Impact of COVID-19 on maternal health and child care behavior: Evidence from a quasi-experimental study of vulnerable communities in Boa Vista, Brazil

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A B S T R A C T

Background: COVID-19 related distress has been shown to have negative associations with family well-being.
Objectives: To determine the immediate impact of acute COVID-19 infection on maternal well-being and parenting practices among Brazilian families.
Participants and setting: We studied 2′579 mothers (29′913 observations) of young children from vulnerable neighborhoods in Boa Vista, Brazil over 12 months.
Methods: We monitored family health and caregiving behavior including the incidence of COVID-19 infections in the surveyed households through bi-weekly phone interviews over 50 weeks, from June 2020 to May 2021. Primary outcomes were home-based child stimulation, positive parenting behavior, and parenting stress. We used fixed effects panel regressions to estimate the impact of household COVID-19 infections on parenting outcomes.
Results: Over the study period, 441 participants (17.1%; 831 (3.0%) observations) reported at least 1 positive COVID-19 infection in their household. Household COVID-19 infections significantly reduced home-based stimulation by 0.10 SDs (95%CI: −0.18, −0.01), positive parenting behaviors by 0.14 SDs (−0.21, −0.01), and increased parenting stress by 0.07 SDs (0.02, 0.12). The impact on home-based stimulation was most pronounced when the mother herself had a COVID-19 infection (−0.16; −0.29, −0.04). Parenting stress responded most strongly to mother or child COVID-19 infections. Effects were relatively short-lived, only children's infections' on parental stress was still detectable 2 weeks after initial infection.
Conclusion: Our findings suggest that COVID-19 infections cause substantial disruptions in children's home environments - additional short-term support for families with acute infections could attenuate the negative impact on children's home environment during the pandemic.

1. Introduction

The COVID-19 pandemic has impacted lives globally not only through an increased burden of infections and death but also through societal changes partly induced by government restrictions imposed to restrict the spread of the SARS-Cov-19 virus. Both the pandemic

and accompanying measures can be perceived as stressors for families. Recent studies show that various factors related to these preventive measures such as social isolation lead to an increased burden on families or households even when they were not directly exposed to the virus (Bavel et al., 2020; Chung et al., 2020). Along with the progressing pandemic, increasingly detailed reports have documented the negative impact of the pandemic on parental behaviors and attitudes, family bonding, and economic status of families (Brown et al., 2020; Calvano et al., 2021; Croda & Grossbard, 2021; Fabbri et al., 2020; Kimura et al., 2021; Lawson et al., 2020; Lee et al., 2021; Ortega Pacheco & Martinez Rudas, 2021; Wong et al., 2021; Zhang, 2020), particularly those living in poorer and minority communities (Brown et al., 2020; Kim & Bostwick, 2020; You et al., 2020).

Changes in mental health appear to play a crucial part in explaining how the pandemic has affected families and parenting behavior. Declines in mental health have been documented in several countries (Xiong et al., 2020), particularly during the first pandemic shock in the first half of 2020. Sustained declines in mental health were reported especially for deprived neighborhoods and mixed race (Pierce et al., 2020, McKnight-Eily et al., 2021, Pierce et al., 2021, Tausch et al., 2022, Wong et al., 2022). The adverse impacts were found to be stronger among women, more so in childbearing age (18–34), people living with young children, people being infected with COVID-19, and people in areas of local lockdown and with financial difficulties. Mental health has long been recognized as key risk factor for healthy child development (McPherson et al., 2008). Caregiver mental health is critical especially at developmental periods at younger ages, when the brain is particularly sensitive to environmental inputs (Berens & Nelson, 2019; Black et al., 2017; Shonkoff et al., 2012). The economic impact of the COVID-19 crisis might act in a similar way on health and wellness outcomes as demonstrated for other economic crises (Mucci et al., 2016). Economic implications might furthermore act as stronger stressor in non-affluent countries, poorer communities and household (Egger et al., 2021).

Despite growing evidence of the impact of COVID-19 on family behaviors and strain, there are to date no studies that assessed the immediate effects of COVID-19 infections in a given household with maternal behaviors and attitudes. Previous studies have mostly been cross-sectional and focused on the impact of the pandemic on average behavior, without separating those who get directly exposed to the virus from those mostly affected by restrictions and by external threat perceptions. A majority of studies so far has been conducted in affluent countries where governments have the financial resources to mitigate economic strain on households and discrepant effects on poorer and more vulnerable communities might have been missed. Finally, there is some evidence that the pandemic affects women stronger (Croda & Grossbard, 2021) but in depth analysis are lacking.

