Familial Mechanisms Linking COVID-19 Lockdown with Mental Health Problems in Singaporean Children and Adolescents

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Abstract

The COVID-19 pandemic and related confinement measures have profound impacts on the mental health of children and adolescents. This study investigated familial mechanisms underlying such impacts by studying the unique case of Singapore, which has undergone a period of local transmission without many restrictions (February–March 2020), followed by a nationwide lockdown (April–May 2020). In June 2020, we collected retrospective reports on everyday activities, social relationships, and mental health of 164 children and adolescents ($M_{\text{age}} = 14.3$, Range = 7–18, 49% female) across three timepoints: Pre-pandemic, Pre-lockdown, and Lockdown. Parental mental health, parenting values and practices were also collected. Multilevel modelling showed increased mental health problems in children from Pre-pandemic to Pre-lockdown, and from Pre-lockdown to Lockdown. Mediation analyses indicated that the increase in children’s mental health problems from Pre-pandemic to Pre-lockdown was partially explained by a decrease in time spent outdoors, an increase in their conflict with fathers, and an increase in their mothers’ mental health problems, with the last factor being the only significant mediator when all three factors were considered simultaneously. The increase in children’s mental health problems from Pre-lockdown to Lockdown was partially explained by a further increase in their mother’s mental health problems. These findings suggest that lockdown measures issued by authority may lead to further deterioration of children’s mental health beyond the pandemic itself. Multiple personal and familial factors may underlie these deteriorations, among which maternal mental health could be especially influential and should be targeted in family support service and intervention.

Keywords: COVID-19, lockdown, mental health, Singapore, children, familial mechanism.

Introduction

The Coronavirus Disease 2019 (COVID-19) pandemic has profound psychosocial impacts on the well-being of children and adolescents around the world. While children are less likely to have their physical health directly impacted by the virus, they are among the biggest victims of the psychosocial detriments related to the crisis [1, 2]. The COVID-19 pandemic is a unique combination of a public health crisis, an economic recession, and a prolonged period of social isolation, giving rise to a multitude of factors that can directly (e.g., school closures) or indirectly (e.g., adult unemployment, adult mental health) impact children and adolescents worldwide [3]. In the United States, 14% of parents reported worsening behavioural health in their children during the pandemic [4]. Levels of depression and anxiety also increased among Chinese children and adolescents, where 22.3% displayed clinical depressive symptoms, 11.1% higher than the estimated prevalence of youth depression before the pandemic [5]. Among Chinese high school students alone, prevalence rates were even higher, at 43.7%, 37.4%, and 31.3% for depressive symptoms, anxiety symptoms, and a combination of both, respectively [6]. German children and adolescents also reported experiencing more mental health problems and higher anxiety levels than before the pandemic [7]. In Australia, effects on mental health were worse among adolescents with a previous diagnosis of depression and/or anxiety [8].

Confinement measures, either voluntary or imposed, may have caused additional mental health problems among children and adolescents. With the closure of schools, classes had to shift to a home-based distance-learning model which caused major disruptions to children and youth's school and social routines. Loneliness and stress from social isolation during this period can increase levels of depression and anxiety among children and adolescents [9], especially if they last for prolonged periods of time [10]. Home confinement is also associated with uncertainty and anxiety attributable to disruption in education, physical activities, opportunities for socialization [11], and changes to examinations and academic events for older adolescents [12]. Losing additional support on multiple fronts during lockdown, such as behavioural and mental health support from schools [13], or welfare support from other family figures outside the immediate household [14], can also cause changes and harm to children's emotional and behavioural health.

Indeed, as much as 85.7% of Spanish and Italian parents perceived changes to their children's emotional state and behaviours during lockdown, such as difficulty concentrating, irritability, loneliness, and uneasiness. They also used computers more frequently, moved less, and slept more [15]. In Italy, deterioration in children's mental health was observed for all ages and both genders [16]. In a France community sample, 7.1% of children presented with emotional difficulties and 24.7% presented symptoms of inattention and hyperactivity during lockdown [17]. Different patterns in the impact of the COVID-19 pandemic and lockdown on children and adolescents' mental health surface in different countries and regions, possibly due to vastly different social, economic, and political contexts. For example, a longitudinal study on three

European countries showed that children from Italy and Spain were more psychologically impacted by lockdown than Portuguese children, who already followed a general duty of home confinement in regular daily life [18]. This finding highlights the urgent need for studies in underrepresented populations for research generalization and comparison purposes. Currently, there is a paucity of pertinent studies outside Western countries and China, and such studies are especially lacking in Southeast Asian countries.

