC group children were significantly older than in the control group, but there were no group differences in the distribution of children's sex and level of economic difficulties.

Exposure to COVID-19-related stressful events

The extent of exposure to COVID-19-related stressors was significantly greater in the LC group as compared to the control group (Table 2). The LC group experienced more quarantines, for a significantly longer time, and reported more instances of family members infected with COVID-19 or hospitalized due to COVID-19. Since age and COVID-19 exposure were significantly different between the groups, we controlled for these variables in later statistical analyses.

Functional difficulties and mental health

Children's functional impairments due to COVID-19 were compared between the groups, controlling for age and COVID-19 exposure (Table 3). Parents of the LC group reported that their children presented significantly greater prevalence of memory problems compared to the control group. No significant group differences were found in concentration problems, peer relationships, or engagement in physical activity (although the difference in physical activity trended toward significance, such that the LC group reported greater impairment in this domain).

When controlling for children's age and exposure to COVID-19 stressors, parents of the control group were significantly more worried regarding their children's overall functioning (social, academic, and mental) than parents of the LC group. No group difference was found in parents' distress related to COVID-19 pandemic (Table 3).

Children's mental health was assessed by the PSC and the CATS. Children's internalizing, externalizing, and ADHD symptoms (reported on the PSC), and PTSD symptoms related to the COVID-19 pandemic (reported on the CATS) were compared between the groups, controlling for children's age and COVID-19 exposure (Table 4). No significant group differences were found in the PSC general and subscales scores, overall level of PTSD symptoms, or any of the CATS's subscales.

Table 2 Differences between the LC and control groups in exposure to COVID-19-related stressors

	LC ($n=103$)	Control ($n=113$)	Chi^2	Sig. (p)	
Was the child quarantined?	Yes 100%	Yes 42.5%	84.75**	0.000	
Family member sick with COVID-19	Yes 78.6%	Yes 8.8%	107.65**	0.000	
Family member hospitalized due to COVID-19	Yes 6.8%	Yes 0.8%	5.28*	0.029	
Family member deceased from COVID-19	Yes 1.9%	Yes 0%	2.22	0.226	
			T	Sig. (p)	Effect size (Cohen's d)
Length of isolation (M, SD)	14.02 (12.15)	4.53 (7.07)	−6.85**	0.002	−0.97
COVID-19 exposure – total score (M, SD)	2.48 (1.28)	0.65 (0.91)	−12.19**	0.000	−1.67

*$p<0.05$; **$p<0.001$

Table 3 Differences between the LC and control groups in children's functional impairment, controlling for children's age and COVID-19 exposure

	LC ($n=103$)	Control ($n=113$)	F	Sig. (p)	Partial eta^2
Connection with friends (M, SD)	0.39 (0.63)	0.36 (0.66)	1.1	0.746	0.000
Physical activity (M, SD)	1.09 (0.74)	0.81 (0.77)	3.46	0.064	0.016
Memory problems (M, SD)	2.54 (1.37)	1.73 (1.09)	5.29*	0.023	0.032
Concentration problems (M, SD)	2.76 (1.48)	2.25 (1.47)	2.22	0.138	0.014
Parental worries regarding their child (M, SD)	2.08 (1.01)	2.63 (1.06)	17.18***	0.000	0.075
Parental distress	2.37 (0.89)	2.33 (0.89)	0.03	0.862	0.000

Bonferroni corrections were employed

*$p<0.05$; **$p<0.01$; ***$p<0.001$

Prevalence of psychological impairment assessed by the PSC and CATS

We used the cutoff scores of the PSC and the CATS to calculate the prevalence of psychological impairment in each group. Two logistic regression tests were performed to predict PSC's clinical cases and probable PTSD. The predictors were children's group (LC/control), age, and COVID-19 exposure (Table 4). Children's group (LC/control) did not predict the prevalence of PSC's clinical cases or probable clinical PTSD cases, suggesting that having LC does not change the probability of having mental health problems at a clinical level.

Predicting children's mental health using the PSC and CATS

Correlations between the different individual, familial, and environmental factors to children's emotional problems are presented in Table 5. Both the PSC and CATS scores correlated with children's connection with friends, economic difficulties, and parents' worries regarding their child.

Next, in order to examine the unique contribution of these variables and assess the contribution of LC to children's mental health above and beyond these variables, two multiple regression tests were conducted, with PSC total scores and CATS general scores as the dependent variables in each test. In the first step of each test, children's age and LC were entered into the model as predicting variables. In the second step, connections with friends, economic difficulties, and parental worries regarding their child were added as predictors (Table 6).

