

life. Parental mental wellbeing was assessed with the 21-item self-report Depression and Anxiety Stress Scales (DASS—21) [16]. Answer categories range from 0, ‘did not apply to me at all’, to 3, ‘applied to me very much’/‘most of the time’, leading to a minimum subscale score of 0 and a maximum subscale score of 21 for each of the 7-item domain scores. The domain scores for depression and anxiety were taken into account when determining the parent’s mental health status in the currently described project. The recommended cut-off scores of 10 or higher on the depression domain and 8 or higher on the anxiety domain were used to indicate if a parent experienced depressive and/or anxiety symptoms (PMH).

The four previously discovered parental concern patterns (resilient, recovering medium concern, recovering high concern, continuous high concern) [11] were considered potential fixed effects influencing CYP emotional wellbeing and HRQOL. Further factors considered to impact CYP psychosocial wellbeing were CYP’s clinical (diagnosis) and demographic (age, gender) characteristics, which were assessed at baseline (March-July 2020). Parental demographic and household information (gender, age, geographical location, rural/urban, green space, household income, household composition, number of siblings, and employment), collected in September 2021, were also taken into account.

Quantitative analysis

The data has been cleaned, processed, and analysed in SAS9.4 [17]. First the descriptive characteristics of the sample were determined. Then we used repeated-measure analysis of variance to assess unadjusted differences in emotional wellbeing and HRQOL measured in November/December 2021, January/February 2022, and March/April 2022. Next, we visualized unadjusted differences in emotional wellbeing and HRQOL over time for those CYP with and without parents experiencing PMH. Finally, a linear mixed model repeated measure (MMRM) approach was used to explore the predictors of the CYPs HRQOL and emotional wellbeing [18]. Different models were calculated for the separate subscales (positive mood, negative mood, physical wellbeing, psychological wellbeing, parent relations and autonomy, social support and peers, and school functioning). PMH was entered as fixed effect, this independent variable changed over time, as parental mental wellbeing was measured at the same intervals as CYP’s emotional wellbeing and HRQOL.

Time, CYP’s age (0-10 vs 11-18), CYPs gender (male/female), CYPs diagnosis (rheumatological diagnosis vs other), receipt of COVID vaccine by September 2021 (yes/no), report of SARS-CoV-2 infection by September 2021 (none vs 1 or more infections), parental gender (male/female), parental age (27 – 40, 41 – 50, 51 – 62), geographical location (South -, Middle -, North of England, Wales/Scotland/

Ireland), urbanization (rural, semi-rural, urban), access to green space (difficult, easy), household income (<£29500, ~£29500, > £29500), household composition (single parent vs 2 parents), number of siblings (0, 1, 2+) parental employment (full/parttime vs non-working/disabled/retired), and parental concern level were entered into the model as fixed effects. The significance of these independent variables was first tested in univariable models. Only significant variables were entered into multivariable models, with the aim of building similar multivariable models for each of the outcomes. Parental concern, CYP’s diagnosis, report of SARS-CoV-2 infection by September 2021, geographical location, urbanization, and household composition were not significant in predicting CYP’s emotional wellbeing or HRQOL in the univariable models and thus these fixed effects were not entered in the multivariable models.

Multiple measurements taken on the same CYP are correlated with each other. Depending how far apart the measurements are taken this correlation often differs. To acknowledge this dependence between repeated measures, the MMRM model offers different covariance matrix structures to model different dependence structures. A heterogeneous Toeplitz covariance matrix was chosen for the MMRM models in this study as this matrix structure had the best fit (AIC=4263 and BIC=4283). This covariance structure has heterogeneous variances and heterogeneous correlations between the elements, meaning that the correlation between measurements taken in Nov/Dec 2021 with measurements in Jan/Feb 2022 differ from the correlations between measurements in Jan/Feb 2022 and Mar/Apr 2022 and again differ from the correlations between measurements in Nov/Dec 2021 and Mar/Apr 2022. The heterogeneous Toeplitz covariance matrix represented the simplest model with lowest AIC/BIC combination [18] when compared to compound symmetry (4274/4282), unstructured (4262/4287), autoregressive (4281/4289), heterogenous autoregressive (4270/4287), and Toeplitz structures (4273/4285). The Kenward-Roger correction was applied to reduce bias in estimation of standard errors and F-Statistics [18]. The results are presented as parameter estimates with standard errors and P-values.