In addition to a lack of studies in the underrepresented parts of the world, much also remains unknown on the relative impact of public policies imposed by authority (e.g., school closures and stay-at-home orders) versus families' voluntary responses to the threat of the virus (e.g., self-quarantine) on the mental health of children and adolescents. Singapore provides a unique opportunity to examine these differences. Singapore experienced relatively distinct periods of the pandemic occurring but with no mandatory restrictions (February to March 2020), and of a nationwide lockdown known as the "circuit breaker" enforced by authority (April to May 2020). Contrasting these two periods of time can help separate the effects of voluntary versus imposed measures on children's mental health. The Singaporean population is also unique because being a small island nation means that policies like school closures and gathering bans were applied consistently nationwide (see Fig. 1 for Singapore policy implementation timeline). Thus, differences found between families were less likely to be confounded by varied isolating or social distancing conditions and policies in local communities. Lastly, Singapore has one of the lowest coronavirus death rates in the world (36 deaths out of over 62,000 cases as of mid-July 2021) [19]. This provides an ideal ground to study the indirect impact of COVID-19 on people's mental health, with little confounding effect from its direct impact on people's physical health.

Another understudied area in research on children's COVID-related mental health problems is the underlying mechanisms [2]. COVID-19 related stressors likely impact children's mental health indirectly through a myriad of factors, and these mediators are worth exploring to inform intervention. Social disruption caused by COVID-19 plausibly impacts child adjustment and mental health through a cascading process of first influencing caregiver mental health (e.g., parental depression and anxiety), which subsequently influences proximal family processes (e.g., parent-child interactions, familial conflict) and in turn affect child adjustment on multiple domains [20]. Recent emerging evidence supports the link between parental mental health during COVID-19, parent-child closeness and conflict [21, 22], and children behavioural maladjustment [4]. Moreover, parental emotion regulation mediated the impact of COVID-related stress on children's stress reactions [23], while parental stress mediated the impact of quarantine on children's behavioural and emotional problems [17, 24]. Particularly, maternal mental health may be more crucial in this process, as past research has shown that maternal but not paternal mental health predicts children's emotional lability [25], and that children whose mothers experience more psychological distress are at higher risk for socioemotional difficulties [26]. Other non-familial mediators may include

Fig. 1 Timeline of the COVID-19 Pandemic in Singapore

physical activity or time spent outdoors, which are crucial for adults' mental health during COVID-19 [27, 28], and children's mental health in general [29].

Taking advantage of the naturally occurring contrast between the different time periods in Singapore, we aimed to examine the effects of the pandemic and lockdown on children's lives and mental health. Specifically, we first aimed to investigate the effects of the pandemic on Singaporean children and adolescents' daily activities, social relationships, and mental health, and to explore potential additional effects that can be attributed to the imposed lockdown measures, above and beyond the effects of families' voluntary responses to the pandemic. Second, we aimed to explore the factors that may mediate the effects of the pandemic and lockdown on children and adolescents' mental health. To address these questions, we collected families' reports on children's lifestyles and mental health at three timepoints: Pre-pandemic (before local transmission), Pre-lockdown (during local transmission but before the "circuit breaker"), and Lockdown (during the "circuit breaker"). By comparing responses between Pre-lockdown and Pre-pandemic, we can estimate the effect of the pandemic as well as families' voluntary responses to it. By comparing responses between Lockdown and Pre-lockdown, we can estimate the additional effect of government-imposed lockdown measures. Parental mental health and parenting values and practices were also collected and analysed as potential mediators.

Method

Participants

The survey was part of a larger study approved by Nanyang Technological University Internal Review Board. The survey was distributed by email lists and social media to families with at least one child under the age of 18 years. Participants signed a consent form prior to participation, and received an eVoucher worth of SGD \$10 afterwards. We collected complete responses from 198 families residing in Singapore, which included 515 adults and 235 children. Of the 235 children, 164 were in the target age range (7–18 years, $M_{\text{age}} = 14.3$, $SD_{\text{age}} = 3.1$, 80 girls), including 44 school-aged children (7–12 years) and 120 adolescents (13–18 years). An additional 25 responses were excluded because they either were incomplete or failed a basic quality check (e.g., indicated < 20 hours of sleep per week). The demographics of the sample are comparable with the Singapore population (see Supplementary Table 1), except that sample median monthly household income (SGD \$6,500) was lower than the national median (SGD \$7,981), $\chi^2(1) = 10.3$, $p < .001$, and that Singaporean citizens were overrepresented, $\chi^2(1) = 67.9$, $p < .001$.