The first full model was significant (F (5, 182) = 33.69, $p<0.000$) and accounted for 48% of variance in PSC. At the first step, children's age and LC did not significantly predict the levels of PSC. Only parental worries and economic difficulties significantly predicted the levels of PSC, such that greater economic difficulties and parental worries predicted

Table 4 Differences between LC and controls in PSC and CATS, controlling for age and COVID-19 exposure

PSC	**LC ($n=87$) M (SD)**	**Control ($n=101$) M (SD)**	***F***	**Sig. (p)**	**Partial eta^2**
General PSC score	17.09 (11.56)	19.26 (13.01)	2.07	0.152	0.011
PSC internalizing	2.51 (2.54)	2.79 (2.75)	2.20	0.140	0.012
PSC externalizing	1.89 (2.48)	3.27 (3.22)	2.25	13.6	0.012
PSC ADHD	3.05 (2.47)	3.59 (2.76)	2.28	13.3	0.013
Clinical cases, n(%) [a]	18 (20.6%)	26 (25.7%)	$X^2=2.33$	0.506	
CATS	**LC ($n=52$)**	**Control ($n=92$)**	***F***	**Sig. (p)**	**Partial eta^2**
CATS general score (M, SD)	8.65 (9.62)	11.11 (10.93)	0.94	33.2	0.007
CATS arousal	1.21 (1.85)	1.27 (1.68)	0.01	0.943	0.000
CATS re-experiencing	0.31 (0.74)	0.42 (1.00)	0.05	0.822	0.000
CATS avoidance	0.09 (0.43)	0.17 (0.52)	0.01	0.921	0.000
CATS negative cognitions	0.65 (1.14)	1.29 (1.81)	3.51	0.063	0.027
CATS functional impairment	1.75 (1.85)	2.08 (1.81)	0.70	0.404	0.006
Clinical cases, n (%) [b]	6 (10.1%)	22 (23.9%)	$X^2=5.12$	0.163	

PSC Pediatric Symptom Checklist, *CATS* Child and adolescent trauma screen. Bonferroni corrections were employed

[a]Clinical cases were defined according to the PSC age-appropriate cutoff points

[b]clinical cases were defined according to the CATS age-appropriated cutoff points of probable PTSD

Table 5 Correlations between background variables and children's mental health for the whole sample

	PSC ($n=188$)		CATS ($n=144$)	
	r	Sig. (p)	r	Sig. (p)
Child's age	0.027	0.713	0.003	0.976
Child's sex	−0.002	0.979	0.083	0.323
Exposure to COVID-19	−0.036	0.626	−0.110	0.188
Connection with friends	0.273***	0.000	0.289***	0.000
Physical activity	0.119	0.103	0.005	0.950
Economic difficulties	0.337***	0.000	0.386***	0.000
Parental worries	0.670***	0.000	0.617***	0.000

PSC Pediatric Symptom Checklist, *CATS* Child and Adolescent Trauma Screen

*$p<0.05$; **$p<0.01$; ***$p<0.001$

higher overall levels of children's internalizing, externalizing, and ADHD symptoms.

The second full model was significant (F (5, 138) = 21.29, $p<0.000$) and accounted for 42% of variance in CATS. At the first step of this model, children's age and LC did not significantly predict the levels of CATS. Only parental worries and economic difficulties significantly predicted the levels of CATS, such that greater economic difficulties and parental worries predicted higher levels of PTSD in children.

Discussion

Mental health of children with LC

The current study is one of the first attempts to examine the consequences of LC on children's mental health. The results of this study indicate that children with LC had greater exposure to COVID-19-related stressors. When controlling for variances in age and exposure to COVID-19-related stressors, children with LC also reportedly exhibited more memory difficulties. However, they did not differ in the other functional aspects we measured (connection with friends and engagement in sport activities), or in self-reported concentration difficulty. They also did not differ in their emotional-behavioral problems. LC did not predict the frequencies of psychological impairment, as measured by the PSC and CATS cutoffs. These findings are in accordance with Stephenson et al. (2021) [29] and suggest that LC itself does not impose more mental health problems on children. However, LC may be related to impairments in some aspects of academic functioning, specifically relating to memory problems.

