Mental Well-Being During Covid-19 in Adults, Mothers, and Children: Behavioral Evidence and Neural Pre-Markers

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Abstract

Covid-19 and associated restrictions greatly impact our physical and mental well-being, with particular challenges for children and families. We describe data from adults and children (N = 69, 41♀, age range = 7-51y, including 26 children and mothers), including pre-pandemic brain function and ~ 2'500 tests acquired during the early pandemic. We investigated (**1**) variability in child and adult well-being, (**2**) mother-child associations of mental well-being during the first months of the pandemic, and (**3**) the association between pre-pandemic neural brain correlates during mentalizing and later fears or subjective burden. Significant variation in mental health was observed in both, adults (e.g., anxiety, depression, or caregiver burden) and children (mood and emotional and behavioral problems). Mothers' subjective burden of care was associated with children's emotional and behavioral problems, while depression levels in mothers impacted children's mood. Furthermore, friends met was a significant predictor of children's mood during restrictions. Pre-pandemic neural correlates of mentalizing in prefrontal regions preceded later development of fear of illnesses and viruses in all participants, while temporoparietal activation preceded higher subjective burden in mothers. This study demonstrates a significant effect on, and variations in, mental well-being in adults and children during the early phase of Covid-19, emphasizes dyadic effects and possible neural precursors.

Introduction

The global onset of the coronavirus disease 2019 (Covid-19) pandemic has been recognized as a significant threat to our physical and mental well-being. Worldwide efforts have been implemented including protective health measures to slow down or prevent the direct physical viral effects. In Switzerland these restrictions included school closure, work-from-home orders, and travel restrictions. Past and accumulating evidence indicates that restrictions (e.g., school closure, lockdown, social distancing) may have a significant effect on individuals' psychosocial functioning, possibly through increases in emotional distress[1,2]. Evidence indicates that mental health consequences include an increase in neuropsychiatric symptoms of affect and behavior[3,4]. Such increases in negative effects (e.g., stress, anxiety, depression, or somatic complaints) associated with Covid-19 and restrictions are reported globally[1,2,5,6]. The duration of lockdown and restrictions have been linked to increased distress[5]. Negative effects tend to be higher in younger individuals, those with chronic disease or pre-existing health conditions, females and those living alone or in socioeconomic adversity[1,2,7].

Children's, parents', and families' lives may be particularly impacted by Covid-19-related restrictions[8]. A sudden decrease in social contacts is opposite to the human social nature and our existing routines[9,10]. For children and adolescents, positive peer-relationships, the ability to pursue hobbies and educational opportunities are affected[11]. For parents, an increased burden may result from a disrupted work-life balance. Parental exhaustion, irritability, and mental health symptoms (e.g., depression and anxiety) have been reported to increase during pandemics[12,13]. Moreover, parents' psychological distress can affect children's ability to adjust to novel situations and may therefore promote the development of behavioral and emotional problems[14]. High anxiety or depressive symptoms in parents have been associated with an increase in harsh parenting and child abuse potential[15], indicating urgent consideration for policymakers to provide resources and support for at-risk families.

Notably, reports on increases in emotional distress are complemented by reports of a smaller, but significant, proportion of individuals who describe no changes or increases in well-being during restrictions. Such data indicates that interindividual differences in the effect of restrictions on mental health should be considered[2]. For example, restrictions may bring some families closer together, increase parent-child bonding and joint experiences[7]. An increased understanding of interindividual differences that protect or increase risk for psychopathologies holds the potential to inform personalized support associated with pandemics.

The identification of potential precursors for psychosocial functioning during challenging life events is crucial for the development and implementation of prevention and intervention measures. Socioemotional abilities represent different skill sets of social and emotional functioning[16] which may serve as potential antecedents of psychosocial functioning during challenging life events[17]. Successful socioemotional skill development in children is positively linked to present and future well-being[18] and a disruption of these has been linked to externalizing and internalizing problems[19]. Furthermore, socioemotional skill development strongly relies on caregiver-child relationships and dyadic learning[20].

A fundamental ability for many later-emerging socioemotional abilities is mentalizing, a sociocognitive skill enabling the understanding of emotions, thoughts or motives of others and oneself (enabled by our so-called Theory of Mind and impacted by parenting behaviors[21]). Having a well-developed Theory of Mind has been associated with higher social competences, psychological and physiological functioning[22]. Contrariwise, impaired mentalizing abilities have been linked to stress and depression[23], potentially serving

as a predictor of these[17]. On a neural level, the functional brain network associated with mentalizing typically includes areas such as the bilateral temporoparietal junction, precuneus, medial prefrontal cortex and right superior temporal sulcus[24], with the temporoparietal junction and prefrontal cortex particularly relevant when thinking about others' and one's own mental states[10]. A disrupted ability to mentalize, including associated neural alterations, can be found in clinical disorders, such as borderline personality disorder, conduct disorder or alexithymia[25,26].

Increasing evidence highlights the urgent need to consider the indirect consequences of the pandemic on physical and psychological well-being. Children's, parents', or families' lives may be particularly affected, and parental well-being is suggested to be intertwined with that of children. Past evidence further indicates that well-being and stress are moderated by sociocognitive skills. In this study, we aimed (**1**) to investigate the impact of Covid-19-related restrictions on variability in child and adult well-being over time as measured repeatedly during the months after Covid-19 onset and introduction of restrictions; (**2**) to assess associations of mental well-being (e.g., anxiety, depression, caregiver burden) in mothers with children's emotional and behavioral problems or self-reported mood; (**3**) to examine the association between the neural correlates of mentalizing as measured prior to Covid-19 on the later development of fear of contamination and illnesses in all, or caregiver burden in mothers. We expect significant variation over time in mental well-being (e.g., general health, anxiety, distress, depression) after Covid-19 onset. Emotional and behavioral problems in children may vary over time. Furthermore, we suggest that variations in emotional and behavioral problems or mood in children are significantly explained by variables of mental well-being of their mothers. In everyday life, increased mentalizing skills are linked to improved socioemotional functioning[22], but an elevated tendency to mentalize may also be negatively associated with our well-being under extreme circumstances (e.g., higher anxiety in those with better mentalization skills[17]). We suggest that neural correlates of mentalizing are associated with later caregiver stress or the development of higher anxiety and fears associated with viruses.

Methods

Participants

Participants of a previous cross-sectional neuroimaging study investigating socioemotional development between 2018 and 2020, including behavioral and neuroimaging assessments (including functional MRI during mentalizing (Borbás et al., 2020)), were asked to participate in the Covid-19 online follow-up assessments. Sixty-nine European participants (43 adults, 31 females; average age = 35.14 years; age range 22–51 years / 26 children; 10 females; average age = 10.69 years; age range 7–17 years / 21 adults were the mothers to the here described 26 children) completed an overall of eight testing time points (overview in Fig. 1). In line with guidelines and approval by the local ethics board (Ethikkomission Nordwest- und Zentralschweiz) all participants signed an informed consent form. Additionally, in case of children, verbal assent of the child and written informed consent from a parent and/or legal guardian was collected. All research presented here was performed in accordance with the relevant guidelines and regulations of the Ethikkomission Nordwest- und Zentralschweiz.

Assessments

Across eight testing time points the first (T0) represents a baseline obtained within two years prior to the pandemic. Additionally, seven testings were included across 75 days (11 weeks) after Covid-19 onset. The online assessment started following nationwide restrictions implemented in Switzerland on March 16th, 2020 including the ban of events, school closure, closure of all non-essential and hardware stores, garden centers, markets, museums, zoos, nightclubs, closure of hairdresser, restaurants, ban of gatherings (five people) or home-office orders, etc. Schools were re-opened on May 11th, 2020, resulting more parents returning to work. Details of assessments conducted prior to Covid-19 (T0) and during restrictions (T1-T6) are reported in **Supplementary Methods**. Only assessments relevant to the present analyses are described below.