Instruments

Each family completed one survey online using the Qualtrics software. The survey was comprised of questions about the whole family and each child and adult in the family. Respondents who filled out the survey were asked to consult their family members on questions regarding them to ensure everyone's opinions were accurately represented. For measures

that may change because of COVID-19, we asked participants to report answers regarding three timepoints: Pre-pandemic (January 2020), Pre-lockdown (February to March 2020), and Lockdown (April to May 2020). All data were collected in June 2020. We used a 11-point scale (0–10) for all Likert items because it has superior psychometric properties and normality compared to scales with fewer points [30], and is also easy to comprehend.

Family-level Measures

Measures for the families included demographic information (citizenship, ethnicity, mother tongue language, type of housing), number of adults and children living in the household at each of the three timepoints, as well as whether anyone in the family had been diagnosed with COVID-19 or received a Quarantine Order (QO), a Leave of Absence notice (LOA), or a Stay-Home Notice (SHN).

Parental Measures

Parents reported basic information (gender, age, relation with children, education level, disabilities or mental health conditions) and their parenting values. For each time point, they also reported their mental health and behavioural control.

Parenting Values. Using the Child-Rearing Values Questionnaire [31, 32], adults were asked to choose one quality out of each pair that they thought is more important for a child: respect for elders or independence, curiosity or good manners, obedience or self-reliance, being considerate or being well-behaved. An authoritarianism score (0–4) was calculated by counting how many times respect for elders, good manners, obedience, and being well-behaved were chosen.

Parental Mental Health. The Patient Health Questionnaire-4 (PHQ-4) [33] includes two questions on anxiety and depression, respectively. The questionnaire has good internal reliability (Cronbach's $\alpha > 0.80$) and correlates strongly with the mental health subscale of the longer SF-20 ($r = 0.80$) [34]. We used a 11-point Likert scale (0 = *never*, 10 = *always*) instead of the original 4-point scale to increase sensitivity in our non-patient sample [30].

Behavioural Control Over Children. This construct was measured by two questions on a 11-point Likert scale, one about setting up rules for children, and the other about granting children autonomy (reverse coded).

Children's Measures

We collected children's basic information (gender, age, disabilities or mental health conditions). For each time point, we measured the amount of time they spent on various activities, their social relationships, mental health, and stress.

Time Spent. We collected reports on the time children spent on everyday activities like schooling, homework, social activities, entertainment, and sleeping. We also collected reports on time spent on digital devices and spent outdoors, as well as how much time they spent alone, versus with others such as mother and father. For each of these items, we asked them to report the average number of hours they spent per week. The responses were then divided by seven to get the number of hours per day, averaged across weekdays and weekends.

Social Relationships. This construct was measured by two sets of 11-point Likert scale measures. The first set measured how often children break rules, resist instructions from others, and make decision for themselves, as well as how much they experience conflict with each of their family members and people from outside. The second set measured their subjective ratings of how close they feel with each of their family members and people from outside.

Children's Mental Health. Similar to parental measure, this construct was also measured by PHQ-4 [33] with the same questions. In addition, each child also reported how frequently they experienced other negative emotions such as loneliness, boredom, and fatigue. Children also reported how much stress they felt from everyday activities, as well as from COVID-19-related stressors such as health concerns, restrictions on travel and social activities, and reading negative news.

Data analysis

The data analysis plan was preregistered on the Open Science Framework (<https://osf.io/9rkta>). All data were entered and analysed in Excel, IBM SPSS 22, and R. An α level of .05 (two-tailed) was used for all tests. Given the multilevel structure of our sample (time points were nested under children, and children were nested under families), we used three-level mixed-effects linear regression models for the omnibus tests, with random effects for child and family. Time point was treated as an independent variable with fixed effects, and was dummy coded with Pre-pandemic as the reference group. The models were implemented using the lme4 package in R, and were fitted using the maximum likelihood (ML) estimation instead of restricted maximum likelihood (REML) to facilitate model comparison.

To examine whether the effect of the pandemic and lockdown on children's mental health problems can be partially explained by changes in their lifestyle and relationship with others, we conducted mediation analyses for potential mediators suggested by significant predictions in mixed-effects linear regressions. For each mediator we ran two separate mediation analyses, one on data from Pre-pandemic and Pre-lockdown (pandemic is the independent variable), and the other on data from Pre-lockdown and Lockdown (lockdown is the independent variable). Each mediation effect was considered significant only when both the Sobel's test [35] and the bootstrapping method produced significant results. For the bootstrapping method, we used the Bayesian multilevel mediation model [36], which is suitable for multilevel data with a within-subject design. The indirect effect (*IE*) and its 95% Credible Interval (CI) were estimated by sampling 10,000 times from the posterior distribution.

