



# Daily COVID-19 Stressor Effects on Children's Mental Health Depend on Pre-pandemic Peer Victimization and Resting Respiratory Sinus Arrhythmia

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## Abstract

Children's risk of poorer mental health due to the COVID-19 pandemic may depend on risk and protective factors heading into the pandemic. This study examined same-day associations between COVID-19 stressors and children's mental health using a daily diary design across 14 days, and considered the moderating roles of pre-pandemic peer victimization experiences and resting respiratory sinus arrhythmia (RSA; an indicator of cardiac regulatory capacity). Forty-nine Canadian children aged 8–13 years ( $M_{\text{age}} = 10.69$ , 29 girls) participated in the final wave of a longitudinal study just prior to the pandemic and a daily diary extension during the pandemic ( $N = 686$  pandemic measurement occasions). Multilevel modeling indicated that children had poorer mental health on days when they experienced a COVID-19 stressor (e.g., virtual academic difficulties, social isolation). A three-way interaction indicated that this association was stronger for those with higher pre-pandemic peer victimization experiences and lower pre-pandemic resting RSA; however, highly victimized children with higher resting RSA did not experience poorer mental health on days with COVID-19 stressors. Findings offer preliminary insights into the preceding risk and protective factors for children's mental health amidst major subsequent stress.

**Keywords** COVID-19 · Childhood · Mental health · Peer victimization · Respiratory sinus arrhythmia

The COVID-19 pandemic has heightened psychosocial stress and threatened mental health on a global scale. Accumulating evidence suggests that children and adolescents may be particularly vulnerable due to greater difficulties in understanding and adapting to sudden pandemic changes [1–3]. The majority of extant developmental studies on this topic are cross-sectional [3]; however, given the uncertain and fluctuating nature of the pandemic, effects on child mental health should ideally be examined as a dynamic process [4, 5]. Moreover, relatively novel and poorly understood pandemic effects may be best assessed in an ecologically valid manner as they naturally unfold in daily life [6, 7]. Hence, we adopted a daily diary approach in the present study to explore COVID-19 stressor effects on children's mental health over a 14-day snapshot of pandemic life.

While the pandemic's effects on mental health have been unprecedented in scale, not everyone has been affected to the same degree [3]. Factors denoting pre-pandemic risk and readiness may explain these differential effects [2–4]. We thus accounted for between-child differences in well-known risk and protective factors that were present before the pandemic to further understand which children were more or less likely to experience subsequent pandemic-related mental health challenges.

## COVID-19 Stress and Child Mental Health

The enduring COVID-19 pandemic has put children and adolescents of various backgrounds at risk of poor mental health [8]. A meta-analysis of 29 studies indicated that global rates of anxiety and depression in children and adolescents doubled during the pandemic relative to pre-pandemic estimates [9]. Suggested causes include limited peer contact and the transition to online learning due to school closures and lockdowns [10]. Nonetheless, the majority of evidence concerning the impacts of COVID-19 on child

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mental health is based on cross-sectional studies that utilized one-time, retrospective reports [3]. This methodological approach offers preliminary support for a link between COVID-19 and mental health challenges but falls short of explaining the dynamics of *when and whether these factors actually co-occur for children on a daily basis*. Even during typical times, indicators of mental health can vary considerably day-to-day within children and these within-child processes can further differ from one child to another [11–13]. Considering stress and mental health as dynamic processes may be especially worthwhile during COVID-19 because pandemic-related stressors are likely to introduce even more volatility [4, 14].

Capturing within- and between-child variations in mental health and isolating the contributions of ongoing COVID-19 stressors requires intensive longitudinal assessments of children's daily lives. A common intensive longitudinal method is the daily diary approach, which taps into the micro-level processes that unfold in real life by requiring respondents to report on the same set of variables once per day for a given period of time—usually about 2 weeks [15]. Yet, only a handful of studies examining pandemic impacts on child mental health have leveraged the daily diary approach [4, 7, 14, 16]. Moreover, although some of these studies have considered moderators immediate to the pandemic, such as child age [16], daily coping strategies and parental support [14], and COVID-related worries and isolation [4], none have considered *pre-pandemic* moderators. Addressing this gap is important because discerning how children's existing or pre-pandemic capacities support or hinder their adjustment *during* the pandemic can inform proactive efforts to foster resilience to future challenges [2, 5].

## Pre-Pandemic Risk and Protective Factors

Well-studied pre-pandemic factors may represent a promising starting point for explaining which children fare worse or better throughout the pandemic [2, 5]. In this study, we considered children's peer victimization experiences as a well-established risk factor [17, 18] and their resting respiratory sinus arrhythmia (RSA) as a biological regulatory capacity with links to various aspects of well-being and adjustment [19, 20].