Testing prior to Covid-19 (T0) took place between March 2018 and February 2020 including functional neuroimaging during mentalizing. Online assessments after Covid-19-onset were conducted from March to May 2020. Participants filled out six biweekly online questionnaires (labelled as T1, T2, T3, T4, T5, T6). For adults, these targeted **anxiety** (State-Trait Anxiety Inventory: STAI-6; a self-report questionnaire to assess anxiety level as state[27]), **depression** (Center for Epidemiologic Studies Depression Scale (CESD-R, German version[28], assessing symptoms in the last 1–2 weeks relating dysphoria, anhedonia, appetite, sleep, thinking, guilt, fatigue, movement and suicidal ideation), **general health** (General Health Questionnaire (GHQ-12, German version, a self-report instrument to screen for psychosocial well-being[29], **distress** (questions were adapted from the Kessler Psychological Distress Scale, but answer format was

modified allowing participants to indicate their emotional state in relation to their usual emotional state[30]) and **subjective burden of caregiving** for mothers (the Burden Scale for Family Caregivers (BSFC-s[31]; a self-report questionnaire assessing subjective burden of family caregivers, which was adapted to capture increased burden in parental responsibilities during restrictions). In children **emotional and behavioral problems** were assessed using the Strengths and Difficulties Questionnaire[32] and subjective mood ratings (children have to choose between 5 different smileys in order to indicate their mood in the last days). **Media consumption** and **time spent outside** were further assessed by asking participants to indicate the amount of time spent on these activities on a 5-point Likert scale. One extra questionnaire (T_E, between T4 and T5) was added before a first ease in restrictions was introduced by the government. This extra testing (T_E) consisted of the Child Behavior Checklist (CBCL[33]) evaluating **child behavior** as acquired at T0 and the **Fear of Illness and Virus Evaluation** (credits: Dr. Ehrenreich-May (2020), https://adaa.org/node/5168). Of the six biweekly testing, the last two (T5, T6) were conducted after schools reopened.

Behavioral data analyses

Mental well-being during Covid-19-related restrictions. Variations over time for repeated measures assessments collected in the first months after Covid-19 onset were calculated in R (https://www.r-project.org/). First, missing data points were checked whether they were missing at random (MAR). In case of no violation of MAR assumption missing data was replaced by Multivariate Imputation by Chained Equations MICE package in R[34] employing the predictive mean matching method. Overall, 14.41% of the testing time points reported in the present analyses were imputed (12.79% in adults, 16.03% in children). For dimensional data repeated measures ANOVAs were conducted using the 'ez' package in R (https://cran.r-project.org/web/packages/ez/ez.pdf). Sphericity was tested using Mauchly's test for sphericity and, if violated, Greenhouse-Geisser-corrected p-values were reported. For non-parametric data, Friedman tests were used. Significant main effects were followed up using post-hoc pairwise comparisons and adjusted using Holm-Bonferroni correction. Adults' scores in anxiety and depression were screened to identify scores of clinical relevance. Finally, one-way analysis of variance was employed to test whether emotional and behavioral problems (SDQ and CBCL) in children differed prior to and during Covid-19-related restrictions.

Mother-child associations. To test whether mental well-being in mothers (anxiety, depression, and caregiver burden) explained variability in children's emotional or behavioral problems a multiple regression analysis was implemented corrected for children's age and sex. Since emotional and behavioral problems in children were assessed through parental reports, parental bias may impact findings. Therefore, we repeated the multiple regression analysis by using mood scores provided by the children as a dependent variable.

Post-hoc follow-up assessment. Mental well-being and the development of negative symptoms during stressful life events have been suggested to be influenced by further variables of interest, including sex and parenting[35], news exposure[2] or time spent outside[36]. For adult participants, multiple regression analysis controlling for age was conducted to assess whether variation in mental well-being (i.e., anxiety, depression, or distress) were explained by sex, news consumption, time spent outside or parenthood. For children, we assessed whether children's well-being (self-report for mood) during restrictions was explained by time spent outside or friends met (yes/no) using multiple regression analyses, controlling for age and sex of the children.

Children's subjective reports. Children were asked two open-ended questions: At T1-T4, these were "What do you like about spending more time at home now?" and "What do you like less about spending more time at home now?". At T5 (after the first week of school opening) and T6 (3 weeks after school reopened) these were changed to "What do you like about going back to school?" and "What do you like less or think, is a bit annoying, about going back to school?" Subcategories based on topics mentioned were built and coded by two independent reviewers (**Supplementary Methods**).

fMRI data analyses

fMRI data was analyzed using SPM12 running on MATLAB R2020b (www.fil.ion.ucl.ac.uk/spm). Neural correlates of mentalizing were tested using the CAToon task (see (Borbás et al., 2020) and **Supplementary Methods**). fMRI was acquired for all participants between 2018-2020. In short, fMRI during mentalization was acquired using a cartoon-based Theory of Mind task (experimental condition: affective (AT) and cognitive (CT) Theory of Mind; control condition: physical causality (PC)). The neural correlates of mentalizing were based on a regressor of interest including both cognitive and affective Theory of Mind as compared to physical causality ((AT|CT)>PC). Whole-brain T2-weighted echo-planar images were collected using a 20-channel head coil on a Siemens 3T Prisma MR scanner (specifics in **Supplementary Methods).** Group analyses included age and sex as covariates and all findings were corrected for multiple comparisons

using whole brain family-wise error correction (FWE). For the present purpose mean parameter estimates were extracted for areas of interest consistently recruited in mentalizing[24], which included right temporoparietal junction (TPJ; sphere of 7mm radius based on group peak) and dorsolateral prefrontal (dlPFC; group cluster) region, using the MarsBar toolbox (Brett et al., 2002; http://marsbar.sourceforge.net/). To test whether these regions were significant predictors of fears about contamination and illness or caregiver burden, we employed multiple regression analyses controlling for age and sex when applicable. In-scanner data collection was only evaluated to assure task compliance (i.e., no more missings than 10% of all trials; **Supplementary table S1)**.

Results

Behavioral findings

Descriptive statistics. A summary of behavioral scores is included in Table 1. In children scores prior to and during the initial 11-week phase of Covid-19 restrictions are reported.

Variation over time. In adults, Mauchly's test indicated violation of sphericity for **anxiety, distress**, and **depression**. Repeated measures analysis of variance revealed a significant main effect of time for **anxiety** ($F(5,210) = 8.692$, $p_{GG}<0.001$; post-hoc comparisons revealed significant differences in mean anxiety between T1 and T6 (T1 = 42.70, T6 = 35.4; $p = 0.016$). Group average scores of anxiety were indicating clinical levels at T1 (mean = 4.70, SD = 8.952) and T4 (mean = 41.62, SD = 8.798). A significant main effect of time was also observed in **depression** ($F(4,168) = 3.084$, $p_{GG}=0.0320$; no post-hoc pairwise comparisons remained significant). Considering depression scores reported by each individual, 32.56% of adults reported increased depression, with 4.65% meeting criteria at least once for a major depressive episode. No significant main effect of time was reported for **distress** ($F(4,168) = 1.005$, $p_{GG}=0.3799$). No violation of sphericity was reported for **general health** (Mauchly-W(5) = 0.590, $p = 0.097$). A significant main effect of time existed $F(5,210) = 3.608$, $p = 0.004$), but no post-hoc Holm-Bonferroni corrected pairwise comparisons remained significant.

Table 1
Group characteristics of adults and children prior to and during the first months after Covid-19 onset.