Results

None of the participating families had any family member who were diagnosed with COVID-19. Six children from five families had received a QO, LOA, or SHN because they had travelled from another country or were in close contact with confirmed cases. Their anxiety and depressive symptoms did not differ from their peers for all time points, $ps > .40$. The pandemic and lockdown had little effect on household composition in our sample. Between January and May 2020, two

out of 198 families observed a change in children living in the household because of new-borns, and four families observed a change in adults because of long-term pass holders not being able to renew their passes, or adult children or relatives moving out.

Changes in Children's Everyday Activities, Social Relationships, and Mental Health

As shown in Table 1, children's time spent outdoors decreased significantly from Pre-pandemic (1.30) to Pre-lockdown (0.97 hour per day). During Lockdown, their time spent outdoors decreased further (0.46), as well as their time spent in school (0.98 vs. 3.52) and tuition/enrichment classes (0.24 vs. 0.53). At the same time, children spent more time on homework/home-based-learning, enrichment activities at home, digital devices (both for learning and for fun), social activities with family and relatives, indoor solitary play, and sleeping. Their time spent with mothers (4.12 vs. 3.03) and fathers (3.24 vs. 2.23) also increased significantly during Lockdown. There was a significant increase in children's conflict with mothers and fathers during the lockdown (see Table 2), as well as an increased tendency to resist or question others' instructions. At the same time, their closeness with mothers and siblings also increased significantly during lockdown.

Table 1 *Number of Hours per Day Children Spent on Each Activity*

	Pre-pandemic	Pre-lockdown	Lockdown
School (including school-based student care)	3.93	3.52*	0.98***
Tuition/enrichment classes outside school	0.57	0.53	0.24***
Homework/home-based-learning	1.67	2.03*	3.64***
Enrichment/educational activities at home	0.43	0.53*	0.72***
Using digital devices for learning	0.96	1.23*	2.42***
Using digital devices for fun	2.28	2.53*	3.18***
Outdoors	1.30	0.97***	0.46***
Social activities with friends	1.68	1.62	1.56
Social activities with family and relatives	1.36	1.41	1.83***
Indoor solitary play without digital devices	0.24	0.30	0.47***
Sleeping	7.39	7.58**	8.04***
Total wake time spent alone	3.15	3.13	3.34
Total wake time spent with mother	2.74	3.03	4.12***
Total wake time spent with father	2.02	2.23	3.24***
Total wake time spent with grandparent(s)	0.45	0.37	0.33
Total wake time spent with sibling(s)/friend(s)	2.73	2.96	3.31
Total wake time spent with domestic helper(s)	0.16	0.16	0.22

Note. Bolded numbers indicate that the number of hours at this timepoint were significantly different from that at the previous timepoint. Significant tests were carried out on the unstandardized coefficients (β s) for timepoint in the mixed-effect models, and was performed using the lmerTest package in R. Because we ran 17 mixed models each containing two comparisons (Pre-lockdown vs. Pre-pandemic, and Lockdown vs. Pre-lockdown), the α level was adjusted to .0015 (.05/34) to correct for multiple comparisons. * $p < .05$, ** $p < .01$, *** $p < .0015$.

Table 2 *Children's Interactions and Relationships with Others*

	Pre-pandemic	Pre-lockdown	Lockdown
How often did the child... (0: Never; 10: Always)			
break rules	1.85	1.84	2.24**
resist or question others' instructions	2.36	2.64*	3.10***
made decisions for himself or herself	4.55	4.85*	5.21**
conflict with mother	2.42	2.76**	3.24***
conflict with father	1.92	2.19*	2.66***
conflict with grandparents	0.32	0.28	0.40
conflict with helper(s)	0.17	0.17	0.19
conflict with sibling(s)	2.43	2.67*	3.02**
conflict with adult relatives outside of the home	0.18	0.15	0.17
conflict with children outside of the home	0.70	0.66	0.56
How close was the child with... (0: Not close at all; 10: Very close)			
mother	7.35	7.57**	7.86***
father	6.13	6.25	6.47*
grandparents	4.22	4.20	4.16
helper(s)	1.25	1.34	1.23
sibling(s)	6.48	6.61	7.03***
adult relatives outside of the home	2.72	2.64	2.46**
children outside of the home	4.71	4.49	4.16**

Note. Bolded numbers indicate that the number of hours at this timepoint were significantly different from that at the previous timepoint. The α level was adjusted to .0015 (.05/34) to correct for multiple comparisons. * $p < .05$, ** $p < .01$, *** $p < .0015$.