## Peer Victimization Experiences

Some children may enter the pandemic with pre-existing stressors, which may put them at increased risk of developing mental health problems during the pandemic [2, 5]. One stressor that is common to children is bullying victimization, which is regarded as a global public health issue due to its high prevalence and negative developmental impacts [18].

Previous research indicates that highly victimized children are at heightened risk of mental health problems, particularly depression and anxiety [17, 21], as well as aggressive and externalizing behaviours [22]. Rudolph et al. [23] found that child-reported victimization experiences interacted with cortisol stress measured in anticipation of an impending interaction with an unfamiliar peer to predict depression 1 year later, suggesting that prior victimization heightened children's vulnerability to the negative implications of additional stress. Such findings align with the cumulative risk model, which posits that children who are exposed to multiple stressors in different life domains are at accumulated risk of mental health problems (for more empirical evidence of cumulative risk, see [24, 25]). Based on this cumulative risk perspective, children who were victimized heading into the pandemic may be particularly vulnerable to poorer mental health because they would be exposed to dual stressors and their compounding negative implications. Thus, the stress associated with pre-pandemic peer victimization and COVID-19 may accumulate and surpass children's stress tolerance threshold, heightening their risks of mental health challenges.

## Respiratory Sinus Arrhythmia (RSA)

One potential protective factor that is relevant to the examination of mental health amidst the pandemic is children's capacity to regulate their negative emotions and stress [26, 27]. Previous research from across the developmental spectrum suggests that regulatory capacities reduce the negative implications of stress [28]. For example, children with better emotion regulation tend to be less susceptible to the transgenerational effects of chronic physiological stress [29] and adolescents with more effective regulatory capacities tend to have better physical health in the face of increased family stress [30]. RSA is a biological indicator that allows researchers to assess regulatory capacities without the potential biases of traditional questionnaire reports [31]. It indicates vagus nerve activity in the parasympathetic division of the autonomic nervous system. The vagus nerve acts like a brake that slows the heart when engaged [32]. Higher RSA thus reflects greater autonomic regulatory capacity. When RSA is measured in a resting state (i.e., resting RSA), it is thought to reflect an individual's dispositional autonomic regulatory capacity [32]. Indeed, children with higher resting RSA tend to show better stress regulation and social competence [20, 33], whereas lower resting RSA has been characterized as a general marker of stress vulnerability [34]. Hence, higher resting RSA may buffer the association between pandemic stress and mental health.

## Peer Victimization Experiences and RSA

Pre-pandemic risk and protective factors may also have interactive effects on mental health amidst COVID-19. Specifically, the negative implications of victimization experiences may be weakened by stronger regulatory capacities. Cooley et al. [35] found that children who could effectively regulate their sadness and worry when exposed to bullying victimization were less likely to experience depressive and anxiety symptoms. McLaughlin et al. [36] found that psychosocial stressors across different domains, including peer victimization, were associated with greater anxiety and depression for adolescents with lower resting RSA but not for those with higher resting RSA. In a similar vein, adolescents with a bullying victimization history reported more depressive symptoms when they also demonstrated blunted RSA reactivity in response to a stressful social exclusion paradigm [37]. These findings suggest that higher resting RSA in the current study may attenuate the exacerbating role of victimization experiences on pandemic stress and mental health. This assumption aligns with the risk-protective model of resiliency whereby protective factors mitigate the association between risk factors and negative outcomes [38].

## Developmental Context

We situated our examination within the context of middle childhood because it marks a period when children not only become increasingly sensitive to their environment, but also undergo substantial changes across social and emotional domains of development [39]. For example, children's social networks expand significantly and peer relationships become salient as implied by increases in peer conflicts and friendship formations [40]. These changes can be accompanied by greater social-emotional challenges (e.g., unfamiliar peer and academic problems) and distressed feelings (e.g., anxiety, sadness), which may evolve into early-onset mental health challenges [41, 42]. In contrast, the developmental trajectory of resting RSA begins to level off from middle childhood to adolescence, implying that its regulatory role in middle childhood may continue into adolescence [43, 44]. Due to these developmental patterns, middle childhood presents a relevant context to examine effects of pre-pandemic resting RSA and peer-related challenges on unpredictable COVID-19 stressors and mental health.

## The Present Study

Although the pandemic has generally been associated with poorer mental health for children [3], our understanding of this association remains cursory because of limited research

on the daily effects of specific pandemic stressors on same-day mental health. Additionally, little is known about how pre-pandemic risk and protective factors moderate these dynamic pandemic processes. To address these questions, the current study leveraged a longitudinal project that began prior to and continued into the pandemic. Specifically, we examined the association between pandemic stressors and child mental health across 14 days and hypothesized that children would have poorer mental health on days with a pandemic stressor. We then leveraged point-in-time data collected prior to the pandemic to examine the extent to which between-child differences in peer victimization experiences and resting RSA exacerbated or weakened this day-to-day association. We hypothesized that higher pre-pandemic peer victimization experiences would exacerbate the association between pandemic stress and child mental health. In contrast, we hypothesized that higher resting RSA would buffer the daily effects of pandemic stress. In line with previous empirical findings [36, 37] and the risk-protective model of resiliency [38], we remained open to the possibility that the aggravating effects of pre-pandemic peer victimization on pandemic-induced mental health challenges would be lessened for children with higher resting RSA (i.e., a three-way interaction). Finally, we accounted for child age and gender as covariates based on previous studies linking them to stress tolerance and common mental health outcomes, such as anxiety and depression [9, 45].