Results

Participants

Of the 467 CYP who consented/assented to the mental wellbeing part of the ImmunoCOVID-19 study, most had a rheumatological diagnosis (43%) many had not been vaccinated by September 2021 (77.7%) nor experienced a SARS-CoV-2 infection (89.1%) at the start of the 2021 school year. There was an almost equal split between boys and girls as well as children aged 10 and under versus aged 11 to 18. Additional household and parental characteristics are described in Table 1.

Table 1: Descriptive statistics of the CYP sample (N=467)

Child characteristics	N (%)
<i>Gender (female)</i>	237 (50.7%)
<i>Age</i>	
0 - 10	159 (34.1%)
Nov-18	249 (53.3%)
Age unknown	59 (12.6%)
<i>Diagnosis</i>	
Rheumatological diagnoses	201 (43%)
Other diagnoses*	185 (40%)
Diagnoses unknown	81 (17%)
<i>Vaccinated by 9/2021 (yes)</i>	104 (22.3%)
<i>Reported SARS -CoV-2 infection by 9/2021</i>	51 (10.9%)
Household characteristics	N (%)
<i>Access to green space</i>	
Easy	420 (89.9%)
Difficult	25 (5.4%)
Unknown	22 (4.7%)
<i>Urbanization</i>	
Rural	56 (12%)
Semi-rural	149 (31.9%)
Urban	235 (50.3%)
Unknown	27 (5.8%)
<i>Region</i>	
England – South	208 (44.5%)
England – Midlands	75 (16.1%)
England – North	96 (20.6%)
Ireland – Scotland – Wales	70 (15.0%)
Unknown	18 (3.9%)
<i>Household income</i>	
Below £29500	80 (17.1%)
About £29500	74 (15.8%)
Above £29500	274 (58.7%)
Unknown	39 (8.4%)
<i>Household composition</i>	
Single parent	62 (13.3%)
2 parent-household	373 (79.9%)
Unknown	32 (6.9%)
<i>Number of siblings</i>	
0	90 (19.3%)
1	187 (40%)
2+	86 (18.4%)
Unknown	104 (22.3%)
Parent Characteristics	N (%)
<i>Parental Concern Trajectory</i>	
Resilient	104 (22.3%)

Recovery medium concern	174 (37.3%)
Recovery high concern	137 (29.3%)
Continuous high concern	52 (11.1%)
<i>Parents with mental health problems</i>	
Nov/Dec 2021	37 (7.9%)
Jan/Feb 2022	25 (10.1%)
March/April 2022	23 (4.9%)
<i>Gender parent (female)</i>	395 (84.6%)
<i>Age</i>	
27 – 40 yrs	96 (20.6%)
41 – 50 yrs	204 (43.7%)
51 – 62 yrs	63 (13.5%)
Unknown age	104 (22.3%)

*other diagnosis: airway diseases, immunodeficiency disorder, diabetes, solid organ or bone marrow transplant, nephrotic syndrome, other kidney disease, inflammatory bowel disease, other gastroenterology and hypathology, oncological diagnosis, neurological diagnosis

252 (54%) of the CYP completed the mental wellbeing survey in November/December 2021, 229 (49%) CYP completed the survey in January/February 2022, and 196 (42%) CYP completed the survey in March/April 2022. Table 2 shows the average emotional wellbeing and standardized HRQOL experienced by the CYP at these three timepoints. According to the repeated-measure analysis of variance (F/P-value column table 2) CYP's emotional wellbeing and HRQOL were quite stable over time. Psychological wellbeing was the lowest HRQOL reported, CYP experienced statistically significant lower levels of psychological wellbeing in January/February 2022.

CYP's mental wellbeing in relation to parental mental wellbeing

Figure 1 visualizes the association between CYP's HRQOL as well as emotional wellbeing and parental mental wellbeing. In general, CYP whose parents experienced mental health problems reported lower HRQOL, higher negative mood, and lower positive mood. Differences were especially pronounced in November/December 2021 and March/April 2022.