This study aimed at better understanding the immediate impact of acute COVID-19 infections on maternal caregiving behaviors and attitudes as well as the duration of such effects. To do so, we used recent data from a prospectively collected panel of mothers with young children living in poor urban neighborhoods of Boa Vista, Brazil.

2. Methods

2.1. Study setting

The study was conducted in urban areas of the city of Boa Vista, Brazil (Brentani et al., 2020) from June 2020 to May 2021, during a critical phase of the COVID-19 Pandemic. The municipality of Boa Vista is located in state Roraima in the amazon area in the north of Brazil. In 2021, the population of the capital city of Boa Vista was estimated at 435′000, about two thirds of the state's population (Instituto Brasileiro de Geografia e Estatística, 2021). Approximately 30% of families ($N = 22′377$) were receiving or enrolled in social cash transfers under the bolsa família program; this was comparable to the national average of 35% (Ministério da Cidadania, 2019).

The WHO confirmed COVID-19 as pandemic on 11 March 2020 and Latin America was declared the epicenter of the pandemic, largely based on Brazil's case numbers (Castro et al., 2021; Neiva et al., 2020). The lack of a coordinated, effective and equitable response contributed to Brazil being among the highest ranking deaths worldwide and a disproportionally higher burden among the most vulnerable was reported (Baqui et al., 2020; Hallal et al., 2020).

2.2. Participants and design

The study population was part of the "Survive and Thrive Brazil: The Boa Vista Early Childhood Program", a randomized controlled trial (RCT) studying the effects of early life parenting training programs on childhood development outcomes at the age of 2 years (Brentani et al., 2020). Starting at the beginning of 2018, all vulnerable pregnant women from 53 neighborhoods in Boa Vista, Brazil were contacted (details in supplement Table s1), focusing on areas with a medium or high Social Vulnerability Index (Costa & Marguti, 2015). Women were classified as vulnerable if they were bolsa família recipients, adolescents or had been exposed to domestic violence. RCT study participants were randomly allocated to either control or intervention group; the latter received biweekly visits or center-based meetings to re-enforce positive parenting behaviors regarding child's health and development. Women in the intervention groups were eligible for the present study. All women were contacted and surveyed using telephone calls and Whatsapp messaging as per participants' preferences, aiming at a follow-up assessment at every 2 weeks. For recruitment and follow-up interactions, we attempted to contact participants multiple times per instance, i.e. in case of no response to a first attempted contact, another attempt took place the same day and again on the three following days. The telephone surveys were conducted by trained and supervised staff. Our period of analysis covered 50 weeks, from epidemiological week 24, 2020 (starting 9 June) through week 21, 2021 (until 27 May). We restricted the data to participants who completed at least 2 follow-up assessments to enable the use of family fixed effects in our empirical model.

The data collected for this project was approved under protocol CAAE 73722917.4.0000.0076. No incentives for participation in the present study were given.

Data on Brazil's officially reported COVID-19 case numbers for the period of analysis were retrieved from The Influenza Epidemiological Surveillance Information System (SIVEP-Gripe), an information system of the Ministry of Health that captures all notifications of severe acute respiratory illness (SARI) hospitalizations (Bastos et al., 2020; The Sistema Único de Saúde, 2021).

2.3. Measurements

Sociodemographic variables included the respondents' age and residential neighborhood vulnerability, which were categorized into A (least vulnerable), B (intermediate), and C (highly vulnerable).

