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Mental well-being during Covid-19 in adults, mothers and children: behavioral evidence and neural pre-markers

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Abstract

Objective

Covid-19 and associated restrictions have a great impact on our physical and mental well-being. Children's and families' lives may be particularly affected. In this study, we aimed to (1) investigate variability in child and adult well-being and (2) assess mother-child associations of mental well-being during the first months of the pandemic, and (3) examine the association between pre-pandemic brain characteristics and later fears or experienced burdens.

Method

We describe data on an extensively characterized group of children and adults (N=69, 41 ♀, age range=7-51y, including 26 children and mothers) including pre-pandemic brain function and ~2'500 tests acquired using during the early pandemic months. Repeated measures ANOVA and Friedman tests assessed variability, multiple regression analyses tested mother-child dyadic relations and the explanatory value of pre-pandemic neural correlates of mentalizing and development of fear in all or burden of caregiving in mothers.

Results

Significant variations in adults' and children's mental health were observed (e.g., anxiety, depression, general well-being or subjective burden of caregiving). Mothers' experienced burden of care affected children's emotional and behavioral problems, while mothers' depression impacted children's mood. Furthermore, friends met was a significant predictor of

children's mood. Pre-pandemic neural correlates of mentalizing in prefrontal regions preceded later development of fear of illnesses and viruses for all participants, while temporoparietal activation preceded higher perceived burden in mothers.

Conclusion

This study demonstrates a significant effect on, and variations in, mental well-being in adults and children during the early onset of Covid-19 and 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 distress⁵. 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 restrictions⁸. 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 affected¹¹. 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 problems¹⁴. High anxiety or depressive symptoms in parents have been associated with an increase in harsh

parenting and child abuse potential¹⁵, 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 considered². For example, restrictions may bring some families closer together, increase parent-child bonding and joint experiences⁷. An increased understanding of interindividual differences that protect or increase risk for psychopathologies holds the potential to inform personalized support associated with pandemics.

Mentalizing, the social brain and well-being

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 functioning¹⁶ which may serve as potential antecedents of psychosocial functioning during challenging life events¹⁷. Successful socioemotional skill development in children is positively linked to present and future well-being¹⁸ and a disruption of these has been linked to externalizing and internalizing problems¹⁹. Furthermore, socioemotional skill development strongly relies on caregiver-child relationships and dyadic learning²⁰. 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 behaviors²¹). Having a well-developed Theory of Mind has been associated with higher social competences, psychological and physiological functioning²². Contrariwise, impaired mentalizing abilities have been linked to

stress and depression²³, potentially serving as a predictor of these¹⁷. 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 sulcus²⁴, with the temporoparietal junction and prefrontal cortex particularly relevant when thinking about others' and one's own mental states¹⁰. 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}.

Summary and aims

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 functioning²², 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 skills¹⁷). We suggest that neural correlates of mentalizing are associated with later caregiver stress and/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. In line with guidelines and approval by the local ethics board all participants signed an informed consent form. Additionally, in case of children, a verbal assent and parental consent was collected.

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 **Supplement_1**. 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 state²⁷), **depression** (Center for Epidemiologic Studies Depression Scale (CESD-R, German version²⁸, 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-being²⁹, **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 state³⁰) and **subjective burden of caregiving** for mothers (the Burden Scale for Family Caregivers (BSFC-s³¹; 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 Questionnaire³² 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 (CBCL³³)

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 R³⁴ 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 assessments. 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 parenting³⁵, news exposure² or time spent outside³⁶. 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 (**Supplement_1**).

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 CAToan

task (see (Borbás et al., 2020) and **Supplement_2**). 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 **Supplement_3**). 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 mentalizing²⁴, 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; **Supplement_4**).

Results

Behavioral findings

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 was observed $F(5,210)=3.608$, $p=0.004$, but no post-hoc Holm-Bonferroni corrected pairwise comparisons remained significant. 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.