Table 3 quantifies the association between child, parent, and household characteristics with changes in CYP's emotional wellbeing and HRQOL. When all significant variables were added into the MMRM models, parental experience of anxiety and/or depressive symptoms (PMH) was associated with higher levels of negative mood, lower levels of positive mood, physical wellbeing, social support & peer interaction, and worse school functioning. Keeping in mind that the data collected in March/April 2022 was the reference category for the MMRM models, time (wave)

Table 2: Change in CYP’s mental wellbeing over time

Mental wellbeing	Measurement points			Outcome repeated-measure analysis of variance
	Nov/Dec 2021 N=252	Jan/Feb 2022 N=229	March/Apr 2022 N=196	
	Mean (SD)	Mean (SD)	Mean (SD)	F (P-value)
<i>Mood</i>				
Positive	31.99 (8.63)	32.38 (8.90)	32.99 (8.91)	0.72 (0.49)
Negative	18.7 (7.67)	18.17 (7.12)	17.14 (6.12)	2.72 (0.07)
<i>HRQOL</i>				
Physical wellbeing	43.50 (12.30)	43.13 (7.93)	45.38 (12.21)	2.34 (0.10)
Psychological wellbeing	42.44 (5.29)	34.87 (3.40)	43.25 (5.25)	206.10 (<0.001)
Parent relations & autonomy	50.39 (8.86)	50.38 (8.69)	51.34 (10.32)	0.70 (0.50)
Social support & peers	43.85 (11.59)	44.34 (11.57)	45.16 (11.73)	0.66 (0.52)
School functioning	48.64 (10.79)	48.15 (10.12)	50.09 (10.49)	1.83 (0.16)

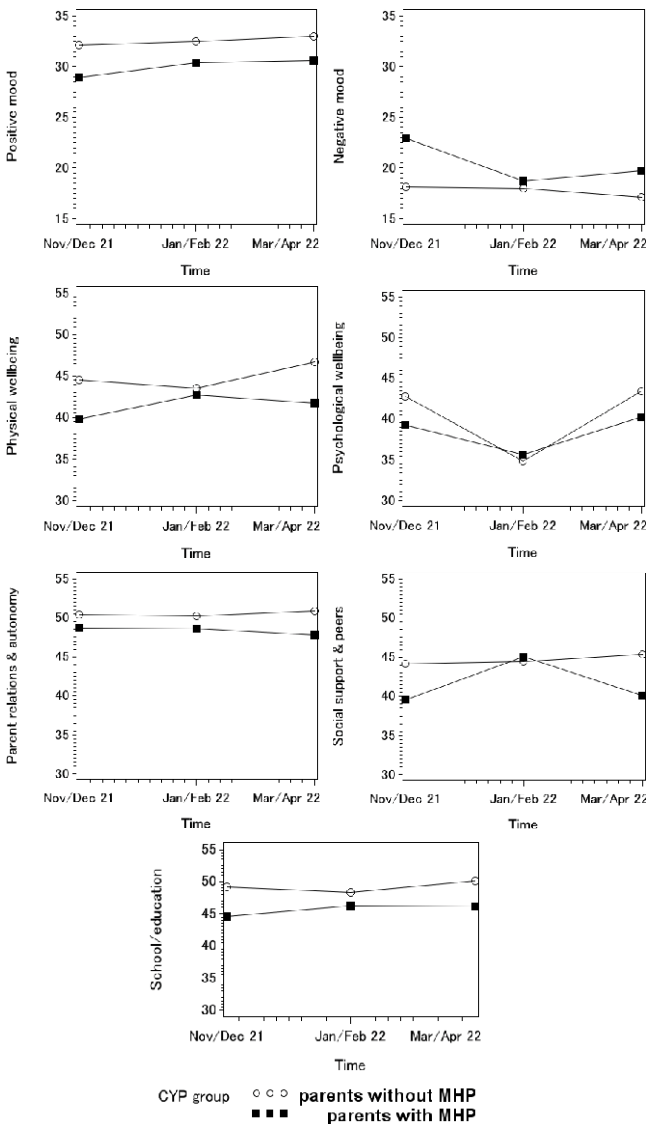


Figure 1: Impact of parental mental health problems on CYPs’ emotional wellbeing and HRQOL

was significantly associated with a reduction in physical and psychological wellbeing, school functioning and an increase in negative mood. Furthermore, age 10 and under and not having received the vaccination by September 2021 was significantly positively associated with positive mood, physical and psychological wellbeing. Age 10 and under was also associated with higher levels of school functioning. In contrast, lower levels of household income were associated with lower positive mood, higher negative mood, lower levels of physical wellbeing, lower levels of social support and peer interaction, and lower levels of school functioning. Parent relations and autonomy was only significantly positively related to the number of children in the household, with participants with less siblings reporting better child-parent relationships.