2.3.1. Outcome variables

The outcome variables for this study were the occurrence of the following subject level parental and household variables during the week (7 days) prior to the phone interview, with the exception of occurrence of home-based stimulation which was assessed for 3 days prior. Home-based child stimulation was defined as sum (range 0–6) of the presence of six parent-child activities developed for the Multiple Indicator Cluster Survey (MICS) (Cuartas et al., 2020), including looking at or reading with the child, telling stories, singing songs, doing outdoor activities, playing together, singing, counting, or drawing together. A composite "positive parenting index" was derived from single-item questions (adapted from the parenting and family adjustment scales (PAFAS) (Sanders et al., 2014)) on any occurrence of positive caregiver behaviors i) whether the child was praised or ii) affection was shown, and similarly for unfavorable behaviors iii) shouting at or iv) hitting the child; i.e. positive behaviors in a given week were rated +1 and negative ones −1 point and the 4 behaviors were then summed up resulting in an overall parenting rating per weekly observation. A composite "parental stress" variable was constructed using questions on maternal burden and doubt. Burden was assessed by self-rating items (adapted from the parenting stress index (PSI) (Pereira et al., 2016)) on the frequency of the following attitudes: I have little self-time, I wish for fewer responsibilities, the child gets on my nerves, the child demands too much, I am worse at parenting than I could be, parenting is more work than pleasure, I give everything so the child has a good life, and I feel tired of parenting. Questions on maternal self-doubt were taken from the parenting sense of competence scale (PSOC) (Karp et al., 2015) and it was defined by agreement to either of five items on a Likert scale of their role as a parent (Being a mother is not rewarding, or difficult at the moment, my parents were better prepared to be parents, I do not know whether I am doing a good job as mother, being a mother makes me tense and nervous). For both burden and doubt the means were calculated per subject and week. Parental stress was then defined as the mean of the normalized parental burden and doubt.

2.3.2. Exposure variables

The exposure variables of household COVID-19 status in the last 7 days were derived from multi-item measures assessing various aspects of COVID-19 presence in a household. A confirmed new COVID-19 infection was defined as a report of a positive COVID-19 test for either the respondent, child, or other persons in the household, separately or on household level as defined as any of the 3 being positive in a given week. Similarly, presence of any COVID-19 symptoms per respondent household was defined as report of any presence of COVID-19 related symptoms (i.e. fever, cough, loss of taste or smell, or headache) for any of the respondent, child, or other persons in the household. The cohort COVID-19 test positivity was defined as the proportion of the respondents reporting a positive COVID-19 test result in their household over the respondents reporting any COVID-19 test was done.

2.4. Data analysis

In our descriptive analysis, time-invariant variables were described as proportions of respondents; due to their missing structure we estimated these proportions from a 50 iteration Multiple Imputation Chained Equation (MICE) approach (Table S2). COVID-19 and behavior variables were described as counts and proportions of observations or means, where appropriate; outcome variables were further stratified by COVID-19 status. Composite behavior variables were normalized to z-scores. Variables were then summarized as proportions of cohort or cohort means per week and trends of the aggregated variables were plotted over the study period to visually examine trends. Average trends over time were tested using linear regression on the aggregated level. SARI reported numbers of Brazil's COVID-19 cases were used likewise but as absolute numbers, as the database total was limited to acute, hospital reported SARS cases (including COVID-19). We explored the relationship between weekly aggregated COVID-19 variables and weekly SARI reported COVID-19 case numbers (i.e. not on subject level) using time series correlations and standard vector auto-regression lag-order selection statistics (i.e. assessing cross-correlation of the two time series variables contemporaneously and at 10 lagged weeks).

Subject level associations were calculated at the family-week level; i.e. the date of a respective assessment was assigned to the epidemiological week it occurred. We used a quasi-experimental panel fixed effects regression approach that estimated the associations of household COVID-19 infections based on assessments for the same individuals at different points in time and to describe the overall relationships between exposures and outcomes rather than longitudinal trends. To explore persistent impact of COVID-19 infections, exposure lags of one or two time points (i.e. two or four weeks) were used to re-run main panel models; i.e. we assessed whether infections in a given week impacted behavior in subsequent weeks. There, to account for potential impact of the reporting of COVID-19 infection between lagged time points, models were additionally adjusted for immediate (Lag0) and intermediate time points (Lag2), where appropriate. We regarded the fixed effect modelling as the most appropriate approach to account for unmeasured time-invariant factors (Gunasekara et al., 2014; Leyland, 2010). For the relatively short study period of 50 weeks, we assumed that demographic factors were constant. We accounted for subject level clustering issues and heteroscedasticity using cluster-robust standard errors. The resulting estimates can be interpreted as causal as long as the exact timing of the infection is independent of other

predictors of the outcomes of interest. Individual components of the positive parenting index and the parenting stress variables were tested analogously to main panel models above.

All analysis were done using STATA 16 SE (StataCorp, College Station, TX), a *p*-value of <0.05 considered statistically significant and confidence intervals were reported for all results.

3. Results

3′061 mothers were contacted between calendar week 24, 2020 to week 21, 2021 inclusive (9 June 2020 to 27 May 2021) of which 2′894 (94.5%) responded at least once with a total of 30′228 observations (average response rate per week (median, IQR): 84.6%, 3.3). The analysis set with at least 2 completed assessments comprised 2′579 (89.1%) subjects and 29′913 (99.0%) total observations. The median (IQR) number of assessments per subject was 11.0 (11.0), the median weeks of follow-up was 36.0 (23.0) and weeks had 6.4% missing on average.