## Methods

### Participants

Participants were children and their caregivers in Canada who participated in a 4-wave annual longitudinal study in the years leading up to the pandemic (2015–2020;  $N=197$  at wave 4). During the pandemic in January–February 2021 (post provincial COVID-19 lockdown), caregivers were contacted to see if they were willing to participate in a 14-day daily diary extension study. Forty-nine caregivers of children aged 8–13 years ( $M_{\text{age}} = 10.69$ ; 59% girls) agreed to participate (84% biological mothers; 84% married; 75% bachelor's degree or above; 76% had multiple children; 63% household income above \$60,000 CAD). Their ethnic composition included 47% Western European, 18% multi-ethnic, 6% Eastern European, 6% South/South-East Asian, 2% Middle Eastern, 2% East Asian, 2% African, 2% Central/South American and Caribbean, and 8% other (6% chose not to report). The present study utilized data from the pandemic diary study and the fourth wave of the prior longitudinal study (collected between February 2018 and February 2020). Independent-samples *t*-tests revealed that families who agreed vs. disagreed to participate in the COVID daily

diary extension did not significantly differ along the relevant demographic characteristics we collected (i.e., caregiver's level of education and household income;  $p$ s = 0.83 and 0.74, respectively).

## Procedures

Ethics approval was obtained from the University's Research Ethics Board. Oral assent was obtained from children and written informed consent was obtained from caregivers. Prior to the pandemic, children and their caregivers attended a 60- to 90-min laboratory session that was led by trained research assistants. Children were outfitted with physiological equipment and completed a battery of assessments in a designated room. Caregivers completed a questionnaire on their child's social-emotional development in a waiting area. At the end of the session, caregivers were debriefed and children were offered an age-appropriate book. For the pandemic daily diary study, caregivers received an email link to a questionnaire asking about their child's negative emotions and related experiences each night at 7 pm for 14 days. They were compensated with an age-appropriate book for their child.

## Daily Mental Health

In line with previous daily diary studies conceptualizing negative emotional experiences as indicators of children's state mental health [4, 7], daily mental health was measured by the intensity of children's sadness and anxiety experiences. This approach was also taken because the repetitive nature of diary studies necessitates brief and specific daily measures [14, 16]. Caregivers responded to the item "To the best of your knowledge, how intensely did your child experience the following emotions today?" for sadness and anxiety on a 10-point scale ranging from 0 = *not at all intense* to 9 = *very intense*. These scores were averaged and higher levels indicated poorer daily mental health.

## Daily COVID-19 Stress

Caregivers indicated whether or not their child experienced a COVID-19 stressor that day (0 = *no*, 1 = *yes*). For descriptive purposes, when caregivers stated *yes*, they were prompted to select the specific stressor from a list including the following: *concerns about own health*, *concerns about the health of a loved one*, *interpersonal or social issues (e.g., couldn't see a family member or friend in person)*, *school issues (e.g., difficulty adapting to a new schooling situation)*, *family issues*, *restrictions on behaviour*, *others' pandemic-related behaviour*, and *other*. This list was based on previous studies examining children's and adolescents' most prominent concerns about the pandemic [46, 47].

## Pre-pandemic Peer Victimization Experiences

Pre-pandemic peer victimization experiences were measured by three items adapted from a widely used peer victimization scale [48]. Items were "is picked on by other children", "is teased or made fun of by other children", and "is called names by other children." Caregivers reported these items on a scale ranging from 1 = *never true* to 4 = *often true*. Items were averaged, with higher levels representing more frequent victimization experiences ( $\alpha = 0.90$ ).

## Pre-Pandemic Resting RSA

Monitoring electrodes were secured slightly below the right clavicle and below the ribs on both sides. Three-lead electrocardiogram data were recorded with a Biopac MP150 data acquisition system and a BioNomadix module at a sampling rate of 2 kHz (Biopac Systems, Goleta, CA, USA). Leads from each electrode were connected to a module fastened around the midsection that communicated wirelessly via the MP150 with a computer in an adjacent room running the AcqKnowledge 4.2 data acquisition software (AcqKnowledge Software, RRID:SCR\_014279). After a 5-min rest period, children were asked to remain still while watching a 120-s video depicting a sea turtle swimming slowly in the ocean (see [49]). The research assistant left the room for the duration of the video. Physiological data collected during the video were imported to Mindware HRV 3.0.21 (Mindware Technologies, Gahanna, OH, USA) for visual inspection, cleaning, and RSA calculation. They were cleaned in two 60-second intervals to ease processing. An interval that required more than 20% of editing was excluded from further analysis. Resting RSA was computed as the mean level of RSA across the video.