Discussion

Our findings indicate that from November/December 2021 to January/February 2022 the average physical wellbeing, psychological wellbeing, and social support & peer interaction levels reported by CYP included in the ImmunoCOVID-19 study was lower than the reported European pre-COVID norm [19]. Even in comparison to pre-COVID average scores reported by adolescent renal transplant patients, the reported ImmunoCOVID-19 study scores on the KIDSCREEN subscales suggest a noticeable reduction in HRQOL [20]. This is in line with findings reported by the CLoCk study who reported that around 40% of the British adolescents included in their study felt worried, sad or unhappy in 2021 irrespective of their SARS-CoV-2 status [21]. On the positive side, our results show that as the CYP included in the ImmunoCOVID-19 study moved closer to the ‘living with COVID’ phase in UK’s COVID-19 pandemic they experienced a significantly increase in physical wellbeing, psychological wellbeing, and school functioning as well as a significant reduction in negative mood. These

Table 3: Association between child, parent, and household characteristics with CYP’s emotional wellbeing and HRQOL

	Positive Mood			Negative Mood		
	estimate	S.E.	P-value	estimate	S.E.	P-value
Wave						
Nov/Dec 2021	-0.85	0.59	0.149	1.32	0.39	0.001
Jan/Feb 2022	-0.06	0.54	0.907	0.81	0.37	0.03
Mar/Apr 2022	Reference			reference		
Gender CYP						
Female	0.95	0.94	0.312	0.72	0.84	0.392
Male	reference			reference		
Age Child						
0-9	5.37	1.14	<0.0001	0.23	1.02	0.823
10+	reference			reference		
Vaccinated by 9/2021						
No	2.61	1.24	0.037	-1.2	1.11	0.28
Yes	Reference			reference		
Access to green space						
Easy	0.29	2.05	0.888	-3.45	1.82	0.06
Difficult	reference			reference		
Parental gender						
Female	-1.45	2.01	0.473	0.56	1.82	0.76
Male	reference			reference		
Age parent						
27 – 40 yrs	0.48	1.72	0.781	-0.74	1.54	0.631
41 – 50 yrs	0.62	1.44	0.669	-0.28	1.28	0.825
51 – 62 yrs	reference			reference		
Parental Employment						
No work/retired/disabled	-1.75	1.13	0.123	-0.48	1.01	0.635
Full/parttime employed	reference			reference		
Parental mental health						
No problems	2.7	1.04	0.01	-2.54	0.79	0.001
Mental health problems	reference			reference		
Number of siblings						
0	0.19	1.41	0.893	0.19	1.26	0.881
1	1.39	1.18	0.242	-0.71	1.06	0.505
2+	reference			reference		
Household income						
Below £29500	-3.58	1.23	0.004	2.98	1.1	0.007
About £29500	-2.75	1.27	0.032	-0.21	1.13	0.85
Above £29500	reference			reference		
	Physical Wellbeing			Psychological wellbeing		
	estimate	S.E.	P-value	estimate	S.E.	P-value
Wave						
Nov/Dec 2021	-1.83	0.86	0.035	-0.98	0.39	0.014
Jan/Feb 2022	-2.9	0.79	0.0003	-8.6	0.4	<0.0001

Citation: Corine Driessens, Lynne Mills, Ravin Patel, David Culliford, Diane Gbesemete, Emma Lee, Meera Shaunak, Harry Chappell, Saul N. Faust, Hans de Graaf, On behalf of the Immuno COVID19 study group (Appendix A). Immunosuppressed Children and Young People, Psychosocial Wellbeing, and the COVID-19 Pandemic: a Prospective Cohort Study. Archives of Microbiology and Immunology. 7 (2023): 350-361.