The mean age of respondents was 26.46 years (95%CI 26.19–26.73) with about a third in the age group of 20–24 years, inclusive (Table 1 and imputation results in supplement Table s3–6). Respondents predominantly lived in more vulnerable neighborhoods (i.e. categories B or C) and about two thirds lived in the most vulnerable ones.

Four hundred and forty one subjects (17.1%) reported at least 1 positive COVID-19 test in their household over the study period which amounted to 831 (3.0%) observations total. Both praising and showing affection for the child were frequent (at least 95% of observations), regardless of household COVID-19 infections. On average, shouting (36.2% vs. 29.7%) and hitting (11.5% vs. 8.1%) the child was more prevalent in households with COVID-19 infections; similarly, parenting burden and doubt appeared on average higher in infected households while home-based stimulation appeared lower.

Time trends of SARI reported COVID-19 cases showed substantial variability over the study period, with the lowest reported numbers in week 45, 2020 and the highest in week 12, 2021 (Fig. 1). Visually, trends of aggregated household COVID-19 symptoms appeared similar to SARI reported data, albeit with a lag of several weeks. Correlations for bivariate time series suggested that over the full study period changes in SARI reported COVID-19 cases in Brazil preceded changes in proportion of COVID-19 symptoms in our cohort by 8 weeks, as indicated by the strongest correlation at that lagged time point (Fig. S1). Correlations were weaker for household COVID-19 infections confirmed by tests.

Neither positive parenting nor parenting stress displayed a clear trend over the study period (p for linear trends were 0.697 and

Table 1
Sample overview covering epidemiological weeks 24, 2020 to week 21, 2021.

	Time-invariant[a] N = 2′579		Time-variant N = 29′913			
	%	(SE)	Total	N/A	COVID positive test in household[b]	
					No (N = 27′169)	Yes (N = 831)
Respondent age in years						
10–14	0.4	0.0020	–	–	–	–
15–19	13.7	0.0075	–	–	–	–
20–24	32.8	0.0099	–	–	–	–
25–29	24.7	0.0096	–	–	–	–
30–34	16.5	0.0091	–	–	–	–
35–39	8.7	0.0060	–	–	–	–
40–44	2.5	0.0034	–	–	–	–
>45	0.6	0.0064				
Neighborhood vulnerability						
A	8.6	0.0063				
B	23.5	0.0091				
C	68.0	0.0102				
Counts (%[c])						
Praising child	–		27′236 (96.2%)	5.4%	25′694 (96.2%)	777 (95.5%)
Affection shown	–		28′106 (99.2%)	5.3%	26′512 (99.2%)	802 (98.8%)
Shouted at child	–		8′444 (29.8%)	5.3%	7′939 (29.7%)	294 (36.2%)
Hit child	–		2′297 (8.1%)	5.3%	2′150 (8.1%)	94 (11.5%)
Mean (SD)						
Home-based stimulation	–		5.23 (1.08)		5.23 (1.08)	5.10 (1.21)
Parenting burden	–		1.58 (0.63)		1.58 (0.63)	1.66 (0.65)
Parenting doubt	–		1.42 (0.43)		1.42 (0.43)	1.48 (0.45)

[a] Based on imputed data.

[b] 6.4% N/A; discrepancies in % due to overlapping N/As in cross-tabulated variables.
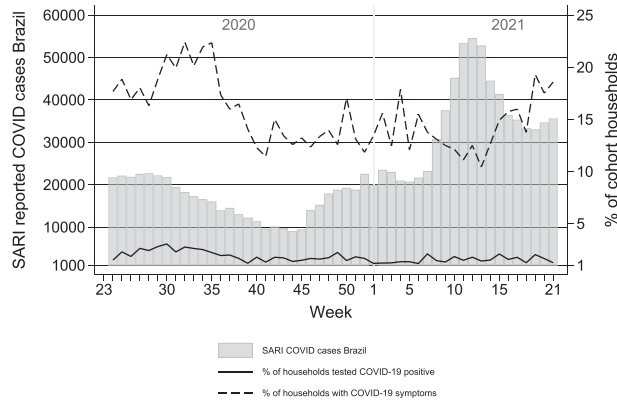
[c] Referring to available.

Fig. 1. SARI reported COVID-19 cases per week in Brazil and weekly proportions of sample reported COVID-19 symptoms in household.