## Analytic Strategy

First, missing data and preliminary analyses (i.e., tests of normality, descriptive statistics, correlations) were conducted. Given the nested structure of the data (i.e., daily measures of COVID-19 stress and mental health nested within children), multilevel modeling (MLM) was conducted in *Mplus* 8.5 [50]. An intercept-only model was examined to determine if there was variability in mental health to warrant an investigation of within- and between-child factors. Following this, a random slope model with COVID-19 stressors as a random effect at level 1 and the sole predictor was tested to determine if there was significant between-child variability in the within-child association between daily COVID-19 stress and mental health. Significant variability in the slope would allow an examination of the moderating roles of pre-pandemic peer victimization experiences and resting RSA.



In the model with predictors, COVID-19 stress was specified as a time-varying predictor at level 1 to determine its daily association with mental health and this slope was allowed to randomly vary between children at level 2. At level 2, pre-pandemic peer victimization experiences and resting RSA were specified as time-invariant predictors of the aforementioned slope to determine their respective roles in the association between daily COVID-19 stress and mental health. Additionally, the interaction term Peer Victimization Experiences  $\times$  Resting RSA was created and added at level 2 to test whether resting RSA moderated a potential aggravating effect of peer victimization experiences on the level-1 stress–mental health slope. To account for potential confounds of age and gender differences, these two variables were added as covariates at level 2 predicting mental health and the level-1 stress–mental health slope. However, only significant covariates were retained in the final model to maintain model parsimony and as much power as possible [51]. Simple slopes analyses were conducted to probe significant interactions [51].

## Results

### Missing Data

Missing data rates for victimization experiences and resting RSA were 8.16% and 18.37%, respectively. Caregivers completed an average of 10.96 ( $SD = 3.61$ ) records for the 14-day diary study. In other words, the compliance rate for the daily diary variables was approximately 78%. Little's MCAR test was not significant,  $\chi^2(819) = 772.29$ ,  $p = 0.88$ , indicating that the data might be missing completely at random (MCAR). Accordingly, full information maximum likelihood (FIML) estimation was used to retain all participants at level 2 and bolster the level-1 sample size to 686. This estimation method has been found to provide more reliable estimates than listwise deletion, pairwise deletion,

and multiple imputation under the assumption of ignorable missing data patterns [52].

### Preliminary Analyses

Within-child variables (i.e., COVID-19 stress and mental health) were averaged up to create between-child scores for descriptive analyses. No issues concerning normality (skewness = 0.08 to 1.54, kurtosis =  $-0.73$  to 2.99) were evident based on recommended guidelines (skewness  $< 3$ , kurtosis  $< 8$ ; [53]). Descriptive statistics and zero-order correlations between the examined variables and covariates are presented in Table 1. COVID-19 stress was at moderate levels. Frequencies of underlying reasons for stress are outlined in Table 2 to aid interpretation of results. The most frequently cited COVID-19 stressor for children was school issues, such as difficulty adapting to a new schooling situation (e.g., online learning). COVID-19 stress was correlated with poorer mental health at the within and between level. In other words, the presence of COVID-19 stress was correlated with same-day poorer mental health (as compared to typical days with stress unrelated to COVID-19). In addition, children who were exposed to more COVID-19 stress across the entire study tended to have poorer overall mental health relative to other children with less stress. Pre-pandemic victimization experiences were associated with poorer overall mental health during the pandemic. On average, girls were more likely to experience COVID-19 stress across the 14 days.

### Predicting Mental Health and the Daily Association Between COVID-19 Stress and Mental Health

A preliminary null (intercept-only) model revealed an intra-class correlation (ICC) of 0.48, indicating that 48% of the variance in mental health could be explained by between-child factors and thus confirming the use of multilevel modeling to disaggregate variance into within variance = 1.63,

**Table 1** Descriptive statistics and zero-order correlations

Variable	1	2	3	4	5	6	<i>M</i>	<i>SD</i>	Range (min–max)
1. Mental health	1	0.19***					1.57	1.76	0.00–9.00
2. COVID-19 stress	0.51***	1					0.31	0.31	0.00–1.00
3. Victimization experiences	0.30*	0.24	1				1.70	0.65	1.00–3.33
4. Resting RSA	0.02	0.02	$-0.04$	1			6.96	1.08	4.71–9.87
5. Age	$-0.06$	$-0.16$	$-0.01$	0.01	1		10.69	2.21	8.23–13.99
6. Gender	$-0.11$	$-0.29^*$	0.20	0.20	$-0.18$	1	–	–	–