Mar/Apr 2022	reference			reference		
Gender CYP						
Female	-1.19	1.07	0.27	-0.07	0.48	0.877
Male	reference			reference		
Age Child						
0-9	4	1.31	0.003	1.29	0.59	0.03
10+	reference			reference		
Vaccinated by 9/2021						
No	3.28	1.42	0.022	1.39	0.63	0.029
Yes	reference			reference		
Access to green space						
Easy	3.52	2.5	0.161	1.8	1.1	0.102
Difficult	reference			reference		
Parental gender						
Female	-3.14	2.53	0.215	-0.25	1.12	0.824
Male	Reference			reference		
Age parent						
27 – 40 yrs	0.2	1.97	0.918	-0.69	0.88	0.431
41 – 50 yrs	-0.99	1.63	0.547	-0.78	0.72	0.282
51 – 62 yrs	reference			reference		
Parental Employment						
No work/retired/disabled	-2.24	1.29	0.084	-0.11	0.57	0.842
Full/parttime employed	reference			reference		
Parental mental health						
No problems	2.72	1.36	0.047	1.04	0.66	0.117
Mental health problems	reference			reference		
Number of siblings						
0	0.14	1.61	0.929	1.26	0.72	0.083
1	0.92	1.36	0.502	0.47	0.61	0.447
2+	reference			reference		
Household income						
Below £29500	-3.94	1.43	0.006	-0.96	0.63	0.131
About £29500	-3.14	1.48	0.035	-0.42	0.66	0.527
Above £29500	reference			reference		
	Parent relations & autonomy			Social support & peer interaction		
	estimate	S.E.	P-value	estimate	S.E.	P-value
Wave						
Nov/Dec 2021	-0.81	0.65	0.215	-0.74	0.86	0.393
Jan/Feb 2022	-0.79	0.71	0.262	0.16	0.93	0.867
Mar/Apr 2022	reference			reference		
Gender CYP						
Female	-0.73	1.12	0.518	1.78	1.34	0.186
Male	reference			reference		
Age Child						
0-9	-0.13	1.37	0.925	1.17	1.65	0.481

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10+	reference			reference		
Vaccinated by 9/2021						
No	1.44	1.48	0.331	1.9	1.76	0.283
Yes	reference			reference		
Access to green space						
Easy	2.66	2.46	0.282	2.13	2.91	0.466
Difficult	reference			reference		
Parental gender						
Female	-2.24	2.55	0.38	0.63	3.08	0.839
Male	reference			reference		
Age parent						
27 – 40 yrs	-0.74	2.04	0.717	-0.59	2.44	0.809
41 – 50 yrs	-1.11	1.69	0.513	-2.53	2.01	0.21
51 – 62 yrs	reference			reference		
Parental Employment						
No work/retired/disabled	-0.28	1.34	0.836	-3.86	1.59	0.016
Full/parttime employed	Reference			reference		
Parental mental health						
No problems	2.21	1.27	0.082	3.76	1.66	0.024
Mental health problems	reference			reference		
Number of siblings						
0	4.53	1.66	0.007	0.84	1.99	0.675
1	3.23	1.42	0.024	1.47	1.7	0.388
2+	reference			reference		
Household income						
Below £29500	-1.92	1.46	0.189	-3.74	1.74	0.033
About £29500	-1.85	1.52	0.226	-2.68	1.83	0.143
Above £29500	reference			reference		
	School functioning					
	estimate	S.E.	P-value			
Wave						
Nov/Dec 2021	-1.74	0.76	0.024			
Jan/Feb 2022	-1.78	0.67	0.008			
Mar/Apr 2022	reference					
Gender CYP						
Female	0.91	1.22	0.457			
Male	reference					
Age Child						
0-9	4.62	1.5	0.002			
10+	reference					
Vaccinated by 9/2021						
No	2.37	1.6	0.14			
Yes	reference					
Access to green space						
Easy	0.25	2.71	0.925			
Difficult	reference					