0.233, respectively) (Fig. 2). The average number of reported home-based stimulation increased consistently over the study period (average increase of 0.01 SDs per week, CI95% 0.009 to 0.012, *p*-value: <0.001). The cohort COVID-19 test positivity was highest near the beginning of the data collection, reaching almost 80% in epidemiological week 30, 2020, and on average roughly halving for the second half of the study period (Figure s2).
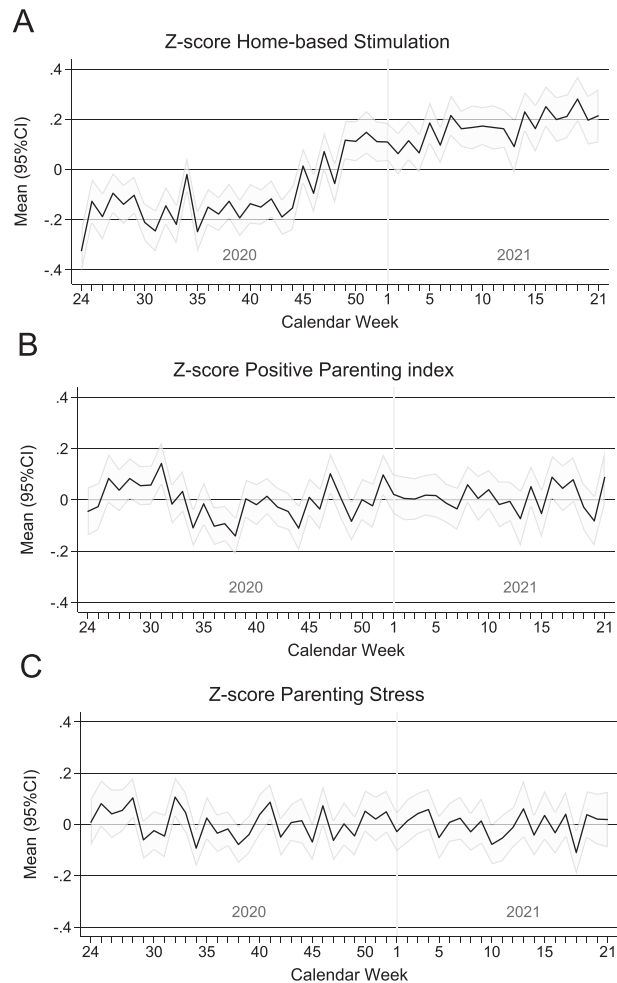

Fig. 2. A–C: Mean (95%) levels of A: Home-based stimulation, B: Positive parenting index, and C: Parenting stress (z-scores) for epidemiological weeks 24, 2020 to week 21, 2021.

A positive COVID-19 infection per household had an immediate and significant negative effect on home-based stimulation (estimated SD change; 95%CI: −0.10; −0.18, −0.01), positive parenting behaviors (−0.14; −0.21, −0.01), and parenting stress (0.07; 0.02, 0.12) (Table 2). Those infections were not found to have significant persistent effects on outcomes of interest on subsequent follow-up weeks (i.e. 2 and 4 epidemiological weeks later). Similar results were found for households that reported COVID-19 related symptoms, although less pronounced for positive parenting and an indication of a persistent effect on parenting stress (supplement Table s7). Assessing effects for individual household members showed that home-based stimulation was only significantly reduced when the mother had a COVID-19 infection (−0.16; −0.29, −0.04), and when the infection was immediate (i.e. same week as reduced stimulation) (Fig. 3 and details in supplement Table s8). Effect size gave some indication that the child being COVID-19 positive might be of some relevance; the association failed statistical significance but contributed to the weighted average negative effect of household COVID-19 infections. COVID-19 infections of all household members were similarly significantly decreasing positive parenting behaviors (estimated SD changes from −0.15 to −0.18) and did not show persistent effects on behavior on subsequent weeks. Parenting stress significantly increased with immediate mother (0.10; 0.02, 0.17) or child (0.12; 0.01, 0.24) COVID-19 infections; the latter also showed a persistent effect on stress 2 weeks later.