Above the diagonal line = within-level correlations. Below the diagonal line = between-level correlations. For between level, COVID-19 stress and mental health = average across 14 days. COVID-19 stress: *unrelated to COVID-19* = 0 and *related to COVID-19* = 1. Gender: *girls* = 0 and *boys* = 1. Descriptive statistics are averaged up to the between level as applicable

\* $p < 0.005$ ; \*\*\* $p < 0.001$

**Table 2** Reasons for children's daily COVID-19 stress

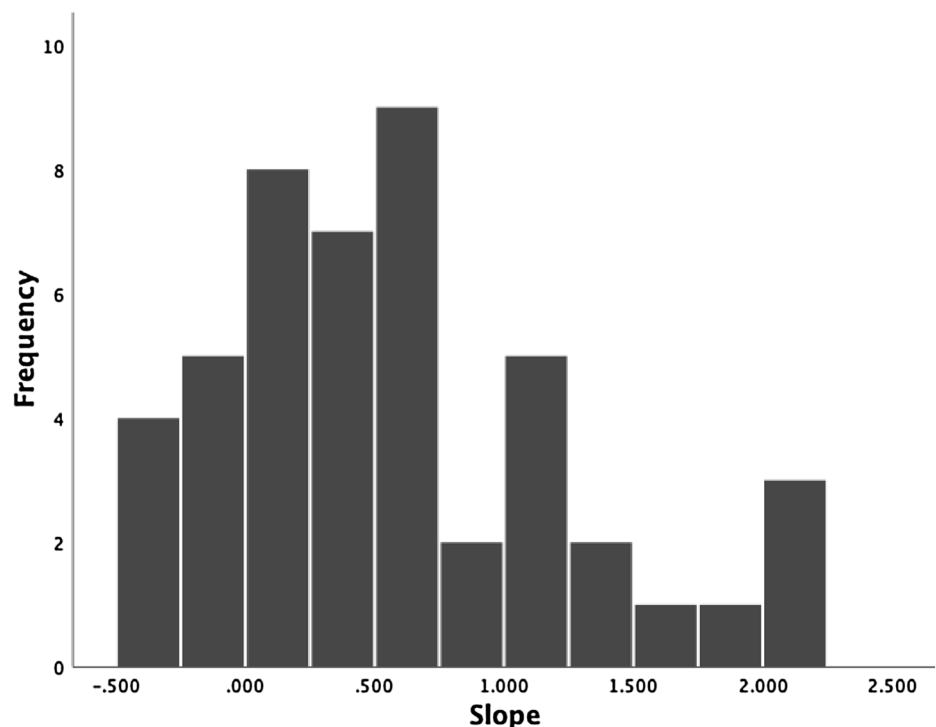
Reason	%
Concerns about own health	6.62
Concerns about the health of a loved one	10.29
Interpersonal or social issues (e.g., couldn't see a family member or friend in person)	12.50
School issues (e.g., difficulty adapting to a new schooling situation)	34.56
Family issues (e.g., conflict with siblings)	11.03
Restrictions on behaviour (e.g., having to wear a mask or follow social guidelines)	12.50
Others' pandemic-related behaviour (e.g., others not following public health guidelines)	7.35
Other	5.15

Percentage frequency of overall occurrence reported

$SE=0.26$ ,  $p<0.001$ , 95% CI [1.28, 2.14], and between variance = 1.48,  $SE=0.53$ ,  $p=0.005$ , 95% CI [0.44, 2.52]. The random slope model, within  $R^2=0.17$ ,  $p<0.001$ , indicated a significant overall effect of COVID-19 stress on mental health,  $b=0.51$ ,  $SE=0.21$ ,  $p=0.01$ , 95% CI [0.10, 0.92], suggesting that, on average across participants, mental health was worse on days with vs. without the presence of COVID-19 stress (residual variance at within level = 1.45,  $SE=0.25$ ,  $p<0.001$ , 95% CI [0.96, 1.93]). As presented in Fig. 1, significant variance was found for this level-1 daily association from child to child at the between level, variance = 1.03,  $SE=0.26$ ,  $p<0.001$ , 95% CI [0.51, 1.54], with some children showing poorer daily mental health in lockstep with COVID-19 stress but others showing little to no link between these factors. Children also differed in

their average level of mental health at between level, variance = 0.88,  $SE=0.28$ ,  $p<0.001$ , 95% CI [0.35, 1.42]). Hence, our planned moderation analyses were conducted to potentially explain this variability.