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

Adults (n=43, 31 females)			Children (n = 26, 10 females)						
First months after Covid-19 onset (average)			Pre-pandemic		First months after Covid-19 onset (average)				
Measurements		M ± SD	Measurements		M ± SD	Measurements		M ± SD	
Age	in years	35.14 ± 9.20	Age	in years	9.58 ± 2.39	Age	in years	10.69 ± 2.52	
Time since first testing	in months	18.76	IQ	verbal (vocabulary)	13.88 ± 8.94	Time since first testing	in months	13.64	
ISCED ^a		4.84 ± 1.75		non-verbal (matrices)	12.88 ± 4.48				
BSFC ^{bc}	subjective burden of care	8.32 ± 4.42	SDQ	emotional problems	1.73 ± 2.24	SDQ ^f	emotional problems	1.21 ± 1.62	
STAI-6 ^b	anxiety	38.85 ± 8.57		conduct problems	1.69 ± 1.72		conduct problems	1.64 ± 1.49	
Distress ^{bd}	mean	4.09 ± 0.56		hyperactivity	2.81 ± 1.86		hyperactivity	2.88 ± 1.93	
GHQ ^b	mental health	5.15 ± 2.57		peer problems	0.92 ± 1.41		peer problems	1.64 ± 1.44	
CESD-R ^b	depression	9.96 ± 10.60		prosocial	7.35 ± 1.67		prosocial	6.56 ± 1.53	
Media consumption ^b (daily)	[1] no time	1.89%	CBCL ^e	total	7.15 ± 4.97		total	7.38 ± 4.87	
	[2] 15 minutes	36.04%		withdrawn	54.27 ± 5.50	CBCL	withdrawn	54.58 ± 5.38	
	[3] 30 minutes	30.76%		somatic problems	55.46 ± 5.57	somatic problems	56.54 ± 7.46		
	[4] 1 hour	21.82%		anxious/depressed	56.73 ± 8.49	anxious/depressed	55 ± 8.32		
	[5] more than 1 hour	9.49%		social problems	53.65 ± 4.63	social problems	53.13 ± 4.78		
Time outside ^b (daily)	[1] no time	1.25%		schizoid-compulsive	54.35 ± 6.36	schizoid-compulsive	54.13 ± 6.49		
	[2] 30 minutes	21.78%		attention problems	55.19 ± 5.84	attention problems	55 ± 5.82		
	[3] 1 hour	19.77%		delinquent behaviour	52.69 ± 3.90	delinquent behaviour	52.38 ± 4.43		
	[4] 1 to 2 hours	34.93%		aggressive behaviour	55.38 ± 6.83	aggressive behaviour	53.29 ± 5.29		
	[5] more than 2 hours	22.28%		total	53.81 ± 8.45	total	51 ± 9.36		
FIVE	fears about contamination and illness	13.53 ± 2.94					FIVE	fears about contamination and illness	12.38 ± 2.78
	fears about social distancing	15.10 ± 3.63						fears about social distancing	15.17 ± 4.27
	behaviors related to illness and viruses	30.55 ± 4.85						behaviors related to illness and viruses	29.63 ± 5.32
	impact of illness and virus fears	2.98 ± 1.05						impact of illness and virus fears	2.83± 1.01
	total	31.6 ± 6.11					total	30.38± 6.76	
						Time outside (daily)	[1] no time	0.72%	
							[2] 30 minutes	12.79%	
							[3] 1 hour	18.49%	
							[4] 1 to 2 hours	32.90%	
							[5] more than 2 hours	35.10%	
						Mood ^f	[1] very happy	31.34%	
							[2] happy	46.07%	
							[3] unsure	15.44%	
							[4] unhappy	5.70%	
							[5] very sad	1.45%	

^aISCED = International Standard Classification of Education ^b average score based on available time points; ^c in mothers only; ^d 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; ^e N=25 (out of a total N pre-/during confinement of 26); ^f average score based on available time points

Group average scores of subjective burden were in the moderate range (BSFC-s scores of 5-14³⁷) throughout the whole assessment period (**Figure 2**). 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 (**Figure 1**).

For children, 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 (**Supplement 5**). 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.

Individual variations during the first months after Covid-19 onset (adults)

Figure 1. Variations of group (bold) and individual (colorful) scores in mental well-being across the first months after Covid-19 onset in adults.

Individual variations during the first months after Covid-19 onset (children)

Figure 2. Variations of group (bold) and individual (colorful) scores in mental well-being across the first months of Covid-19-onset in children and mothers.

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% ($\beta=0.763$, $t(22)=4.762$, $p<0.001$) 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 ($\beta=0.660$, $t(22)=4.136$, $p<0.001$), 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 ($\beta=-0.601$, $t(22)=-3.551$, $p=0.002$). 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

Figure 3.

Children's Statements

(open responses, listed by frequency based on the total number of statements by timepoint and sorted by categories)

Positive about the current situation?

Negative about the current situation?

Positive about going back to/being back at school?

Negative about going back to/being back at school?

Figure 3. Qualitative measures of positive and negative associations with school closure or opening in children.

Neuroimaging findings.

Across all participants, the neural correlates of mentalizing corresponded to brain regions previously associated with Theory of Mind²⁴, including bilateral temporoparietal and prefrontal regions or precuneus (see peak activation reports and figure in **Supplement_6**). 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 ($\beta=0.334$, $t(60)=2.661$, $p=0.010$) 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 predictor. When assessing the relationship between mentalizing-related activation and subjective burden, the right temporoparietal junction emerged as a significant predictor of burden ($\beta=0.623$, $t(18)=3.276$, $p=0.004$), 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).

Figure 4. 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). Associations between mean parameter scores during mentalizing in right TPJ and subjective burden of caregiving for mothers (left) and mean parameter scores in right dlPFC and fear of illnesses and contamination across all participants (right).

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 interactions³⁸ and favorable when present in mother-child dyads³⁹, 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 reports⁷ 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 consequences¹⁴. 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 reports² or longitudinal data⁶). 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 parenting³⁵; news consumption²; time spent outside³⁶).

Mothers reported moderately elevated levels of subjective burden of care which is in line with studies investigating parental burden during Covid-19⁴¹. 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 learning⁹. 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 dyads⁴². 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 burnout¹³ or increased aggression¹⁵. Intergenerational care during early years lays the foundation for healthy social skill development⁴³ and systemic mental health intervention programs commonly draw from this relationship⁴⁴. 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 interactions⁴⁵ and is part of the so-called paternal caregiver brain network⁴⁶. Prefrontal areas are similarly engaged during tasks of mentalizing and are crucial for cognitive control processes¹⁰. 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 animals⁴⁷. 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 functioning²², while impairments have been associated with stress and depression²³. Increased mentalizing skills in caregivers are beneficial for child development. For example, parental mentalization has been positively associated with regulatory skills in children⁴⁸, which may be protective during stressful life events⁴³. However, the opposite effect may occur during stressful situations¹⁷. For example, higher levels of mentalizing abilities are associated with higher cortisol and heart rate reactivity in stressful situations⁴⁹. 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 restrictions⁷. 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 experience⁵⁰. 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.

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