	Adults (n = 43, 31 females)				**Children (n = 26, 10 females)**			
	First pandemic months	M ± SD		Pre-pandemic	M ± SD		First pandemic months	M ± SD
Age	in years	35.14 ± 9.20	**Age**	in years	9.58 ± 2.39	**Age**	in years	10.69 ± 2.52
Time s. 1st test	in months	18.76 ± 7.03	**IQ**	verbal	13.88 ± 8.94	**Time s. 1st test**	in months	13.64 ± 7.01
ISCED		4.84 ± 1.75		non-verbal	12.88 ± 4.48	**SDQ** [a]	emotional problems	1.21 ± 1.62
BSFC [ab]	subjective burden of care	8.32 ± 4.42	**SDQ**	emotional problems	1.73 ± 2.24		conduct problems	1.64 ± 1.49
STAI-6 [a]	anxiety	38.85 ± 8.57		conduct problems	1.69 ± 1.72		hyperactivity	2.88 ± 1.93
Distress [ac]	mean	4.09 ± 0.56		hyperactivity	2.81 ± 1.86		peer problems	1.64 ± 1.44
GHQ [a]	mental health	5.15 ± 2.57		peer problems	0.92 ± 1.41		prosocial	6.56 ± 1.53
CESD-R [b]	depression	9.96 ± 10.60		prosocial	7.35 ± 1.67		total	7.38 ± 4.87
				total	7.15 ± 4.97	**CBCL**	withdrawn	54.58 ± 5.38
Media	[1] no time	1.89%	**CBCL** [d]	withdrawn	54.27 ± 5.50		somatic problems	56.54 ± 7.46
consumption [a]	[2] 15 minutes	36.04%		somatic problems	55.46 ± 5.57		anxious/depressed	55 ± 8.32
(daily)	[3] 30 minutes	30.76%		anxious/depressed	56.73 ± 8.49		social problems	53.13 ± 4.78
	[4] 1 hour	21.82%		social problems	53.65 ± 4.63		schizoid-compulsive	54.13 ± 6.49
	[5] > 1 hour	9.49%		schizoid-compulsive	54.35 ± 6.36		attention problems	55 ± 5.82
				attention problems	55.19 ± 5.84		delinquent behaviour	52.38 ± 4.43
Time outside[a]	[1] no time	1.25%		delinquent behaviour	52.69 ± 3.90		aggressive behaviour	53.29 ± 5.29
(daily)	[2] 30 minutes	21.78%		aggressive behaviour	55.38 ± 6.83		total	51 ± 9.36
	[3] 1 hour	19.77%		total	53.81 ± 8.45	**FIVE**	fears about contamination and illness	12.38 ± 2.78
	[4] 1 to 2 hours	34.93%					fears about social distancing	15.17 ± 4.27
	[5] > 2 hours	22.28%					behaviors related to illness and viruses	29.63 ± 5.32

	Adults (n = 43, 31 females)		Children (n = 26, 10 females)		
FIVE	fears about contamination and illness	13.53 ± 2.94		impact of illness and virus fears	2.83 ± 1.01
	fears about social distancing	15.10 ± 3.63		total	30.38 ± 6.76
	behaviors related to illness and viruses	30.55 ± 4.85	**Time outside**[a]	[1] no time	0.72%
	impact of illness and virus fears	2.98 ± 1.05	**(daily)**	[2] 30 minutes	12.79%
	total	31.6 ± 6.11		[3] 1 hour	18.49%
				[4] 1 to 2 hours	32.90%
				[5] more than 2 hours	35.10%
			Mood[a]	[1] very happy	31.34%
				[2] happy	46.07%
				[3] unsure	15.44%
				[4] unhappy	5.70%
				[5] very sad	1.45%

[a]average score; [b]in mothers only; [c]Distress: 1 - much less than usual, 2 - quite less than usual, 3 - a little less than usual, 4 - as much as usual, 5 - a little more than usual, 6 - quite a bit more than usual, 7 - much more than usual; [d]N=25 (out of a total N pre-/during confinement of 26); Time s. 1st test = time since first testing; ISCED = International Standard Classification of Education; BSFC = Burden Scale for Family Caregivers; STAI-6 = State-Trait Anxiety Inventory; GHQ = General Health Questionnaire; CESD-R = Center for Epidemiologic Studies Depression Scale; FIVE = Fear of Illness and Virus Evaluation; SDQ = Strengths and Difficulties Questionnaire; CBCL = Child Behavior Checklist

For mothers, sphericity was violated for the **burden of caregiving** data. Greenhouse-Geisser corrected results indicated a significant main effect of time ($F(5,105) = 4.7102$, $p_{GG}=0.0026$), with post-hoc comparisons not remaining significant. Group average scores of subjective burden were in the moderate range (BSFC-s scores of 5–14 [37]) throughout the whole assessment period (Fig. 3). Friedman test of differences revealed a significant effect of time for **time spent outside** ($\chi^2 = 18.422$, $p = 0.002$) and **news consumption** ($\chi^2 = 25.177$, $p < 0.001$). Follow-up Bonferroni-corrected pairwise comparisons showed no significant differences for time spent outside between timepoints. For news consumption, follow-up pairwise comparisons showed significant differences between timepoints T2 and T6 (Fig. 2).

For children (Fig. 3), Mauchly's test for sphericity indicated no violation of sphericity for overall **emotional and behavioral problems** and the **hyperactivity** subscale ($p < 0.05$). A significant main effect of time was observed for overall **emotional and behavioral problems** ($F(4,100) = 7.0812$, $p < 0.001$; no post-hoc comparisons remained significant) and all subscales, except **prosocial behavior**, with post-hoc comparisons remaining significant for **hyperactivity** ($F(4,100) = 9.9143$, $p < 0.001$; follow-up significance between T4 vs. T5, $SDQ_{hyperactivity\_T4}=4.043$, $SDQ_{hyperactivity\_T5}=1.800$, $p = 0.0096$). One-way analysis of variance indicated no significant difference in behavioral and emotional problems in children when comparing pre-Covid-19 average scores with those obtained during restrictions (**Supplementary Table S2**). Friedman test revealed a significant variation in **time spent outside** ($\chi^2 = 21.002$, $p < 0.001$), with significant differences between timepoints T1 and T3. A significant effect of time was also revealed in **mood** ($\chi^2 = 13.425$, $p = 0.020$), however, post-hoc pairwise comparisons remained non-significant.

Mother-child associations. The multiple regression analyses controlling for age and sex of the children revealed that mothers' subjective burden of caregiving explained 48.7% (ß=0.763, $t(22) = 4.762$, $p < 0.001$) of the variance in children's emotional and behavioral problems ($F(3,22) = 8.173$, $p < 0.001$; $R^2 = 0.527$ [adjusted $R^2 = 0.463$]) while anxiety and depression in mothers were not entered into the model. Children's self-reported mood was best predicted by mothers' depression scores (ß=0.660, $t(22) = 4.136$, $p < 0.001$), while mothers' experienced burden of caregiving and anxiety was not entered into the final model ($F(3,22) = 6.037$, $p = 0.004$; $R^2 = 0.452$ [adjusted $R^2 = 0.377$]).

Post-hoc follow-up assessments. Post-hoc multiple regression analyses revealed no impact of sex, news consumption, time spent outside or parenthood on variations in scores of anxiety, depression or distress in adults, as neither was entered into the prediction model. For children, friends met (yes/no) explained 35.5% of the variation and was entered into the model as a significant predictor of mood (ß=-0.601, $t(22)=-3.551$, $p = 0.002$). Mood was negatively coded (lowest score representing the best mood and highest scores representing lowest mood/sadness), indicating that friends met were positively linked to a better mood. The model including meeting friends controlling for age and sex was established as a significant predictor of mood with an $R^2 = 0.380$ (adjusted $R^2 = 0.294$; $F(3, 22) = 4.499$, $p = 0.013$).

Children's qualitative reports. An overview about children's subjective statements is given in Fig. 4.