Two models (i.e., with vs. without covariates) were compared to determine the most parsimonious model. For the model with covariates, neither age ( $b=0.07$ ,  $SE=0.09$ ,  $p=0.43$ , 95% CI [- 0.10, 0.24]) nor gender ( $b=-0.55$ ,  $SE=0.48$ ,  $p=0.25$ , 95% CI [- 1.49, 0.39]) emerged as a significant covariate of the slope. Similarly, no significant main effects were evident on mental health for age ( $b=-0.06$ ,  $SE=0.08$ ,  $p=0.43$ , 95% CI [- 0.23, 0.10]) and gender ( $b=-0.24$ ,  $SE=0.29$ ,  $p=0.41$ , 95% CI [- 0.81, 0.33]). To identify the best-fitting model, their Akaike's Information Criterion (AIC) and Bayesian Information Criterion (BIC)

**Fig. 1** Graphical depiction of the dispersion in the association between daily COVID-19 stress and mental health

Note. Average slope effect = .51,  $SE = .21$ ,  $p = .01$ , 95% CI [.10, .92].

values were compared. A difference larger than 10 is considered sufficient and the model with lower AIC and BIC values is deemed a better fit to the data [53, 54]. Results indicated that the model without covariates (AIC = 2706.38, BIC = 2792.47) fit the data better than the model with covariates (AIC = 3004.26, BIC = 3126.59). Moreover, the findings for the core variables were consistent across both models. Hence, the model without covariates was retained (see Table 3).

As presented in Table 3, the between-level residual variance in the slope of COVID-19 stressors on daily mental health became marginally significant with the addition of level-2 predictors (compared to the significant variance found in the slope-only model), indicating that the variance in the slope was meaningfully explained by the predictors. With respect to the core analyses, no significant main effects on mental health were evident at level 2 for victimization experiences, resting RSA, and their interaction. However, peer victimization experiences significantly predicted the level-1 stress–mental health slope, such that the daily association between COVID-19 stress and mental health was stronger for those with higher pre-pandemic peer victimization experiences. No significant moderation effect was evident for resting RSA on the slope but its interaction with peer victimization experiences on the slope was significant. Specifically, the positive, aggravating effect of

peer victimization experiences on the stress-mental health slope was significant for children with lower ( $-1 SD$ ) levels of resting RSA,  $b = 1.25$ ,  $SE = 0.37$ ,  $p < 0.001$ , 95% CI [0.54, 1.97], but not for those with higher ( $+1 SD$ ) levels of resting RSA,  $b = 0.15$ ,  $SE = 0.36$ ,  $p = 0.67$ , 95% CI [ $-0.55$ , 0.86] (see Fig. 2).

## Discussion

The aim of the present study was to examine the dynamic association between pandemic stressors and child mental health while considering the moderating roles of pre-pandemic risk and protective factors. To address this aim, we employed a daily diary approach during the pandemic and leveraged information collected in a longitudinal study prior to the pandemic. Current findings suggest that COVID-19 stressors have negative implications for children's mental health on a daily basis, but also shed light on pre-pandemic factors that may heighten or lower children's susceptibility to these implications.

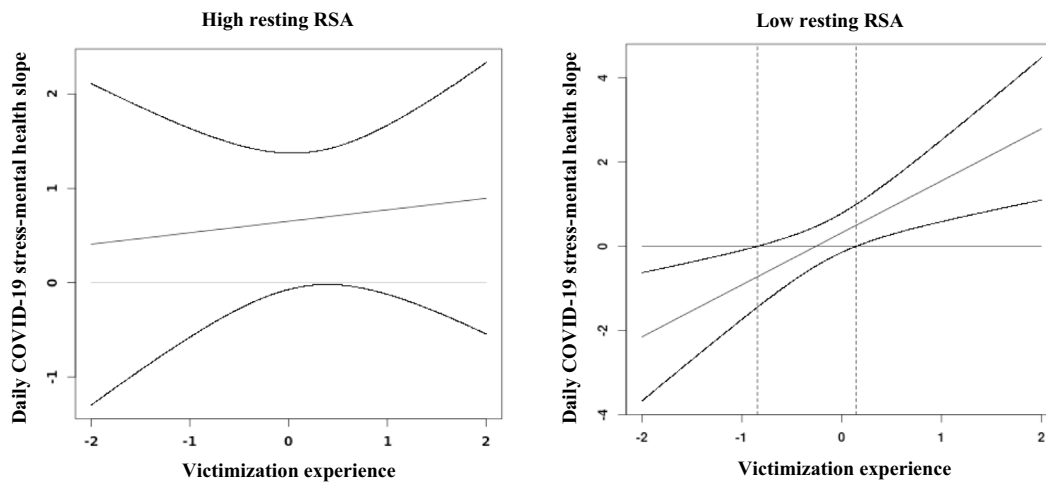
Consistent with our primary hypothesis, children experienced poorer mental health on days when there was a COVID-19 stressor. These findings align with pre-pandemic developmental patterns indicating increased mental health challenges in response to unpredictable stressors in