Decomposing parenting stress into its burden and doubt domain showed that the negative COVID-19 infection effects on stress seemed to be mainly based on parenting burden (Table S9); i.e. we found similar or somewhat stronger effects for household (0.07; 0.02, 0.13), mother (0.11; 0.03, 0.18), and child (0.18; 0.06, 0.30) COVID-19 infections. Unfavorable individual parenting behaviors shouting (OR; 95%CI: 1.37; 1.09, 1.72) and hitting the child (1.57; 1.14, 2.15) were increased in the presence of household COVID-19 infections, most pronounced when others than mother or child in the household were infected. Effect sizes indicated that positive parenting behaviors generally decreased with presence of COVID-19 infections in mothers or children, with a clear statistically significant effect only on reduced reports of showing the child affection when mothers had COVID-19 infections (OR; 95%CI: 0.21; 0.06, 0.72).

Adjusting lag models for COVID-19 infections at immediate (Lag0) and intermediate time points (Lag2) (i.e. potential COVID-19 infections at time points between exposure and outcome) somewhat decreased effect sizes in general but did not change the findings (i.e. persistent associations remained non-significant) (Table S10).

4. Discussion

This study found an immediate negative effect of household COVID-19 infection on maternal caregiving behaviors and children's early home environment. Maybe unsurprisingly, the impact of acute infections was most pronounced when the primary caregiver was the person affected, with substantial reductions in home-based child stimulation and positive parenting practices, and increased maternal parenting stress. Infections of the children showed a similar impact but statistically weaker results, while infections of other household members appear relevant only for positive parenting practices. Furthermore, COVID-19 manifested as general symptoms reduced the investigated maternal parenting outcomes in a similar fashion.

To our knowledge this is the first longitudinal study that investigated the immediate and persistent impact of COVID-19 infection on maternal parenting outcomes on a subject level, were both COVID-19 status and behaviors were assessed at that same level. Our findings are in line with previous reports, that were generally on ecological level or used ecological exposure (i.e. COVID-19 status was derived from societal presence of public policies such as governmental preventive measures). Changes in circumstances and perceptions during COVID-19 outbreak were consistently, across different countries, shown to negatively affect relaxation time, child rearing, partner aggression, domestic violence and emotional abuse, sense of unfairness in mothers with young children, depressive symptoms, anxiety, adverse childhood experiences, job loss and financial strain (Brown et al., 2020, Fabbri et al., 2020, Lawson et al., 2020, Zhang, 2020, Calvano et al., 2021, Croda & Grossbard, 2021, Kimura et al., 2021, Lee et al., 2021, Ortega Pacheco & Martinez Rudas, 2021, Wong et al., 2021). A majority of parents also reported to be negatively affected by social distancing and closure of childcare facilities (Calvano et al., 2021). Furthermore, negative impact of COVID-19 distress on childhood emotional and behavioral problems was found to be mediated by negative parenting practices (Hails et al., 2021). These previous studies and our findings are also in line with prior reports on impacts of other public health crises on (mental) health and individuals' well-being (Earls et al., 2008; Mucci et al., 2016). While other studies predominantly showed these patterns relating to the perceived presence of COVID-19 in the general public, our study assessed the effects of actual presence in the household, suggesting that the impact is more accurately capturing what is directly affecting the household. Furthermore, evidence suggests that ethnic groups are disproportionally affected

Table 2
Panel data associations: Household COVID-19 infection and parenting behaviors.

| | Household COVID-19 positive | | | | | | | | | | |
| | Immediate | | | Lag 2 Weeks | | | Lag 4 Weeks | | |
	Est.	95%CI		p	Est.	95%CI		p	Est.	95%CI		p
Z-scores												
Home-based stimulation[a]	−0.10	−0.18,	−0.01	0.024	−0.07	−0.15,	0.02	0.128	0.06	−0.03,	0.15	0.170
Positive parenting index[a]	−0.14	−0.21,	−0.06	<0.001	−0.03	−0.11,	0.05	0.484	−0.04	−0.15,	0.06	0.401
Parenting stress	0.07	0.02,	0.12	0.009	0.03	−0.04,	0.09	0.472	0.02	−0.06,	0.09	0.648