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Parental gender						
<i>Female</i>	0.9	2.81	0.749			
<i>Male</i>	reference					
Age parent						
<i>27 – 40 yrs</i>	-0.55	2.22	0.806			
<i>41 – 50 yrs</i>	0.33	1.83	0.856			
<i>51 – 62 yrs</i>	reference					
Parental Employment						
<i>No work/retired/disabled</i>	-1.23	1.45	0.397			
<i>Full/parttime employed</i>	reference					
Parental mental health						
<i>No problems</i>	2.78	1.36	0.042			
<i>Mental health problems</i>	reference					
Number of siblings						
<i>0</i>	-1.25	1.82	0.494			
<i>1</i>	-0.74	1.55	0.633			
<i>2+</i>	Reference					
Household income						
<i>Below £29500</i>	-4.86	1.59	0.003			
<i>About £29500</i>	-2.55	1.65	0.123			
<i>Above £29500</i>	reference					

findings suggest that they are on their way to recovery. The psychosocial wellbeing of ImmunoCOVID-19's younger CYP was significantly better than the psychosocial wellbeing of the older CYP. European pre-pandemic findings align with these results showing that CYPs' HRQOL decreased with age, with older CYP self-reporting lower HRQOL than younger CYP [22]. Of concern was our finding that CYP from lower income households reported lower levels of HRQOL and positive mood and higher levels of negative mood. Throughout the COVID-19 pandemic it has been reported that lower income British households are most affected by the COVID-19 pandemic [23]. Early in the pandemic it was determined that CYP from lower income households disclosed higher levels of emotional mental health problems [24, 25]. These findings are however not new, even before the pandemic, research had indicated that lower household income was associated with low HRQOL, especially for older CYP [26]. Research conducted in the last 2 years however has indicated that these existing income inequalities have amplified [27]. Further research is needed to specify the association between low household income and CYP psychosocial wellbeing, especially since recent findings indicate that mediators such as self-efficacy, optimism and social support influence the association between socio-economic status, financial strain, and CYP mental wellbeing [28]. As previously discussed, pre-pandemic CYP mental wellbeing was shown to be significantly affected by parental mental wellbeing [12, 13].

Our findings show that these findings can be generalized to the CEV population, parental mental wellbeing did impact the change in psychosocial wellbeing of CYP living with an immunosuppressive disorder. Other COVID-19 studies confirm that the pre-pandemic association between parental mental wellbeing and their offspring's mental health holds true during the unprecedented time of the COVID-19 pandemic [25] and is not unique to the CEV population. We can only speculate about the relationship between vaccination status and CYPs' emotional wellbeing and HRQOL, theorizing that vaccination status might have been related to severity of long-term health condition, an aspect of CYP clinical condition the ImmunoCOVID-19 study did not explore. CYP with more severe conditions were placed on priority lists for vaccination while other children with long-term health conditions were vaccinated at the same time as their healthy-age-equivalent peers [29]. This speculation is supported by the presence of a significant medium level correlation between vaccination status and CYP age (spearman correlation = 0.50) in the ImmunoCOVID-19 data.

Strengths and limitations

The main strength of this study is that in contrast to most British COVID-19 cohort studies the ImmunoCOVID-19 study focused on a marginalized population, CYP living with an immunosuppressive disease. The psychosocial wellbeing of the CYP and their carers was assessed with well-validated

instruments. Attrition, a methodological problem for all longitudinal studies, deteriorates the generalizability of the findings as does our sampling methods, a form of convenience sampling used by the majority of COVID-19 studies to quickly deploy data collection. A MMRM approach was chosen to analyse the data as it reduces the bias introduced by sporadic non-response. However, it also needs to be mentioned that the underlying assumption of this methodology is that missing data is missing at random [17]. It is important to note that the ImmunoCOVID-19 study did not collect pre-pandemic data, hence comparisons were made with pre-COVID norm data. Regardless of the limitations, the collection of prospective longitudinal data from a marginalized population with diverse demographic backgrounds provided a unique opportunity to examine the prolonged psychosocial impact of the pandemic on CYP living with chronic health conditions.

Conclusion

Our findings revealed important insights into the psychosocial changes of CYP living with an immunosuppressive disease during the transition period from COVID-19 pandemic to COVID-19 epidemic. The findings confirm that parental mental health, household income, and age impacted CYP's psychosocial wellbeing throughout the COVID-19 pandemic. We recommend future studies to focus on enhancing our understanding of the complex relationship between household income and CYP psychosocial wellbeing. Health professionals caring for CYP living with an immunosuppressive disorder should be aware of the greater risk for decreased emotional wellbeing and HRQOL for immunosuppressed CYP. This is particularly relevant in the case of adolescents, CYP living in low-income households and/or living with parents experiencing emotional mental health problems. Health professions caring for immunosuppressed CYP should be aware of appropriate psychosocial interventions and guidance and implement when needed.