Neuroimaging findings

Across all participants, the neural correlates of mentalizing corresponded to brain regions previously associated with Theory of Mind[24], including bilateral temporoparietal and prefrontal regions or precuneus (see peak activation reports and figure in **Supplementary Table S3, Supplementary Figure S2**). The multiple regression analysis revealed that activation assessed prior to Covid-19 during mentalizing in right dorsolateral prefrontal cortex was a predictor of later development of fear about illness or contamination (ß=0.334, $t(60) = 2.661$, $p = 0.010$) constituting a significant model$R^2 = 0.139$ (adjusted $R^2 = 0.096$; $F(3,60) = 3.221$, $p = 0.029$; including age and sex). Right temporoparietal junction was not entered into the model as a significant predict. When assessing the relationship between mentalizing-related activation and subjective burden, the right temporoparietal junction emerged as a significant predictor of burden (ß=0.623, $t(18) = 3.276$, $p = 0.004$), while the dorsolateral cortex was not entered into the model. The model explained 41.9% of the variation in subjective burden (adjusted $R^2 = 0.355$; $F(2,18) = 6.493$, $p = 0.008$; including age; Fig. 5).

Discussion

We describe data on an extensively characterized group of children and adults (N = 69, 41♀, age range = 7–51 years, including 26 children and their mothers) with a total of ~ 2'500 tests conducted across seven assessment timepoints during the Covid-19 pandemic, also including pre-pandemic baseline data. Our findings indicate significant effects of Covid-19-related restrictions on mental well-being and psychosocial functioning in children and adults as for example reflected by heightened scores in anxiety, depression or caregiver stress and significant variation of anxiety, depression, general health, and burden of care in adults or in mood and overall emotional and behavioral problems in children. Well-being in mothers predicted mood and emotional and behavioral problems in children. In children meeting friends was a significant predictor of mood during restrictions. Additionally, neural correlates of mentalizing in prefrontal, but not temporoparietal regions, preceded the development of fear about contamination and illness across all participants. In mothers, higher neural activation in temporoparietal, but not frontal, regions during mentalizing preceded higher reports of subjective burden of care during restrictions. This may indicate that higher tendency to mentalize, usually considered beneficial for social interactions[38] and favorable when present in mother-child dyads[39], can be negatively associated with socioemotional functioning during prolonged stress.

Child behavior as measured by the SDQ or CBCL showed no difference when comparing pre-pandemic scores to those during restrictions, which is in line with longitudinal reports[7] observing a relatively stable level of problem behaviors with Covid-19-onset. However, there was significant variation in emotional and behavioral problems across restrictions. When looking at distinct subscales, a significant variation over time was observed for all scales, except prosocial behavior, which we hypothesized was restricted due to social distancing measures. Follow-up assessment comparing each timepoint revealed significant differences in hyperactivity marked by a strong decrease in scores from T4 to T5. Notably, the observed drop in hyperactivity coincided with eases of restrictions by the Swiss federal government (i.e., reopening of primary and lower secondary schools). Consequently, higher hyperactivity was observed during the most stringent restriction phase, while decreases in hyperactivity were observed once these were eased and thus are likely explained by the

transition towards regular routines. Additionally, children's time spent outside, and mood varied significantly. Slight variations in scores may be explained by several public holidays (Easter) around mid-restrictions, which is marked by more time spent outside in all participants, higher mood in children and lower caregiver burden in mothers (no home-schooling). Evidence highlights that prolonged school closure or restrictive measures are detrimental to children's physical and mental health and can have long-lasting consequences[14]. Our findings further indicate that meeting friends predicted better mood, which is in line with prior evidence emphasizing the importance of friendships and peer relationships in developmental groups[11,36].

Quantitative measures obtained were further supported by qualitative reports, which provide a unique insight into children's values and further highlight sources of resilience. More specifically, children mentioned more time for leisure, sleep, family, and friends or less stress or exams as positive attributes of school closure. Negative mentions centered around restrictions affecting social contacts, prohibiting hobbies or sports, or increased stress and conflict. Interestingly, across two time points, positive mentions about returning to schools across all children solely focused on social domains (e.g., meeting friends, class, teachers again or in-person schooling), whereas negative mentions included less sleep, less free time or increased stress and homework, or restrictions. Themes reported were in line with findings of qualitative reports during Covid-19[11,36].

Anxiety, depression and caregiver burden was high amongst adults with varying group scores across the first pandemic months. Anxiety was highest at the beginning and after seven weeks of restrictions reaching clinically significant levels. An increase in anxiety due to restrictions is in line with accumulating Covid-19 reports[2,5,8,40]. Likewise, findings of possible decreases with time have been reported[2,40]. A significant variation over time was also observed for scores of depression, though follow-up comparisons did not survive multiple comparison correction. While group average scores of depression were in the normal range, it is notable that 32.56% of all adults reported heightened depressive symptoms and 4.65% qualified for a major depressive episode at least once. These observations mirror reports of heightened depression scores in the general population during Covid-19 (e.g., retrospective reports[2] or longitudinal data[6]). Variations in general health, as measured by the General Health Questionnaire across restrictions, were significant, but no significant main effect of time was observed for perceived distress. Participant reports reflected significant changes in news consumption and time spent outside, with decreases in the amount of news consumed. Adults' and children's time spent outside showed similar trajectories, which might be driven by Easter vacation, the inclusion of parents within the adult group or easing of restrictions/return to work towards the end of testing. Sex, media consumption, time spent outside or parenthood did not explain variations in scores of anxiety, depression or distress in adults. This is somewhat surprising given prior evidence of the impact of each of these variables on mental well-being during Covid-19 (gender and parenting[35]; news consumption[2]; time spent outside[36]).

Mothers reported moderately elevated levels of subjective burden of care which is in line with studies investigating parental burden during Covid-19[41]. A moderate burden of care has been associated with elevated risk for physical, psychosomatic, or mental health problems[37,41]. In the present study, mother-child variables were strongly associated. Subjective burden of caregiving in mothers predicted emotional and behavioral problems in children, while anxiety and depression did not. This indicates that higher burden in mothers was linked to more problem behaviors in children. Notably, emotional and behavioral problems in the child were reported by the mother, thus reporting bias can't be excluded. We further investigated the effect of the mothers' well-being on children's self-reported mood, demonstrating that elevated depression in mothers affected children's mood ratings. Dyadic relationships are a primary vehicle for children's learning[9]. While commonly a driver of positive effects, it may also lead to negative consequences, as demonstrated in the example of vicarious conditioned fear learning in parent-child dyads[42]. We thus hypothesize, that negative mental health in adults may have negatively impacted children's well-being, possibly through learnt maladaptive coping or contagion. Increased parental stress and anxiety may lead to parental burnout[13] or increased aggression[15]. Intergenerational care during early years lays the foundation for healthy social skill development[43] and systemic mental health intervention programs commonly draw from this relationship[44]. Our data support programs investing in increased parental support, which are expected to influence children's well-being positively.

The neural correlates of mentalizing as measured prior to the pandemic in prefrontal, but not temporoparietal brain regions, preceded the development of fear about contamination and illness and in all participants. In mothers, higher neural activation during mentalizing in temporoparietal, but not frontal regions was associated with higher burden of caregiving during restrictions. Activation increases in the right temporoparietal junction are commonly reported as a response to tasks of mentalizing, as this area selectively responds to observed social interactions[45] and is part of the so-called paternal caregiver brain network[46]. Prefrontal areas are similarly engaged during tasks of mentalizing and are crucial for cognitive control processes[10]. Our data indicate that neural activation during mentalization in prefrontal cortex prior to Covid-19 precedes the development of fear of contamination and illnesses across all individuals. The assessment of fear about contamination and illness required participants to make statements relating to the likelihood of oneself, a parent, a pet, or

someone else in the world becoming sick and/or dying because of a virus or illness. Activation increases in prefrontal cortex have been linked to psychological state attributions, independent of whether they affect oneself, a relative, imagined people or animals[47]. A higher tendency to think about other people's well-being, as reflected by higher mentalization-related activation in the prefrontal cortex, may thus be linked to the likelihood of developing fear about contamination and illness affecting ourselves and others.