Table 3 *Children's Experiences of COVID-19 Related Negative Emotions and Stressors*

	Pre-pandemic	Pre-lockdown	Lockdown
Felt... (0: Never; 10: Always)			
anxious	1.33	1.89***	2.48***
depressed	1.32	1.81***	2.22***
lonely	1.10	1.71***	2.48***
bored	2.02	3.15***	4.87***
fatigued	2.06	2.62***	3.02*
Experienced stress from... (0: Not stressful at all; 10: Extremely stressful)			
amount of homework or home-based learning	3.11	3.78***	5.06***
inconveniences in completing homework or home-based learning	1.32	1.98***	2.86***
housework	1.32	1.46	1.81**
limited opportunities to travel or go outside	1.62	3.01***	4.24***
limited opportunities to socialize with friends	1.81	3.31***	4.62***
limited opportunities to visit family/relatives	1.46	2.03**	2.85***
not getting enough attention from caregivers	0.69	0.77	0.83
suboptimal living conditions	0.70	1.10***	1.37*
concerns about own health and safety	1.46	2.42***	3.11***
concerns about family members' health and safety	1.75	2.80***	3.45***
reading about negative news	1.55	2.23***	2.81***
financial difficulties	0.98	1.41**	1.72*

Note. Bolded numbers indicate that children's ratings at this timepoint were significantly higher than that at the previous timepoint. The α level was adjusted to .0015 (.05/34) to correct for multiple comparisons. The significance test was performed using the lmerTest package in R. * $p < .05$, ** $p < .01$, *** $p < .0015$.

Children's mental health problems (anxiety and depressive symptoms combined) increased significantly during Pre-lockdown (1.85 out of 10) compared to Pre-pandemic (1.33), $\beta = 0.53$, 95% confidence interval (CI) = [0.33, 0.73], and increased further during Lockdown (2.35) compared to Pre-lockdown, $\beta = 0.50$, CI = [0.29, 0.70]. These effects were significant for both school-aged children (β s = 0.78 and 0.54) and adolescents (β s = 0.44 and 0.48). Moreover, as shown in Table 3, the increase from Pre-pandemic to Pre-lockdown and from Pre-Lockdown to Lockdown were also significant for other negative emotions such as loneliness (β s = 0.60 and 0.77) and boredom (β s = 1.14 and 1.71). Fatigue increased significantly from Pre-pandemic to Pre-lockdown ($\beta = 0.56$), but not from Pre-Lockdown to Lockdown ($\beta = 0.40$). In terms of COVID-related stressors, the top stressor children faced during the lockdown was the amount of homework or home-based learning. The stressors which increased most in severity from Pre-pandemic to Lockdown were limited opportunities to socialize with friends, and limited opportunities to travel or go outside. Children also experienced significant increases in stress from concerns about the health and safety for their family members and themselves, inconveniences in completing homework or home-based learning, limited opportunities to visit family/relatives, reading about negative news, and suboptimal living conditions.

Factors That Influenced Children's Mental Health During COVID-19

Mixed-effect model showed that children's mental health during COVID-19 was predicted by seven factors (Supplementary Table 2): More mental health problems were associated with less time spent outside, $\beta = -0.26$, CI = [-0.56, -0.19], more conflict with fathers, $\beta = 0.15$, CI = [0.05, 0.25], less authoritarian mothers, $\beta = -0.45$, CI = [-0.77, -0.14], more authoritarian fathers, $\beta = 0.31$, CI = [0.03, 0.58], more maternal mental health problems, $\beta = 0.26$, CI = [0.11, 0.42], more adults in the household, $\beta = 0.41$, CI = [0.02, 0.81], and lower household income, $\beta = -3.4 \times 10^{-5}$, CI = $[-6.6 \times 10^{-5}, -7.9 \times 10^{-7}]$. Mediation analyses (Fig. 2) showed that three out of these seven variables partially mediated the effect of pandemic and lockdown on children's mental health. The effect of pandemic on children's mental health problems was partially mediated by time spent outside, *Indirect Effect [IE]* = 0.31, CI = [0.12, 0.42], Sobel's $t = 2.05$, $p = .04$, and conflict with father, *IE* = 0.09, CI = [0.03, 0.13], Sobel's $t = 5.40$, $p < .001$. The effect was fully mediated by mother's mental health problems, *IE* = 0.38, CI = [0.26, 0.52], Sobel's $t = 5.48$, $p < .001$. In contrast, the effect of lockdown on children's mental health problems was partially mediated by mother's mental health problems, *IE* = 0.16, CI = [0.05, 0.27], Sobel's $t = 5.00$, $p < .001$. In supplementary analyses, we further explored a multiple mediator model in Mplus 8.3 [37] to examine the relative contributions of time spent outside, conflict with father, and mother's mental health problems to the link between pandemic and children's mental health problems (see Supplementary Fig. 2). When considering all three potential mediators together, only mother's mental health problems significantly explained the link, *IE* = 0.30, CI = [0.08, 0.53], $p = .008$.

