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Challenges of maternal and child health after the COVID-19 pandemic

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Challenges of maternal and child health after the COVID-19 pandemic

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Editorial: Challenges of maternal and child health after the COVID-19 pandemic

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Editorial on the Research Topic
Challenges of maternal and child health after the COVID-19 pandemic

The COVID-19 pandemic has impacted people's access to and quality of care (1). In several countries, maternal and child health services, including perinatal care, immunization, and facility delivery, declined during the pandemic (2), and emergency care faced the risk of interruption. Accordingly, innovative solutions are required to address these challenges (3). Further research is warranted to determine how these restrictions can affect the health of mothers and children. Moreover, understanding these constraints may prevent further maternal and child healthcare disruptions in future public health emergencies. Thus, we initiated this Research Topic to highlight the status, impact, and solutions of maternal and child healthcare access and quality challenges during and after the pandemic.

Chao et al. systematically reviewed 78 articles to rank COVID-19-related symptoms, such as cough, fever, myalgia, headache, and dyspnea, among pregnant women. The focus of the study was relevant, given that pregnant women are less likely to manifest COVID-19 symptoms and more likely to warrant COVID-19-related intensive care unit admission than non-pregnant women. Therefore, this symptom ranking list may aid clinical screening to determine COVID-19 infection among pregnant women. Regarding COVID-19's impact on child health, Puspitarani et al. reported on adverse events following immunization (AEFI) in children. According to 1,093 parents of children (aged 6–11 years) in Yogyakarta, Indonesia, who received first and second doses of inactivated severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) vaccine, mild AEFI was associated with factors, including previous AEFI experience and receipt of other vaccines containing the same adjuvant as CoronaVac within 1 month.

Cena et al. reported on access to maternal and perinatal healthcare services in Italy during the pandemic. Of the 77 public and private maternity and perinatal centers, 70% reported that the first wave of the pandemic had adversely affected the functioning of one or more aspects of perinatal services, and 23% were understaffed. These findings indicate that healthcare systems are poorly prepared to handle health services during pandemic emergencies. Carter et al. assessed the impact of COVID-19 on the reproductive, maternal, and newborn health services in Ethiopia. According to the Performance Monitoring for

Action-Ethiopia data, the health service provision was minimally disrupted during the initial months of the pandemic, although the number of stillbirths increased in the COVID-19 cohort. Based on distinct findings documented in Italy and Ethiopia, maternal and child healthcare access and consequences differ depending on the medical resource background of the country.

During the COVID-19 pandemic, family care for patients was affected by changes in family visitation and chaperone protocols during hospitalization. In their narrative review, Lessa et al. discussed the negative impact of the pandemic on patient- and family-centered care (PFCC) in the pediatric intensive care unit, including family support and communication. The authors highlighted several strategies used to maintain PFCC and achieve the minimal goal of humanized care during the pandemic.

Several studies have explored the health status of children and their caregivers during this pandemic. Ma et al. reported the prevalence of stunting among children <3 years of age in Longgang, China, and its risk factors during the pandemic. Among 118,404 kindergarten children, the authors identified distal, proximal, and intermediate factors, suggesting the need to strengthen feeding behaviors and healthy lifestyles to prevent stunting in children during a pandemic. Upadyaya et al. identified distinct homogeneous profiles of parents who experienced burnout in Finland during the pandemic. Considering 1,314 parents from the Helsinki Metropolitan area, those whose children faced challenges tended to experience high burnout profiles. Wang et al. explored the association between parental wellbeing and child mental health problems during the pandemic. According to their analyses of data from a population-based survey of parents of children aged 3–6 years across mainland China, higher parental mental health wellbeing, measured by World Health Organization-Five Wellbeing Index, was associated with poor child mental health, noting that harsh parenting and child sleep issues mediated the association. Kokkinaki and Hatzidaki reviewed factors that negatively affected perinatal mental health during pandemic-related restrictions and revealed that maternal emotional wellbeing adversely affected infant development. The authors also highlighted the need to integrate evidence-based promotion of family mental health into prenatal and postnatal care to facilitate patient care. In Germany, Gulde et al. conducted a path model study among 73 mothers recruited shortly after birth at the University Hospital of Ulm between 2013 to 2015 and surveyed during the COVID-19 pandemic. Maternal attachment representation appeared unstable and lacked coping strategies, given the various pandemic-related limitations (Gulde et al.). This may lead to harmful parental behaviors and ultimately affect children's mental health. Fielding-Gebhardt et al. conducted a study at the University of Kansas, United States, regarding the mental wellbeing of 37 mothers of children with fragile X syndrome during the COVID-19 pandemic, who are themselves carriers of the FMR1 gene premutation (Fielding-Gebhardt et al.). The mothers experienced trouble adapting and coping with the circumstances during the pandemic, although positive adaptations, such as increasing feelings of family togetherness, were also observed.