Overall, better mentalizing has been associated with higher social competence, psychological and physiological functioning[22], while impairments have been associated with stress and depression[23]. Increased mentalizing skills in caregivers are beneficial for child development. For example, parental mentalization has been positively associated with regulatory skills in children[48], which may be protective during stressful life events[43]. However, the opposite effect may occur during stressful situations[17]. For example, higher levels of mentalizing abilities are associated with higher cortisol and heart rate reactivity in stressful situations[49]. This may temporarily be beneficial, but may have a long-term negative impact depending on the intensity and duration of negative events. Our data indicate that mentalization can be negatively associated with increased burden and fear development in prolonged stressful situations.

In the present example, extensive phenotyping within individuals (e.g., over 2'500 assessments conducted) allow a comprehensive view and an opportunity to assess effects of time within individuals. Nevertheless, observations such as the existence of potential subgroups will have to be further examined using larger and more diverse populations. An example for possible subgroups reacting differently to stressful life events as associated with pandemics include children that may in fact benefit or even thrive during restrictions[7]. A more detailed understanding of subgroups of individuals that are differently affected may increase opportunities to select the best fitting individualized treatments or prevention. Assessing direct subjective experience of the severity of impact by Covid-19 and associated restrictions would have been a valuable addition. Moreover, it remains to be investigated how far-reaching the herein observed negative effects on well-being are. Past work has indicated that early adversities can have an impact for life, with effects potentially being most significant in younger age and depending on the intensity of the experience[50]. An increased understanding of protective and/or risk factors and mechanisms leading to the development of stress-related psychopathologies may ultimately hold the potential to facilitate more personalized prevention and treatment strategies.

Declarations

Data Availability

Behavioral mean scores are included in the manuscript and neuroimaging data is provided through NeuroVault (https://identifiers.org/neurovault.collection:9780). Further information or data may be obtained from the corresponding author.

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Author contributions

N.M.R conceived the experiments. N.M.R., L.V.F., P.D. and R.B. designed, implemented, and conducted the experiments. R.B., A.N., J.A., L.V.F., and N.M.R. analyzed the results. N.M.R, R.B. and C.B.S. wrote the manuscript and each author reviewed the manuscript. All authors have made an important scientific contribution to the manuscript.

Competing interests

The authors declare no competing interests.

References

1. Kwong, A. S. F. *et al.* Mental health during the COVID-19 pandemic in two longitudinal UK population cohorts.*medRxiv*(2020).
2. de Quervain, D. *et al.*The Swiss Corona Stress Study. (2020).
3. Pearlin, L. I., Menaghan, E. G., Lieberman, M. A. & Mullan, J. T. The stress process.*Journal of Health and Social behavior*,337–356(1981).

4. Shanahan, L. *et al.* Emotional distress in young adults during the COVID-19 pandemic: Evidence of risk and resilience from a longitudinal cohort study.*Psychological medicine*,1–10(2020).
5. Ozamiz-Etxebarria, N., Dosil-Santamaria, M., Picaza-Gorrochategui, M. & Idoiaga-Mondragon, N. Stress, anxiety, and depression levels in the initial stage of the COVID-19 outbreak in a population sample in the northern Spain. *Cadernos de Saúde Pública.* **36**, e00054020 (2020).
6. Ettman, C. K. *et al.* Prevalence of depression symptoms in US adults before and during the COVID-19 pandemic. *JAMA network open.* **3**, e2019686–e2019686 (2020).
7. Achterberg, M., Dobbelaar, S., Boer, O. D. & Crone, E. A. Perceived stress as mediator for longitudinal effects of the COVID-19 lockdown on wellbeing of parents and children. *Scientific reports.* **11**, 1–14 (2021).
8. Wang, C. *et al.* Immediate psychological responses and associated factors during the initial stage of the 2019 coronavirus disease (COVID-19) epidemic among the general population in China. *International journal of environmental research and public health.* **17**, 1729 (2020).
9. Atzil, S., Gao, W., Fradkin, I. & Barrett L. F. Growing a social brain. *Nature Human Behaviour.* **2**, 624–636 (2018).
10. Blakemore, S. J. The social brain in adolescence. *Nature Reviews Neuroscience.* **9**, 267–277 (2008).
11. Chu, K., Schwartz, C., Towner, E., Kasparian, N. & Callaghan, B. Parenting Under Pressure: Chu Et Al., 2020-Mixed Methods Preprint(2020).
12. Nolvi, S. *et al.* Parental depressive and anxiety symptoms as a response to the COVID-19 pandemic: a birth cohort follow-up study. (2020).
13. Marchetti, D. *et al.* Parenting-related exhaustion during the italian COVID-19 lockdown. *Journal of pediatric psychology.* **45**, 1114–1123 (2020).
14. Morgül, E., Kallitsoglou, A. & Essau, C. A. E. Psychological effects of the COVID-19 lockdown on children and families in the UK. *Revista de Psicología Clínica con Niños y Adolescentes.* **7**, 42–48 (2020).
15. McRae, C., Henderson, A. M., Low, R., Chang, V. & Overall, N. Parents' Distress and Poor Parenting during COVID-19: The Buffering Effects of Partner Support and Cooperative Coparenting. (2020).
16. Thompson, R. A. *Socioemotional development* Vol. 36 (U of Nebraska Press, 1990).
17. Sharp, C., Fonagy, P. & Allen, J. G. Posttraumatic stress disorder: A social-cognitive perspective. *Clinical Psychology: Science and Practice.* **19**, 229–240 (2012).
18. Coyl-Shepherd, D. D. & Hanlon, C. Family play and leisure activities: correlates of parents' and children's socio-emotional well-being. *International Journal of Play.* **2**, 254–272 (2013).
19. Eisenberg, N. *et al.* The relations of regulation and emotionality to children's externalizing and internalizing problem behavior. *Child Dev.* **72**, 1112–1134 (2001).
20. Calkins, S. D. & Hill, A. Caregiver influences on emerging emotion regulation.*Handbook of emotion regulation***229248** (2007).
21. Frith, C. & Frith, U. Theory of mind. *Curr. Biol.* **15**, R644–R645 (2005).
22. Devine, R. T., White, N., Ensor, R. & Hughes, C. Theory of mind in middle childhood: Longitudinal associations with executive function and social competence. *Dev. Psychol.* **52**, 758 (2016).
23. Fischer-Kern, M. *et al.* Mentalizing in female inpatients with major depressive disorder. *The Journal of nervous and mental disease.* **201**, 202–207 (2013).
24. Molenberghs, P., Johnson, H., Henry, J. D. & Mattingley, J. B. Understanding the minds of others: A neuroimaging meta-analysis. *Neuroscience & Biobehavioral Reviews.* **65**, 276–291 (2016).
25. Moriguchi, Y. *et al.* Impaired self-awareness and theory of mind: an fMRI study of mentalizing in alexithymia. *Neuroimage.* **32**, 1472–1482 (2006).
26. Fonagy, P. & Bateman, A. The development of borderline personality disorder—A mentalizing model. *Journal of personality disorders.* **22**, 4–21 (2008).
27. Marteau, T. M. & Bekker, H. The development of a six-item short-form of the state scale of the Spielberger State—Trait Anxiety Inventory (STAI). *British Journal of Clinical Psychology.* **31**, 301–306 https://doi.org/10.1111/j.2044-8260.1992.tb00997.x (1992).
28. Schmitt, A. German version of the Center for Epidemiologic Studies Depression Scale Revised (CESD-R)(2016).
29. Schrnitz, N., Kruse, J. & Tress, W. Psychometric properties of the General Health Questionnaire (GHQ-12) in a German primary care sample. *Acta Psychiatry. Scand.* **100**, 462–468 (1999).