Fig. 2 Mediation Analyses on the Effects of Pandemic and Lockdown on Children's Mental Health Problems

Note. All coefficients were estimated by sampling the posterior distribution of the Bayesian multilevel mediation model for 10,000 times. The mean estimate can be different from the midpoint of the 95% Credible Interval because the Credible Interval was derived by sampling the posterior distribution, and was not calculated from the mean and standard error.

Discussion

This study set out to address two research questions. For the first research question, our data revealed significant changes in children's daily activities and social relationships during the COVID-19 period, reflecting general changes in family processes, routines, and dynamics. Notably, most of these changes were observed from Pre-lockdown to Lockdown, suggesting that changes in daily activities and social relationships were much more pronounced following the implementation of a nationwide lockdown than voluntary responses from families. In terms of children's daily activities, only one change was observed from Pre-pandemic to Pre-lockdown, where children spent less time outdoors. Some changes observed from Pre-lockdown to Lockdown were similar to the findings from other COVID-19 studies, such as less time spent indoors, more time spent on digital devices, and more time spent sleeping [15, 38]. Other changes may be more specific to Singapore, such as more time spent on homework and enrichment activities, which may be due to Singapore having educational structures in place to ensure the continuity of learning for students during lockdown. In terms of children's social relationships, significant changes were only observed between Pre-lockdown to Lockdown. Most changes can be attributed to spending more time together with family members, such as increase in conflict with parents, and increase in closeness with mothers and siblings.

For the second research question, our data revealed that mental health declined for both school-aged children and adolescents from Pre-pandemic to Pre-lockdown, and from Pre-lockdown to Lockdown. Mediation analyses showed that, first, mothers' mental health plays a crucial role in both transitions from Pre-Pandemic to Pre-lockdown, and from Pre-lockdown to Lockdown. Particularly, mother's mental health is the only significant mediator from Pre-lockdown to Lockdown. This finding highlights the critical impact maternal parenting has on children and their mental health. This finding is also consistent with the general psychological literature that child well-being is greatly influenced by maternal emotional well-being [26, 39], and as indicated in some studies, more so than paternal emotional well-being [25]. This finding may be due to the fact that mothers are usually the primary caregivers to children in many places around the world. Thus, children's emotional and behavioural well-being could be more contingent on that of their mothers' than fathers'. Indeed, according to the International Labour Organization, women globally spend 3 times more time on household caregiving as compared to their male counterparts. This number is 4.1 times for countries in Asia and the Pacific [40], indicating that children may spend more time with their mothers as caregivers and their well-being and behaviours may thus be more influenced by them.

Nonetheless, fathers still matter in impacting children's mental health. Our mediation analyses also revealed that conflict with father partly explained the effect of the pandemic on children's mental health from Pre-pandemic to Pre-lockdown. Studies on paternal parenting behaviours have shown that father involvement carries an array of positive benefits

for children's development and well-being that are both distinct from, and complementary to that of mother involvement. For example, fathers promote better physical, mental, and behavioural health [41], such as better socio-emotional adjustment [42], as well as better decision-making and problem-solving behaviour through greater physical engagement than is typically done by mothers (e.g., 'rough and tumble' play) [43]. They are also more likely to influence children with role-modelling behaviour such as how to make health and well-being behaviour decisions [41, 44]. Thus, conflict with fathers may deny or lessen these positive benefits and consequently impact children's well-being in a negative manner. Indeed, an Italian study found that with reallocation of household and childcare tasks during lockdown, an increase in father involvement during this period was accompanied by an increase in children's emotional well-being [16]. While the mediation analyses did not reveal a significant role of conflict with father during the lockdown period, we speculate that, unlike the case of the Italian study, Singaporean fathers spent even less time with their children during lockdown than mothers and siblings. Supporting this plausible explanation, our results found that the increase in time children spent with mothers and siblings was significant during lockdown but not so for fathers. In addition, parental data from the larger study of which the current study is a sub-sample [45] found that mother's conflict with other adults in the family (including fathers) partly explained the increase in mother's mental health problems during the pandemic and lockdown. Hence, consistent with the family system perspective [46], even though paternal mental health played a less direct role in affecting children's mental health in our sample, fathers still can influence children's mental health indirectly through affecting family relations and dynamics (e.g., couple relationships).