**Table 3** Two-level MLM predicting mental health and daily association between COVID-19 stress and mental health

Within-level outcome	Predictor	Coefficient	SE	p	95% CI
Mental health	COVID-19 stress	0.48	0.24	0.04	[0.02, 0.95]
Mental health	Residual variance	1.42***			
Mental health	$R^2$	0.17***			
Between-level outcome	Predictor	Coefficient	SE	p	95% CI
COVID-19 stress → Mental health slope	Victimization experiences	0.68	0.29	0.02	[0.12, 1.24]
	Resting RSA	0.16	0.19	0.41	[ $-0.21$ , 0.52]
	Victimization Experiences × Resting RSA	$-0.52$	0.23	0.02	[ $-0.96$ , $-0.07$ ]
Mental health	Victimization experiences	0.27	0.20	0.19	[ $-0.13$ , 0.67]
	Resting RSA	0.05	0.10	0.62	[ $-0.15$ , 0.25]
	Victimization Experiences × Resting RSA	$-0.01$	0.13	0.94	[ $-0.27$ , 0.25]
COVID-19 stress → Mental health slope	Residual variance	0.71, $p = 0.059$			
Mental health	$R^2$	0.93**			
COVID-19 stress → Mental health slope	Residual variance	0.30***			
Mental health	$R^2$	0.11***			

Same-day effect of COVID-19 stress → Mental health was also significant in a random-slope model without level-2 predictors/covariates,  $b = 0.51$ ,  $SE = 0.21$ ,  $p = 0.01$ , 95% CI [0.10, 0.92]

\*\* $p < 0.01$ ; \*\*\* $p < 0.001$



Note. The curved outer lines represent confidence bands. Simple slope was significant for low resting RSA but not for high resting RSA.

**Fig. 2** Moderating role of peer victimization experiences on the association between daily COVID-19 stress and mental health at different levels of resting RSA

middle childhood [39]. Moreover, they corroborate extant cross-sectional literature concerning the negative impacts of COVID-19 stress on children's mental health [8, 9]. Importantly, the findings add to the limited body of work demonstrating the daily dynamics of this association [14, 16]. Given that cumulative effects of daily stress can increase vulnerability to depressive symptoms and anxiety [55, 56], and that internalizing emotions such as sadness and anxiety underpin depression and anxiety disorders [57, 58], these findings suggest that children who are exposed to COVID-19 stressors on a daily basis may be at risk of developing pathological symptoms over time.

However, there is also a possibility that children learn to adapt to COVID stress over time by using relevant coping strategies. In line with this assumption, the stress inoculation model posits that mild to moderate (i.e., manageable) levels of stress may help children develop adaptive stress responses to subsequent stressors [59, 60]. Some empirical studies suggest that exposure to moderate levels of stress activates coping mechanisms and promotes affective regulation in childhood [61, 62]. Longer-term studies conducted later into the pandemic are needed to clarify the potential inoculating effects of chronic pandemic stress.

Although not the primary focus of the present study, results from descriptive analyses pinpointed school-related issues (e.g., sudden transition to online learning) as the most salient source of COVID-19 stress for children on a daily basis. A potential reason is that parents became heavily involved in school-related matters as a result of school closures—a novel challenge that may have increased the likelihood of negative parent-child interactions (stemming from

shared stress) and corresponding negative affect for children (see [7, 63]). Researchers could extend the current findings by considering the effects of specific school-related concerns on child mental health to better understand this association and inform approaches to improve distance learning or hybrid models. Another significant source of children's daily COVID-19 stress was social issues (e.g., not being able to see friends). These findings align with developmental work on the increased significance of peer relationships in middle childhood [40], which may explain why social issues factored prominently into children's stress levels over our 14-day study.

Partly in line with our secondary hypothesis, children who were victimized prior to the pandemic were at increased risk of poorer mental health during the pandemic. These findings substantiate the developmental significance of peer relationships in middle childhood by implicating pre-pandemic peer victimization in the negative mental health impacts of COVID-19 stress for children of this age. They also align with previous studies demonstrating the additive contributions of peer victimization and other sources of stress (e.g., family conflict and adverse childhood experiences) to poor mental health [64, 65]. These findings suggest that pre-pandemic victimization may have long-term compounding impacts with non-victimization-related stressors, including COVID-19. This parallels Guo et al.'s [66] study, which indicated that pre-pandemic adverse childhood experiences (e.g., maltreatment) exacerbated the negative impacts of COVID-19 exposure on post-traumatic stress symptoms and anxiety among a group of adolescents in rural China. Thus, children with cumulative risk experiences may



be particularly vulnerable to mental health challenges in the context of COVID-19 [24].