30. Kessler, R. & Mroczek, D. Final versions of our non-specific psychological distress scale. *Memo dated March.* **10**, 1994 (1994).
31. Abler, B. & Kessler, H. Emotion regulation questionnaire–Eine deutschsprachige Fassung des ERQ von Gross und John. *Diagnostica.* **55**, 144–152 (2009).
32. Goodman, R. The Strengths and Difficulties Questionnaire: a research note. *Journal of child psychology and psychiatry.* **38**, 581–586 (1997).
33. Achenbach, T. M. & Ruffle, T. M. The Child Behavior Checklist and related forms for assessing behavioral/emotional problems and competencies. *Pediatrics in review.* **21**, 265–271 (2000).
34. Buuren, S. & Groothuis-Oudshoorn, K. mice: Multivariate imputation by chained equations in R.*Journal of statistical software*,1–68(2010).
35. Huebener, M., Waights, S., Spiess, C. K., Siegel, N. A. & Wagner, G. G. Parental well-being in times of Covid-19 in Germany.*Review of Economics of the Household*,1–32(2020).
36. Idoiaga Mondragon, N., Sancho, B., Dosil Santamaria, N., Eiguren Munitis, A. & M. & Struggling to breathe: a qualitative study of children's wellbeing during lockdown in Spain. *Psychol. Health.* **36**, 179–194 https://doi.org/10.1080/08870446.2020.1804570 (2021).
37. Pendergrass, A., Malnis, C., Graf, U., Engel, S. & Graessel, E. Screening for caregivers at risk: extended validation of the short version of the burden scale for family caregivers (BSFC-s) with a valid classification system for caregivers caring for an older person at home. *BMC health services research.* **18**, 1–9 (2018).
38. Caputi, M., Lecce, S., Pagnin, A. & Banerjee, R. Longitudinal effects of theory of mind on later peer relations: the role of prosocial behavior. *Developmental psychology.* **48**, 257 (2012).
39. Camoirano, A. Mentalizing makes parenting work: A review about parental reflective functioning and clinical interventions to improve it. *Frontiers in psychology.* **8**, 14 (2017).
40. Fancourt, D., Steptoe, A. & Bu, F. Trajectories of depression and anxiety during enforced isolation due to COVID-19: longitudinal analyses of 59,318 adults in the UK with and without diagnosed mental illness. medRxiv(2020).
41. Russell, B., Hutchison, M., Tambling, R., Tomkunas, A. & Horton, A. Initial challenges of caregiving during COVID-19: caregiver burden, mental health, and the parent–child relationship. *Child Psychiatry & Human Development.* **51**, 671–682 (2020).
42. Marin, M. F. *et al.* Vicarious conditioned fear acquisition and extinction in child–parent dyads. *Scientific reports.* **10**, 1–10 (2020).
43. Bridgett, D. J., Burt, N. M., Edwards, E. S. & Deater-Deckard, K. Intergenerational transmission of self-regulation: A multidisciplinary review and integrative conceptual framework. *Psychological bulletin.* **141**, 602 (2015).
44. Marcus, B. A., Swanson, V. & Vollmer, T. R. Effects of parent training on parent and child behavior using procedures based on functional analyses. *Behav. Interv.* **16**, 87–104 (2001).
45. Saxe, R. The right temporo-parietal junction: a specific brain region for thinking about thoughts.*Handbook of theory of mind*,1–35(2010).
46. Feldman, R., Braun, K. & Champagne, F. A. The neural mechanisms and consequences of paternal caregiving. *Nature Reviews Neuroscience.* **20**, 205–224 (2019).
47. Baetens, K., Ma, N., Steen, J. & Van Overwalle, F. Involvement of the mentalizing network in social and non-social high construal. *Social cognitive and affective neuroscience.* **9**, 817–824 (2014).
48. Senehi, N., Brophy-Herb, H. E. & Vallotton, C. D. Effects of maternal mentalization-related parenting on toddlers' self-regulation. *Early Childhood Research Quarterly.* **44**, 1–14 (2018).
49. Tollenaar, M. S. & Overgaauw, S. Empathy and mentalizing abilities in relation to psychosocial stress in healthy adult men and women. *Heliyon.* **6**, e04488 (2020).
50. Nelson, C. A. *et al.* Adversity in childhood is linked to mental and physical health throughout life.*bmj***371** (2020).

Figures

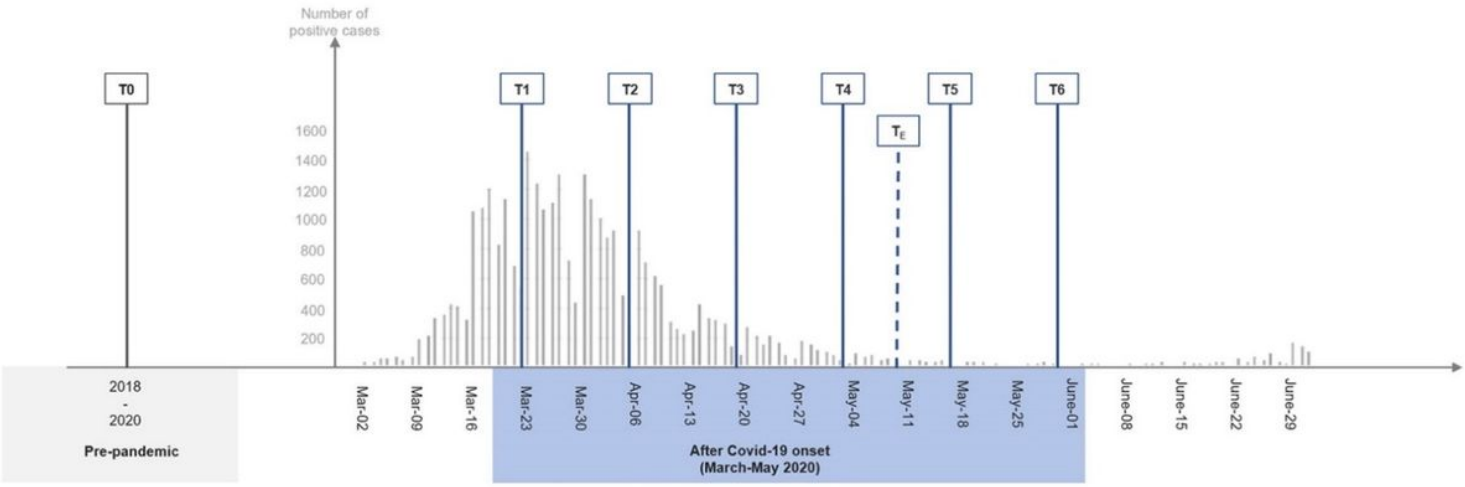

Figure 1

Study design and overview of assessments conducted prior to (T0) and during restrictive measures (T1-T6).