Declarations

Ethics approval

The Leeds NHS Research Ethics Committee provided ethical approval to this study (IRAS 281544). All procedures contributing to this work comply with the latest version of the Helsinki Declaration. Informed consent was obtained from all the participants and their legal guardians to participate in the study.

Consent to participate

Informed consent/assent was obtained from CYP and their carers included in the ImmunoCOVID-19 study. Informed consent was obtained from all the participants and their legal guardians to participate in the study.

Consent for publication

Not applicable.

Competing interest

The authors have no competing interests to declare that are relevant to the content of this article.

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Author contribution

SNF, HdG and RP conceived and designed the original ImmunoCOVID-19 study, and secured partial funding. ImmunoCOVID study group have recruited the participants and provided clinical guidance to the original ImmunoCOVID-19 study. RP, HC, MS, DG have been responsible for the weekly data collection, project administration, and data quality checks of the original ImmunoCOVID-19 study. CD and LM conceptualized and designed the mental wellbeing extension study. EL provided clinical psychological expertise. RP has been responsible for the mental wellbeing data collection. LM has been responsible for weekly survey and mental wellbeing data management. CD and DC conceptualized methodology to be used in data analysis and CD led on data analysis. CD has had full access to all the data in this study and takes responsibility for the integrity of the data and accuracy of the analysis. CD drafted this manuscript which was reviewed and edited by all co-authors.

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Data availability

Due to the quick deployment of the ImmunoCOVID-19 study we have not actively asked for participants' permission to safely deposit their data for re-share and re-use, thus while

quantitative analysis code can be shared (available upon request from corresponding author) the data for this project cannot be deposited.

References

- Sinaei R, Pezeshki S, Parvaresh S, Sinaei R. Why COVID-19 is less frequent and severe in children: a narrative review. *World Journal of Pediatrics* 17 (2021): 10-20.
- Memoli MJ, Athota R, Reed S, Czajkowski L, Bristol T, Proudfoot K, et al. The natural history of influenza infection in the severely immunocompromised vs nonimmunocompromised hosts. *Clinical infectious diseases* 58 (2014): 214-24.
- Lasseter G, Compston P, Robin C, Lambert H, Hickman M, Denford S, et al. Exploring the impact of shielding advice on the wellbeing of individuals identified as clinically extremely vulnerable amid the COVID-19 pandemic: a mixed-methods evaluation. *BMC Public Health* 22 (2022): 1-1.
- Fisher A, Roberts A, McKinlay AR, Fancourt D, Burton A. The impact of the COVID-19 pandemic on mental health and well-being of people living with a long-term physical health condition: a qualitative study. *BMC Public Health* 21 (2021): 1-2.
- Raw JA, Waite P, Pearcey S, Shum A, Patalay P, Creswell C. Examining changes in parent-reported child and adolescent mental health throughout the UK's first COVID-19 national lockdown. *Journal of Child Psychology and Psychiatry* 62 (2021): 1391-401.
- McKinlay AR, May T, Dawes J, Fancourt D, Burton A. 'You're just there, alone in your room with your thoughts': a qualitative study about the psychosocial impact of the COVID-19 pandemic among young people living in the UK. *BMJ open* 12 (2022): e053676.
- Samji H, Wu J, Ladak A, Vossen C, Stewart E, Dove N, et al. Mental health impacts of the COVID-19 pandemic on children and youth—a systematic review. *Child and adolescent mental health* 27 (2022): 173-89.
- Shaunak M, Patel R, Driessens C, Mills L, Leahy A, Gbesemete D, et al. COVID-19 symptom surveillance in immunocompromised children and young people in the UK: a prospective observational cohort study. *BMJ open* 11 (2021): e044899.
- Chappell H, Patel R, Driessens C, Tarr AW, Irving WL, Tighe PJ, et al. Immunocompromised children and young people are at no increased risk of severe COVID-19. *Journal of Infection* 84 (2022): 31-9.
- Driessens C, Mills L, Culliford D, Patel R, Lee E, Gbesemete D, et al, ImmunoCOVID19 study group (Appendix A). Parental concern for clinically vulnerable child during first 18 months of the COVID pandemic. *Pediatric Research* 22 (2022): 1-9.
- Driessens C, Mills L, Patel R, Culliford D, Lee E, Gbesemete D, et al. Psychological distress experienced by parents caring for an immunosuppressed child during the COVID-19 pandemic. *Journal of Psychiatric Research* (2022).
- Lawrence PJ, Murayama K, Creswell C. Systematic review and meta-analysis: anxiety and depressive disorders in offspring of parents with anxiety disorders. *Journal of the American Academy of Child & Adolescent Psychiatry* 58 (2019): 46-60.
- Warner V, Mufson L, Weissman MM. Offspring at high and low risk for depression and anxiety: Mechanisms of psychiatric disorder. *Journal of the American Academy of Child & Adolescent Psychiatry* 34 (1995): 786-97.
- Watson D, Clark LA, Tellegen A. Development and validation of brief measures of positive and negative affect: the PANAS scales. *Journal of personality and social psychology* 54 (1988): 1063.
- Ravens-Sieberer U, Herdman M, Devine J, Otto C, Bullinger M, Rose M, et al. The European KIDSCREEN approach to measure quality of life and well-being in children: development, current application, and future advances. *Quality of life research* 23 (2014): 791-803.
- Lovibond PF, Lovibond SH. The structure of negative emotional states: Comparison of the Depression Anxiety Stress Scales (DASS) with the Beck Depression and Anxiety Inventories. *Behaviour research and therapy* 33 (1995): 335-43.
- SAS software. Copyright © (2022). SAS Institute Inc., Cary, NC, USA
- Stroup WW, Milliken GA, Claassen EA, Wolfinger RD. SAS for mixed models: introduction and basic applications. SAS Institute 12 (2018).
- KIDSCREEN Group Europe. The KIDSCREEN Questionnaires-Quality of life questionnaires for children and adolescents. Handbook (2006).
- Dobbels F, Decorte A, Roskams A, Van Damme-Lombaerts R. Health-related quality of life, treatment adherence, symptom experience and depression in adolescent renal transplant patients. *Pediatric transplantation* 14 (2010): 216-23.
- Stephenson T, Pereira SM, Shafran R, De Stavola BL, Rojas N, McOwat K, et al. Physical and mental health