Results from panel fixed effects models.
[a] Models using robust standard errors.
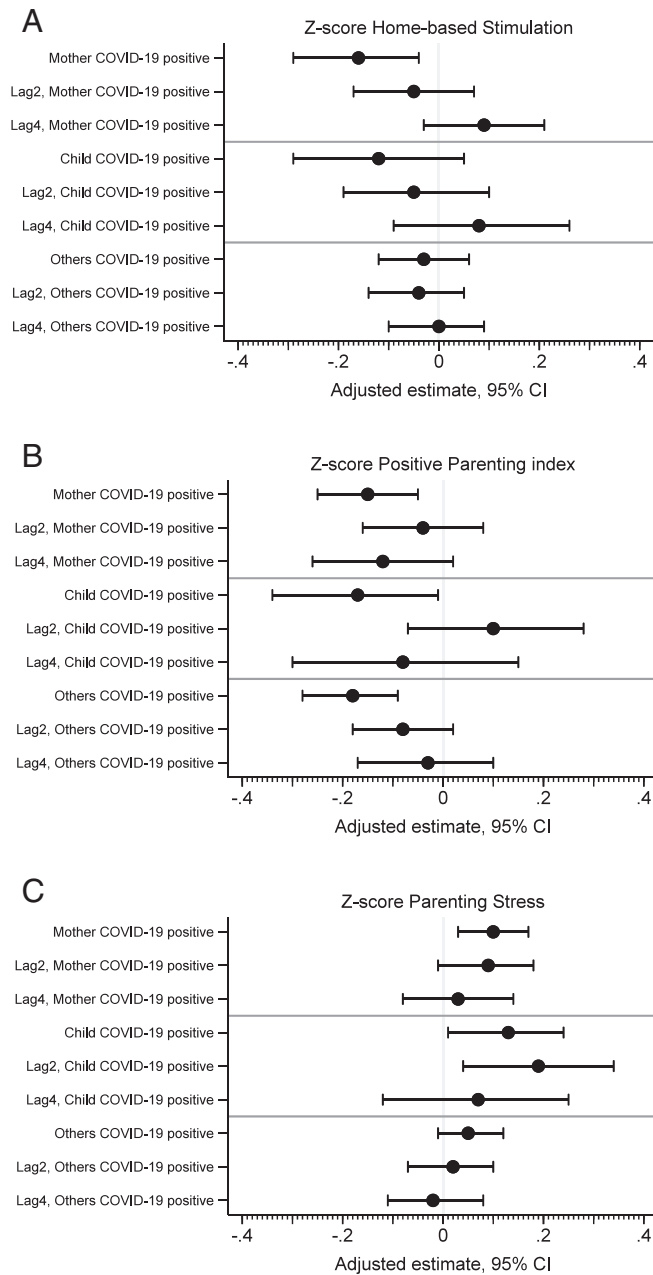
Fig. 3. A–C: Panel data associations: Household members COVID-19 infection and A: Home-based stimulation, B: Positive parenting index, and C: Parenting stress (z-cores).

and women and less favored Brazilian communities are more severely affected by COVID-19 stressors (Brown et al., 2020, Lins-Filho et al., 2020, Croda & Grossbard, 2021, Souza et al., 2021). Our study did indeed confirm and elucidate in depth the burden on the mother during this pandemic. Data on fathers or other caregivers in the household to contrast against maternal outcomes was, however, not available in our study.

Taken together, the impact of COVID-19 infection on maternal parenting is likely explained by the (perceived) presence of COVID-19 and related societal changes leading to an increased burden of care and resulting in higher levels of organizational and psychological stress and fear for the mother or caregivers, or elevated household stress due to incapacitation of the parents or caregivers themselves. Indeed, when assessing the relevance of infections for individual household members, we found that the negative impact on parental behaviors was most consistent and pronounced when the mother was affected. Based on our findings and previous research that showed mental health was significantly affected by the pandemic and mental health affects level of child care (McPherson et al., 2008; Xiong et al., 2020), it could be speculated that changes in mental health play a crucial role in our findings. We found that general

COVID-19 symptoms in a household showed negative effects on maternal parenting outcomes, similar to infections confirmed by test. Symptoms were presumably less specific in picking up the presence of an actual COVID-19 infection, but these results might be indicative of a more general impact of household stress and maternal health on her parental behaviors. For some of our investigated outcomes maternal mental health aspects might be more relevant than incapacitation due to being ill. Specific household stress factors relevant to our effects were, however, not assessed and we could not further investigate the causal mechanisms or interdependence of factors relating to the adverse impact of the pandemic on the studied outcomes; further research with appropriate design is warranted to elucidate these causal pathways.