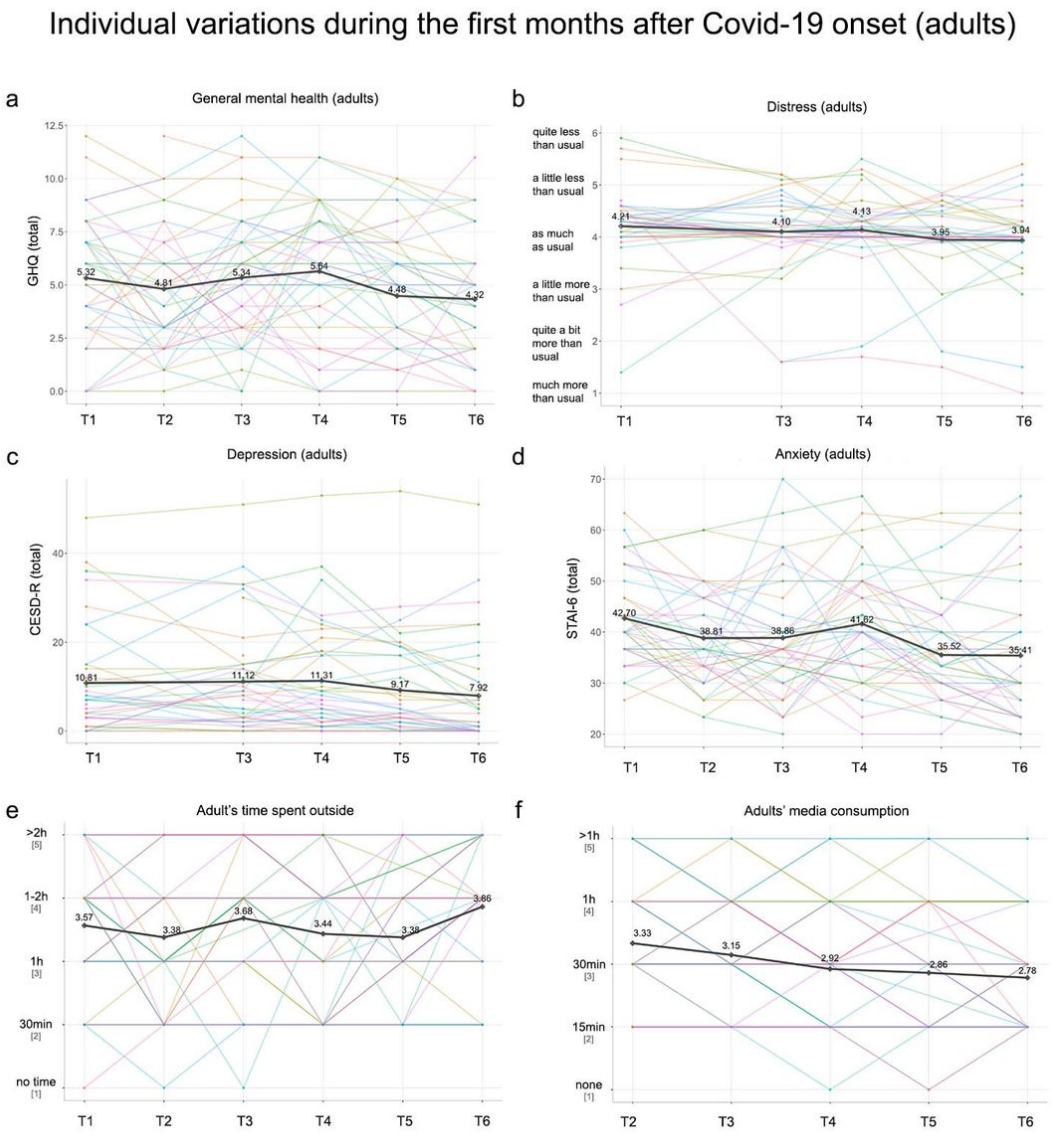

Figure 2

Variations of group (bold) and individual (colorful) scores in mental well-being across the first months after Covid-19 onset in adults for (a) general mental health, (b) distress, (c) depression, (d) anxiety, (e) time spent outside and (f) media consumption.

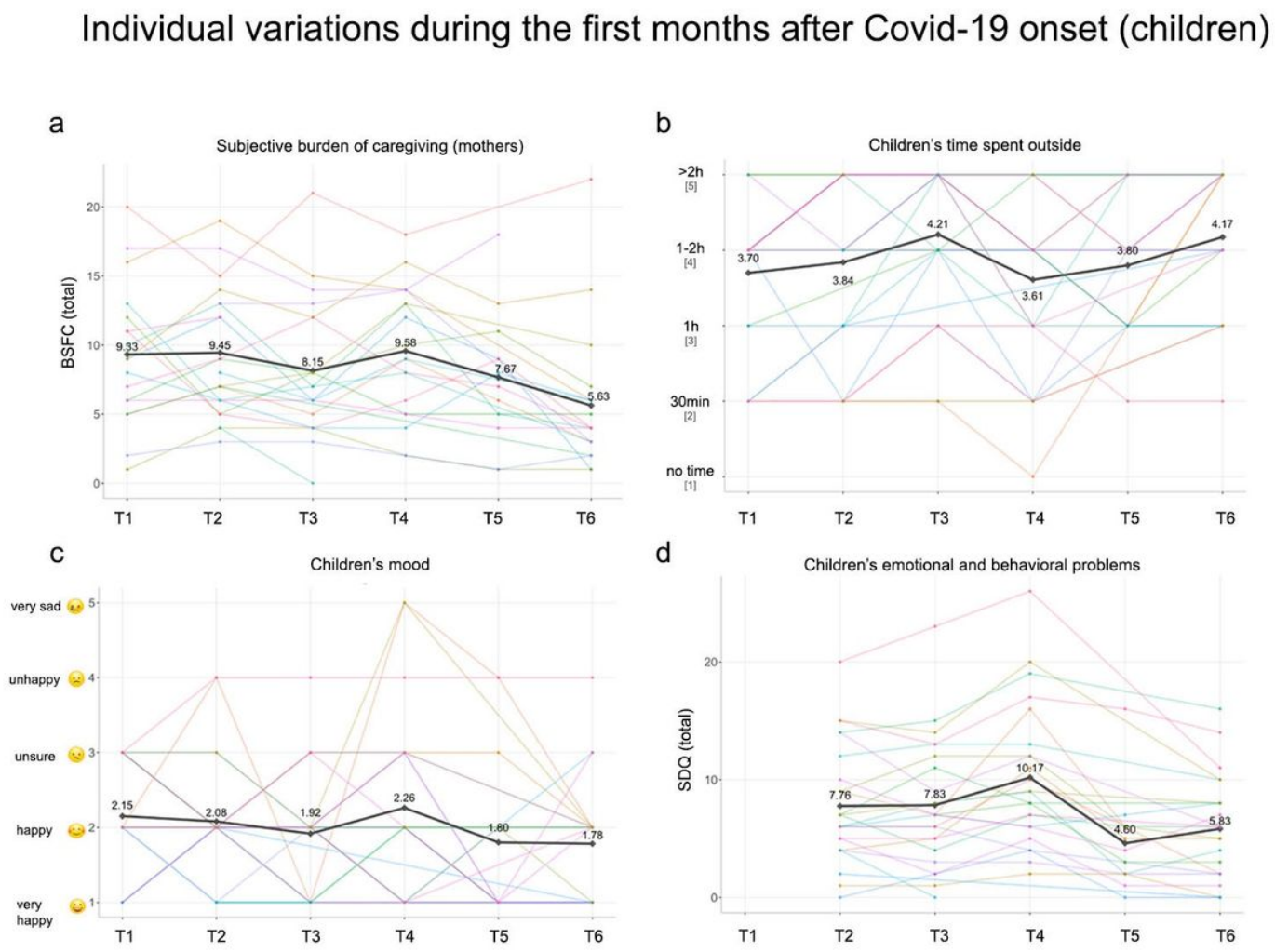

Figure 3

Variations of group (bold) and individual (colorful) scores in mental well-being across the first months of Covid-19-onset in children and mothers for (a) mother's subjective burden or care, (b) children's time spent outside, (c) children's mood, and (d) children's emotional and behavioral problems.