Our study found that the LC group reported more memory problems. Memory problems have previously been reported in adults and children with LC. For example, Graham et al. (2021) [30] found that adults with LC performed worse in

Table 6 Multiple regression predicting children's mental health for the whole sample

PSC ($n=188$)							
Variables	Beta	B	SE	R^2	F change	R^2 change	Sig. F change
Step 1				0.01	1.19	0.01	0.307
Child's age	0.08	0.26	0.26				
LC	−0.12		1.99				
		−2.99					
Step 2				0.48	54.67***	0.47	0
Child's age	0.07	0.21	0.19				
LC	0.04	0.86	1.54				
Connection with friends	0.02	0.33	1.14				
Parental worries	0.63**	7.23	0.73				
Economic difficulties	0.15*	1.6	0.62				
CATS ($n=144$)							
Step 1				0.02	1.23	0.02	0.294
Child's age	0.08	0.22	0.28				
LC	−0.15	−3.29	2.09				
Step 2				0.42	34.08	0.42	0
Child's age	0.13	0.38	0.22				
LC	−0.07	−1.58	1.75				
Connection with friends	−0.00	−0.04	1.15				
Parental worries	.53***	5.37	0.79				
Economic difficulties	.24**	2.2	0.67				

PSC Pediatric Symptom Checklist, *CATS* Child and Adolescent Trauma Screen

*$p<0.05$; **$p<0.01$; ***$p<0.001$

attention and working memory cognitive tasks as compared to a demographic-matched US population. Also, Blomberg et al. (2021) [31] found memory problems in 18% of a sample of adults and children with LC.

Surprisingly, parents of the control group reported higher levels of concerns regarding their children's academic, social, and mental functioning than parents of children with LC. This unexpected finding may be explained in several ways. First, parents of children with LC may be less worried by their child's functioning difficulties because they are more focused on their physical condition [32, 33], attributing these functional difficulties to the medical condition [34] or have limited psychological resources to be preoccupied with it. Another possibility is that the psychosocial functioning of uninfected children is indeed more impaired, due to sustained fear of being infected [35, 36]. Lastly, it is possible that being under medical supervision at the LC clinic decreased parents' concerns, as it provided hope and affirmation [37]. However, it should be noted that parents completed the questionnaires during their first visit at the clinic, prior to establishing a therapeutic alliance with the medical staff.

The contribution of environmental, familial, and individual factors to children's mental health during the COVID-19 pandemic

One of this study's goals was to identify pandemic-related stressors, other than the illness itself, which may be related to the children's distress. We found that higher levels of parental concerns and economic difficulties significantly predicted higher levels of child's internalizing, externalizing, ADHD difficulties and post-traumatic symptoms, above and beyond the child's age, having LC, and their connection with friends. This supports previous findings that lower socioeconomic status is a risk factor for greater psychological distress among children during the pandemic [9, 15–17, 19]. It also aligns with previous studies that found parental stress and emotional dysregulation, during the pandemic, was associated with more behavioral and emotional difficulties among their children [20, 22]. Taken together, our results highlight the importance of parents' mental burdens on their children's mental health. This relationship should be considered as bidirectional, such that the child's and the parents' mental state may reciprocally influence one another [38].

The current study has some important strengths and limitations. The LC group was thoroughly examined both physically and psychologically, using validated and comprehensive tools, within a specialized LC clinic. In contrast, the illness status of the control group was based only on self-reports, and they were recruited differently from the LC group as not receiving medical care. Secondly, our study did not include a group of children who were infected with COVID-19 but did not develop LC. In addition, since our LC group included only children referred to a specialized LC clinic, this group may represent children with a more complicated presentation of LC. Future studies should use varied multiple-informant assessment, including clinical interviews, children and parents' reports, and objective tests.

Conclusions

Despite limitations, the current study provides a preliminary mapping of the effects of LC on children's mental health. The findings of this study indicate that some aspects of children's cognitive-academic functioning, and specifically memory problems, may be impacted by LC. A more thorough investigation of these functions is necessary. The results of this study also underscore the important contribution of parents' economic stress, and parents' worries of their children's emotional adjustment during stressful times. Medical and psychosocial practitioners who treat children with LC may find it useful to consider the parents' emotional state, inquire about the parents' challenges, and if needed, to refer parents to psychosocial help.

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Authors' contributions ISL has full access to the study's data and takes responsibility for the integrity and accuracy of the data analysis. MS, ISL, HS, SF, and LAH contributed to the study design, data collection, statistical analyses, and manuscript writing and editing. SF contributed to the manuscript editing.

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Data availability The data that support the findings of this study are available from the corresponding author, [ISL], upon request.

Declarations

Ethics approval This study was performed in line with the principles of the Declaration of Helsinki. Approval was granted by the Ethics Committee of Schneider Medical Center (December 2020, No. 0885–20).

Consent to participate Informed consent was obtained from all individual participants included in the study. Written informed consent was obtained from the parents.

Competing interests The authors declare no competing interests.

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