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- 3 months after SARS-CoV-2 infection (long COVID) among adolescents in England (CLOcK): a national matched cohort study. *The Lancet Child & Adolescent Health* 6 (2022): 230-9.
22. Berman AH, Liu B, Ullman S, Jadbäck I, Engström K. Children's quality of life based on the KIDSCREEN-27: child self-report, parent ratings and child-parent agreement in a Swedish random population sample. *PLoS one* 11 (2016): e0150545.
 23. Whitehead M, Taylor-Robinson D, Barr B. Poverty, health, and covid-19. *bmj* 12 (2021): 372.
 24. Waite P, Pearcey S, Shum A, Raw JA, Patalay P, Creswell C. How did the mental health symptoms of children and adolescents change over early lockdown during the COVID-19 pandemic in the UK? *JCPP advances* 1 (2021): e12009.
 25. Adegboye D, Williams F, Collishaw S, Shelton K, Langley K, Hobson C, et al. Understanding why the COVID-19 pandemic-related lockdown increases mental health difficulties in vulnerable young children. *JCPP advances* 1 (2021): e12005.
 26. Von Rueden U, Gosch A, Rajmil L, Bisegger C, Ravens-Sieberer U. Socioeconomic determinants of health related quality of life in childhood and adolescence: results from a European study. *Journal of Epidemiology & Community Health* 60 (2006): 130-5.
 27. Gagné T, Nandi A, Schoon I. Time trend analysis of social inequalities in psychological distress among young adults before and during the pandemic: evidence from the UK Household Longitudinal Study COVID-19 waves. *J Epidemiol Community Health* 76 (2022): 421-7.
 28. Schoon I, Henseke G. Social inequalities in young people's mental distress during the COVID-19 pandemic: Do psychosocial resource factors matter?. *Frontiers in public health* 14 (2022): 10.
 29. Majeed A, Pollock K, Hodes S, Papaluca M. Implementation of covid-19 vaccination in the United Kingdom. *bmj* 29 (2022): 378.