Regarding our final, more exploratory hypothesis, pre-pandemic resting RSA interacted with pre-pandemic peer victimization experiences when predicting the effects of daily pandemic stressors. Specifically, children who had been victimized but had higher resting RSA were less likely to be emotionally impacted by COVID-19 stressors. Higher resting RSA capacities might have helped children modulate pre-pandemic victimization experiences, thereby mitigating their exacerbating role in later COVID-19 stress. These findings align with previous studies indicating that children with lower resting RSA tend to have worse mental health when exposed to stressors (e.g., violence exposure), whereas children with higher resting RSA experience lesser or null effects of stress [6, 36, 67]. However, contrary to our hypothesis that pre-pandemic resting RSA would directly mitigate the role of pandemic stress on mental health, no significant moderation effects were evident on the daily stress–mental health slope after controlling for effects of pre-pandemic peer victimization and the aforementioned significant interaction of pre-pandemic peer victimization and resting RSA. As resting RSA is subject to changes as a function of environmental stress [44, 68], future studies may wish to investigate pre-pandemic and concurrent (i.e., pandemic) resting RSA to gain a more comprehensive understanding of its protective potential. For example, in the present case, the buffering role of resting RSA might have been stronger on pre-pandemic victimization relative to pandemic stress because it was also measured before the pandemic.

### Limitations, Contextual Considerations, and Future Directions

The current findings need to be interpreted in light of some limitations. First, pre-pandemic peer victimization experiences were parent reported. Although child–parent agreement on peer victimization can be quite high (e.g., interrater reliability = 0.81 to 0.92) in middle to late childhood; [71]), future research should include child reports because children might not disclose all victimization experiences to their parents. Relatedly, daily diary data were parent reported. Although the pandemic might present a context for parents to be more aware of children’s mental health (e.g., parents may have more opportunities to interact with children due to less commuting/more home time) and child–parent agreement on children’s feelings and emotions is significant and moderate (albeit weaker compared with external symptoms/behaviors; [69, 70]), future research should include child reports to fully capture the dynamics of their daily mental health. These limitations should also be considered within the mitigating context of our design, as repeated measures

gave parents more opportunities to observe and capture their children’s experiences in the realm of mental health and the time lapse between pre-pandemic reports of peer victimization experiences and pandemic daily diary reports may have offset potential shared-informant/shared-method effects. Second, mental health was evaluated by the intensity of internalizing emotions (i.e., sadness and anxiety). To better account for the spectrum of child mental health, future studies should incorporate behavioral mental health symptoms in children that are pertinent to the pandemic (e.g., disruptive and aggressive behaviors). Lastly, our relatively small sample size limited our power at level 2. Although our main effect of pre-pandemic victimization and our interaction effect held across models with and without covariates and align with previous findings and theory, they should be interpreted with proportionate caution relative to our level-1 findings. Nonetheless, these sample limitations should be considered in light of the diary portion being mobilized in the middle of a global pandemic. The level-2 findings also add to very limited literature on potential pandemic moderators and can be used as a starting point to further consider the buffering and hindering roles of pre-existing factors in major subsequent stress.

### Conclusions

The American Academy of Pediatrics, American Academy of Child and Adolescent Psychiatry, and Children’s Hospital Association have declared a national emergency for child and adolescent mental health due to the COVID-19 pandemic [72]. Our findings concur with these cautionary calls by underscoring the effects of COVID-19 stressors on children. Daily pandemic stressors had a greater mental health impact than other sources of daily stress. Children who experienced peer victimization heading into the pandemic were seemingly less equipped to deal with pandemic challenges. Autonomic regulatory capacities may act as a potential buffer for such children. From a practical perspective, our findings tentatively suggest that preventative initiatives and/or interventions to support vulnerable or victimized children’s capacity to cope with concurrent stressors (see [26, 73]) may have knock-on benefits, as well-regulated victimized children may be better equipped to deal with major subsequent stress in novel realms.

### Summary

Not all children are affected by COVID-19 to the same degree, suggesting that pre-pandemic risk and protective factors may be at play. We adopted a daily diary approach to examine dynamic associations between daily COVID-19

stressors and mental health while leveraging longitudinal data to account for pre-pandemic risk and protective factors, namely peer victimization and resting respiratory sinus arrhythmia (RSA). Children had poorer mental health on days when they experienced a COVID-19 stressor, and this association was stronger for those with higher pre-pandemic peer victimization experiences and lower pre-pandemic resting RSA. Current findings suggest that preventative initiatives and/or interventions may benefit from focusing resources on vulnerable or victimized children's coping .

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**Data Availability** The data underlying this manuscript cannot be shared publicly because we did not receive permission from our Research Ethics Board.

## Declarations

**Conflict of interest** The authors have declared that they have no competing or potential conflicts of interest.

**Ethical Approval** This study was approved by the University's Research Ethics Board.

**Informed Consent** Children provided informed oral assents and caregivers provided informed consents.

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