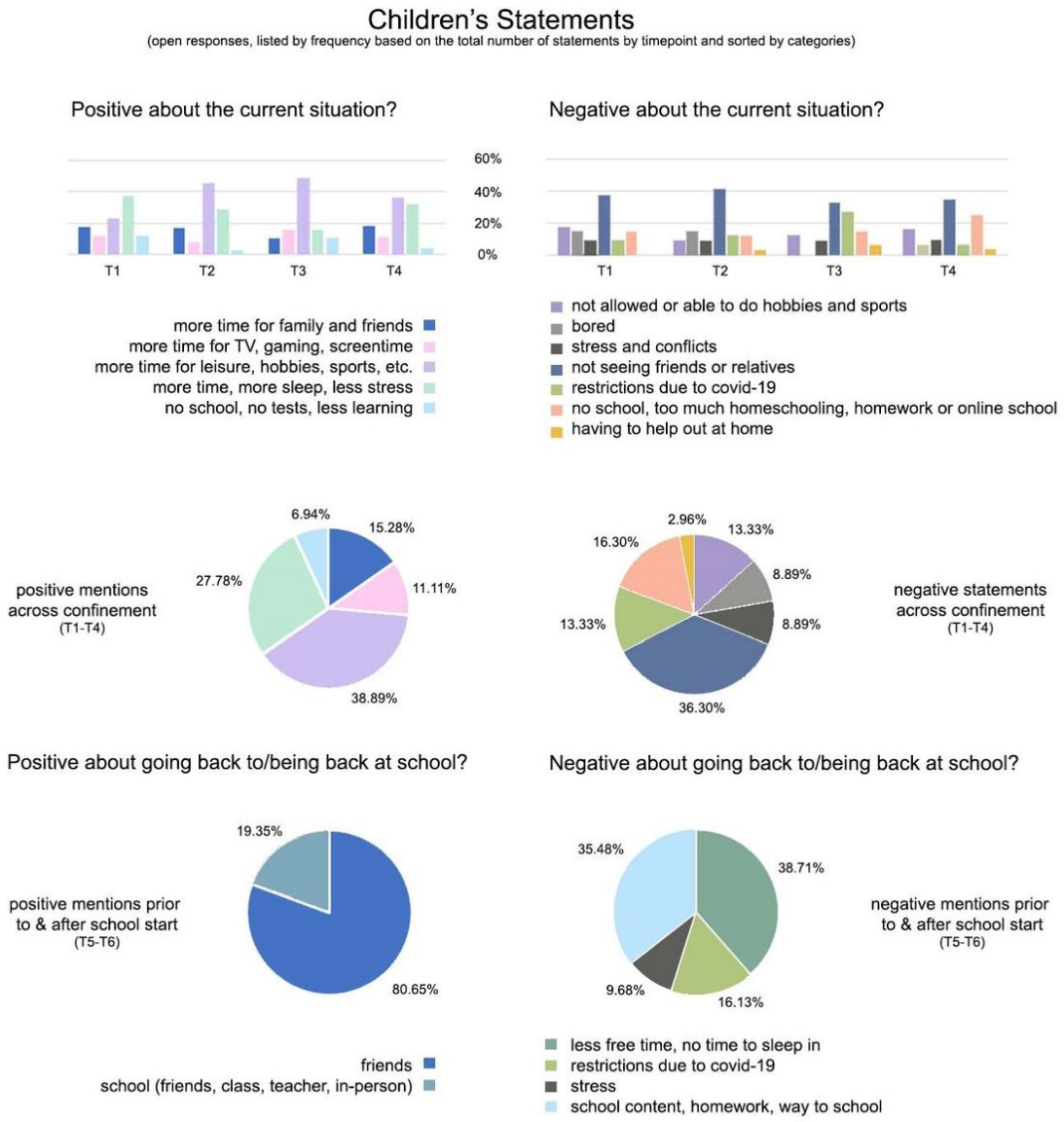

Figure 4

Qualitative measures of positive and negative associations with school closure or opening in children.

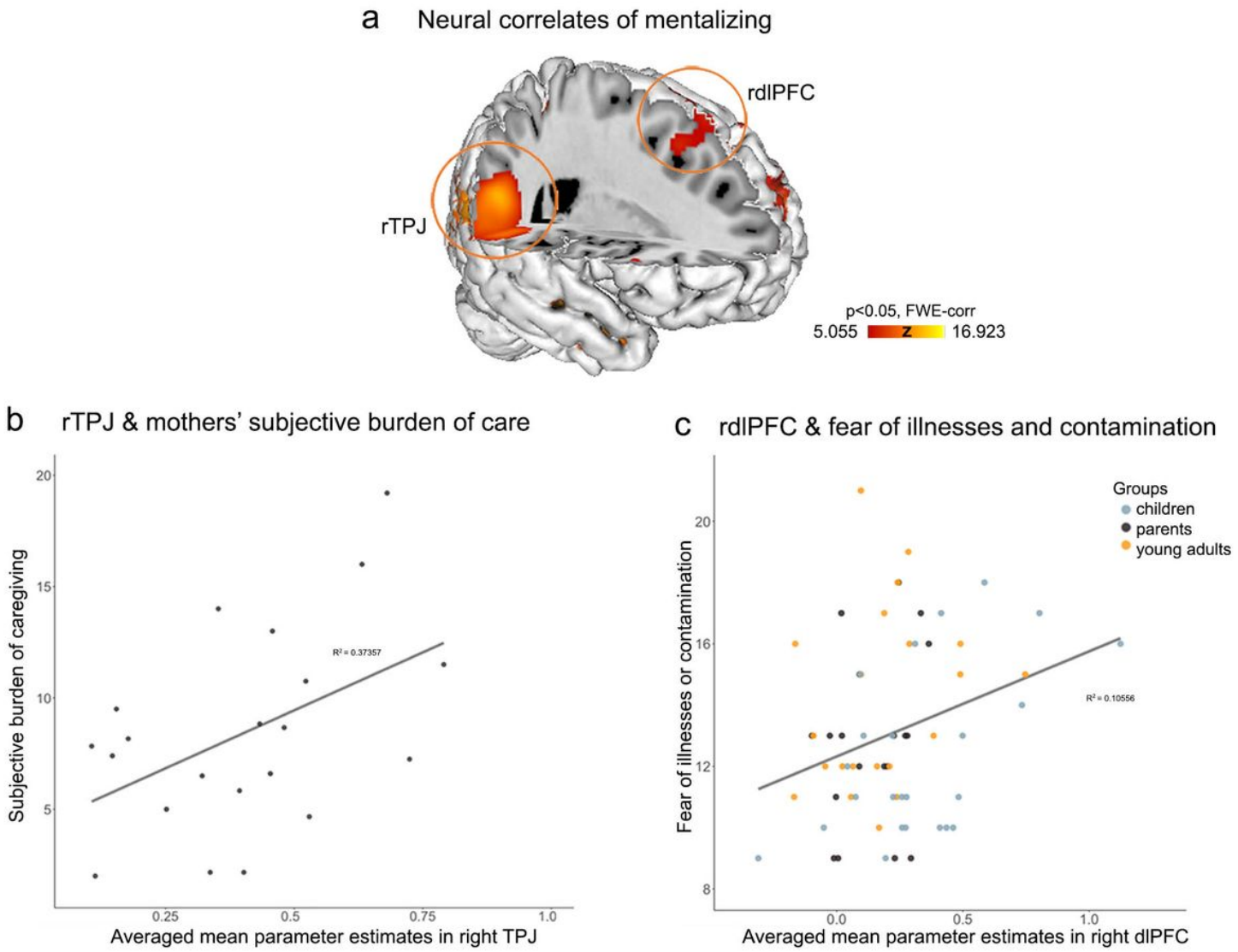

Figure 5

Functional brain correlates of pre-pandemic mentalizing and associations with subjective burden and fear of illnesses and contamination during Covid-19. (a) Brain rendering for the neural correlates of mentalizing (Theory of Mind > control) across all participants (corrected for age and sex and whole brain FWE-corrected; regions of interest in right TPJ and dlPFC are circled in red). (b) Association between mean parameter scores during mentalizing in right TPJ and subjective burden of caregiving in mothers. (c) Association of mean parameter scores in right dlPFC and fear of illnesses and contamination across all participants.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- SUPPLEMENTMentalwellbeingCOVID19NMR.doc