Lastly, our mediation analyses revealed that the number of hours children spent outside partially explained the effect of the pandemic on children's mental health from Pre-pandemic to Pre-lockdown. Physical activity has been shown to be more consistently associated with positive mental health when done outdoors than indoors [47], and the presence of green space has positive effects on reducing depressive and anxiety symptoms [48]. Studies conducted during the COVID-19 period have found that people who maintained or increased their time outside reported better mental health and less stress [49, 50]. Thus, less time spent outside due to COVID-related restrictions may lead to decreased physical activities and less exposure to natural environments, which may explain the partial mediation effect we found for children and adolescents' mental health problems. This finding underscores the need to facilitate outdoor opportunities in a manner that reaps its benefits but maintains safety amidst pandemic crises.

Overall, mothers' mental health appears to play the most critical role in influencing children's mental health during the pandemic as it remains significant in the multiple mediator model indicated in the supplementary analysis. In other words, maternal mental health appears to contribute more to children's mental health during the pandemic than time spent outside and conflicts with father. Again, this finding is congruent with the literature highlighting the more important role of

maternal parenting than paternal parenting in general on children and adolescents' mental health [26, 39]. The finding also suggests that targeting maternal mental health in intervention and counselling services and other family supports could achieve larger effectiveness than other potential environmental targets.

Strengths and Limitations

One notable strength of the current study is that we took a holistic view on COVID-related changes among children and adolescents by assessing not only their mental health, but also in multiple domains in their daily activities, social relationships, and stressors. We also collected reports on mental health of both their mothers and fathers, which allowed for analyses on the familial mechanisms underlying the impact of COVID-19. Another strength is that we took advantage of two unique time periods in Singapore (pandemic with and without lockdown) to try to separate the effects of families' voluntary responses to the pandemic, versus the effects of restrictions imposed by authorities. Our relatively representative sample demographically of the Singaporean population also increases the generalizability of the current findings.

Strengthen bearing in mind, a major limitation of this study to be considered when interpreting the current findings is that we relied solely on retrospective self-reports. These reports can be subject to biases related to social desirability [51, 52], memory errors [53, 54], and common method variance [55]. Nonetheless, we attempted to minimize memory errors by asking participants to think about concrete time points so that their reports can be contextualized, and we finished data collection within one month after the "circuit breaker". Findings from the current study need to be replicated and extended by future studies that combine self-report data with data collected by other methodologies (e.g., multi-informants), ideally collected longitudinally during the development of a crisis.

Implications

The current findings have several theoretical and practical implications. Our findings contribute novel empirical evidence of the impact of COVID-19 on Singaporean children and adolescents' daily life and mental health. The current study joins the emerging global effort and attention to elucidate various modifiable environmental variables underlying the link between COVID-19 and children's well-being to inform tailored intervention, and further corroborates the extant literature on the role of parental well-being and parent-child relationships in shaping the development of child well-being. In practice, the current findings call for attention towards the social and psychological costs of lockdown measures by government authority on top of economical ones. Supporting services should be made available for families as a whole. In order to promote children's well-being, parents' well-being and relationships with their children should also be supported and promoted. Parents can be provided with parenting resources, counselling services, and other forms of support that could aid in this process. COVID-19 has changed the way our society works, where remote learning and work may become more acceptable in the future, posing similar risks to families and children's well-being observed during lockdown. Thus,

Singapore and other countries should still have appropriate measures and support in place for families and children, and equip schools and community groups with relevant knowledge and tools.

Ethical standards

This work was approved by the appropriate ethics committee. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. All participants and their parents gave their informed consent prior to their inclusion in the study.

Conflict of Interest

The authors declare that they have no conflict of interest.

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Supplementary Table 1 *Demographic Information of Participating Families*