A major strength of this study is the large panel data set with multiple repeated measurements on a large number of participants, allowing to specifically study mothers with young children. The study furthermore spanned a critical period of the COVID-19 pandemic, covering a majority of time the pandemic was only controlled via public preventive measures before roll out of large scale vaccination programs. As such, the temporal trend of COVID-19 symptoms in our Boa Vista cohort seemed to correlate with the official reports of cases for Brazil, albeit with a lag of a several weeks. This seems plausible as distinct spatiotemporal patterns by states were reported (Castro et al., 2021). We consider the sample that was based on an ongoing RCT to have a good representativeness of the more vulnerable population of Boa Vista, i.e. all pregnant women classified as vulnerable were eligible for the RCT but only participants on treatment were then used for the present study; the assignment to treatment was, however, randomized and we expect no selection bias here. The sample was on an active intervention to improve parental behaviors and we anticipate our associations on subject level to be similar or more pronounced in the comparable population without intervention. Should the intervention turn out to be effective in improving parental behaviors, we can assume that these behaviors in the (untreated) vulnerable population of Boa Vista were generally less favorable; i.e. the intervention might have offset some of the COVID-19 impact we found. Similarly, we expect a fair but somewhat limited generalizability to other vulnerable communities in Brazil and comparable emerging countries. Studies in other countries showed that similar parenting interventions increased positive parenting behaviors (Aboud & Yousafzai, 2015); Brazil's response to the pandemic was (during the study period) among the less restrictive ones globally (Neiva et al., 2020), and areas with more restrictive measures may have placed more (perceived) stress on households. Furthermore, we expect that these COVID-19 findings could to some extent be applied to other future potential public health crises of similar nature with comparable societal changes.

By using a quasi-experimental fixed effect panel approach, we were able to inherently account for unmeasured potential time-invariant confounding. Given the relatively short follow-up period of 50 weeks, we assume to have adjusted adequately for demographic variables that we believe to be consistent. Despite these steps to arrive at unbiased results, we cannot rule out presence of residual confounding as we did not collect additional information on potentially relevant subject level behaviors or events. Fixed effects estimates are derived only from subjects for whom change was present as this approach uses the variation within individuals to account for time-invariable confounding. Despite the longitudinal nature of the study design and data analysis, reverse causality cannot be fully ruled out. However, it seems unlikely that on subject level, parental behaviors affect reporting positive COVID-19 infections. It is also important to highlight that the empirical strategy applied here does not allow us to identify the total impact of Covid-19 and accompanying measures on parenting behavior and children's home environment: our empirical strategy is based on a comparison of families under the same external stress, and thus identifies only the additional changes in this outcomes triggered by acute infections in the household. Composite behaviors were used to better capture global constructs of parent competency and child interaction and increase statistical efficiency regarding relatively low numbers of active COVID-19 infections. While individual questions for the composite outcomes were adapted from validated scales, the positive parenting index and stress composite were not validated as such. To capture different constructs of parenting behaviors and attitudes but also minimizing the response burden in the frequent assessments, only few questions were used for each construct which did not reflect the validated scale domains fully. Future studies should ensure using full scales or sub-domains to better understand the psychometric properties of these constructs. Furthermore, the presented composite associations cannot be presumed to relate to all components equally. We did, however, test some lower level constructs to explore whether the effects are consistent and disparate, albeit with reduced statistical power.

In addition to limitations discussed above, this study had several other limitations. The data collection was administered via phone and relied on self-reporting of main outcome and exposure variables. Phone surveys are prone to ownership bias and some of the poorest RCT participants who did not have access to a phone at the time of the present study were not included. Self-reporting is generally prone to recall bias, whereas we'd expect a limited impact on results as all questions were covering events of the past 7 days maximum. We cannot rule out that responses were to some extent biased towards social desirability which could have attenuated the strength of our findings. We'd expect this to be non-differential regarding the main exposure of presence of COVID-19 in the household and it would such not affect the main associations presented. We used the SARI surveillance protocol to assess Brazil's COVID-19 trends which is likely to have underestimated the overall pandemic spread in absolute numbers. The SARI surveillance protocol has included the test for SARS-CoV-2 starting in the 12th epidemiological week 2020 but by definition no mild cases were captured, and therefore patterns reflect only severe COVID-19. Also, a recent report showed that while COVID-19 spreads fast in Brazil, there were distinct patterns of burden by state (Castro et al., 2021).

4.1. Conclusion

Our findings suggest acute COVID-19 infections lead to substantial increases in parental stress and a corresponding reduction in the quality of children's home environments in the days and weeks immediately after infection. Additional support for families during this period could likely help absorb the negative impact of these experiences on children, at least partially.

Ethical considerations

Data collected for this project was approved under protocol CAAE 73722917.4.0000.0076. No incentives for participation in the present study were given.

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Appendix A. Supplementary data

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