Survey item	Categories	Sample			Singapore population	
		No. of families	Percentage	Cumulative percentage	Percentage	Cumulative percentage
Citizenship	Singapore citizen	178	89.9%	89.9%	61.4%	61.4%
	Permanent residents	15	7.6%	97.5%	9.2%	70.6%
	Long-term pass holders	5	2.5%	100.0%	29.4%	100.0%
Ethnicity ^a	Chinese	155	78.3%	78.3%	74.4%	74.4%
	Malay	13	6.6%	84.8%	13.4%	87.8%
	Indian	27	13.6%	98.5%	9.0%	96.8%
	Mixed or others	3	1.5%	100.0%	3.2%	100.0%
Monthly household income before COVID-19 ^{a,b}	0 - 1,999	17	8.6%	8.6%	20.3%	20.3%
	2,000 - 3,999	32	15.2%	23.9%	10.1%	30.4%
	4,000 - 5,999	37	19.3%	43.1%	10.3%	40.7%
	6,000 - 7,999	35	18.3%	61.4%	9.5%	50.2%
	8,000 - 9,999	18	9.1%	70.6%	8.7%	58.9%
	10,000 - 11,999	22	10.7%	81.2%	8.0%	66.9%
	12,000 - 14,999	17	8.6%	89.8%	9.2%	76.1%
	15,000 - 19,999	10	5.6%	95.4%	9.5%	85.6%
	20,000 & Over	9	4.6%	100.0%	14.4%	100.0%
Mother's education level ^{a,c}	Secondary or lower	33	19.2%	19.2%	36.0%	36.0%
	Post-secondary	58	33.7%	52.9%	26.3%	62.3%
	University	81	47.1%	100.0%	37.7%	100.0%
Housing ^a	1 or 2 room HDB	5	2.5%	2.5%	6.2%	6.2%
	3 room HDB	23	11.6%	14.1%	17.5%	23.7%
	4 room HDB	53	26.8%	40.9%	31.8%	55.5%
	5 room HDB	62	31.3%	72.2%	23.1%	78.6%
	Condominium	45	22.7%	94.9%	16.2%	94.8%
	Landed property	10	5.1%	100.0%	5.0%	99.8%

Note. Information for Singapore population was retrieved from 2019 data published by the Singapore Department of Statistics. HDB = Public housing managed by the state Housing and Development Board.

^a For these items, “Singapore population” refers to Singaporean citizens and permanent residents (PRs) only.

^b Monthly household income for the sample was calculated by summing up all adult family members’ January 2020 income (including commissions, allowances, bonuses, and government subsidies), except for foreign domestic helpers (FDH). Monthly household income for the Singapore population was based on 2019 data, and included income from work and employer contributions to the Central Provident Fund (CPF).

^c Mother’s education level for the Singapore population is estimated based on the education level of all women between 25 and 64 years of age.

Supplementary Table 2 *Factors Predicting Children's Mental Health Problems During the COVID-19 Period*

	χ^2	<i>df</i>	<i>p</i>	VIF
Timepoint	4.23	2	.12	2.65
Measurements for the child				
Age	0.18	1	.67	1.29
Gender (0 = male, 1 = female)	2.08	1	.15	1.15
Number of hours spent...				
in school	0.37	1	.54	1.86
on digital devices	2.76	1	.10	1.85
outside	15.7	1	<.001	1.46
on social activities	0.75	1	.39	1.19
sleeping	0.00	1	.96	1.36
with mother	0.48	1	.49	4.34
with father	0.43	1	.51	4.08
Conflict with mother	0.87	1	.35	1.87
Conflict with father	9.01	1	.002	1.99
Closeness with mother	1.06	1	.30	1.91
Closeness with father	0.15	1	.70	1.57
Measurements for the child's parents				
Mother's education level	0.75	1	.39	2.29
Father's education level	0.61	1	.43	2.41
Mother's authoritarian values	7.92	1	.005	1.40
Father's authoritarian values	4.70	1	.03	1.42
Mother's behavioral control	2.28	1	.13	2.02
Father's behavioral control	1.72	1	.19	2.01
Mother's mental health problems	11.2	1	<.001	4.54
Father's mental health problems	1.3	1	.25	4.17
Measurements for the family				
Number of children	0.06	1	.81	1.20
Number of adults	4.20	1	.04	1.19
Ethnicity	1.27	3	.73	2.28
Monthly household income	4.03	1	.04	1.27

Note. The fixed-effect variables in the model included timepoint, children's everyday activities and social relationships, their parent's mental health and parenting values/practices, and family demographics. To avoid problems of multicollinearity, we did not include any predictors with a variance inflation factor (VIF) higher than 5. Children's experiences of various stressors were not included as predictors because they were highly correlated with each other as well as with mental health problems. Child and family were entered as random-effect variables in the mixed-effect model. Significant predictors are bolded. Because all statistical tests were parts of the same model, the α level was not adjusted following common practice.

Supplementary Fig. 2 Estimates from the Multiple Mediator Model Examining the Relative Contributions of Time Spent Outside, Conflict With Father, and Mother's Mental Health Problems to the Link Between Pandemic and Children's Mental Health Problems

Note. $^{**}p < .01$, $^{***}p < .001$.