Several factors are associated with perinatal mental health among mothers. According to a review by Bottemanne et al., fear of being infected/infecting others and uncertainty regarding the effect of the virus on fetuses and infants might affect mothers' mental health. As a potential solution to mental health issues, Liu et al. reported the effectiveness of a mental health program implemented in Massachusetts, the United States. Helping Us Grow Stronger (HUGS/Abrazos) is an emergency assistance program supporting vulnerable patients, including pregnant women and children. The program integrated and streamlined social and behavioral health support, which served as a buffer to protect pregnant women and families with young children and foster resilience.

Sharing correct COVID-19 information with family members could be related to family wellbeing, including perceived family health, happiness, and harmony. Using the Jockey Club SMART Family-Link Project in Hong Kong, Wong et al. conducted a study among 4,891 adults. The authors revealed that family wellbeing was associated with the confirmation of correct information, followed by sharing with families. Accordingly, public healthcare professionals should encourage verifying and forwarding COVID-19-related details to family members to ensure family communication and wellbeing (Wong et al.).

In conclusion, this special issue examines diverse maternal and child health challenges introduced by the COVID-19 pandemic. The subtopics included (a) COVID-19-related symptoms in pregnant women, (b) vaccine-induced adverse events in children, (c) access to and implementation of perinatal care varying by country and time context, (d) challenges faced by families of pediatric patients owing to limitations on visitations, and (e) mental health of mothers and children and the support program. The present editorial discusses the impact of the COVID-19 pandemic on mothers and children, including both direct and indirect causes, such as long-term behavioral restrictions, considering mental health and parent-child and family relationships. These studies provide essential information to circumvent critical situations during future pandemics.

Author contributions

KK, KN, SY, and JY were the associate editors. KK was the editorial author. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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BRIEF RESEARCH REPORT
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Estimating the Impact of the COVID-19 Pandemic on Maternal and Perinatal Health Care Services in Italy: Results of a Self-Administered Survey

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The coronavirus disease 2019 (COVID-19) pandemic is strongly changing the way most people live their lives, and disrupting specialist healthcare systems. Such public health disruptions have resulted in significant collateral damage with particular implications for vulnerable populations, including the perinatal population. This Study aims to estimate the impact of the COVID-19 pandemic on Italian maternal and perinatal health care services. A questionnaire was designed to evaluate the COVID-19 impact on Italian maternal and perinatal healthcare facilities and their activities and provision of services from March to May 2020. The survey was completed by hospital-based and community-based Italian maternal and perinatal healthcare facilities. Most of these were located in Lombardy or Veneto (the most affected Italian regions). 70% of all facilities reported that the first wave of the COVID-19 pandemic negatively influenced the functioning of one or more aspects of the perinatal service; only 28.4% of facilities all over the country continued to provide outpatient routine visits and examinations as usual; 23.4% of facilities became understaffed during the index period due to various reasons such as ward transfer and sick leave. This is the first Italian study, and among very few international studies that describe the effects of the COVID-19 pandemic on antenatal and postnatal healthcare facilities and their provision of activities and services. Our findings confirm that healthcare systems even in high-income countries were not entirely prepared to handle such a global health emergency; indeed, specialized maternal and perinatal healthcare services have been disrupted by this global health emergency.

Keywords: health services, antenatal and postnatal healthcare services, newborn's health, women's health, public health, maternal services

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INTRODUCTION

The coronavirus disease 2019 (COVID-19) pandemic quickly and widely spread from the Hubei Province in the People's Republic of China, where the virus originated in December 2019, throughout the world, starting in early 2020 (1, 2). It has extensively changed the way most people live their daily life, including interpersonal relationships and health habits (3).

Furthermore, the morbidity and mortality associated with severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection have put healthcare systems worldwide under great strain (4) and also disrupted a variety of general and specialist health facilities that deliver non-COVID-19 health care services (5–10). These disruptions to public health have resulted in significant collateral damage with particular implications for vulnerable populations (11–13), including the perinatal population (7, 14–16).

Italy was the second epicenter of the spread of COVID-19 (17) and major changes have been made to the provision of health services since the outbreak in March 2020 (see **Table 1**). The initial rapid spread of infections and the limited number of intensive care beds available posed a critical threat to the Italian national health system (18) and its workers (thousands of healthcare professionals have been infected by the virus and many of them have died) (19, 20). Healthcare facilities constituted the main source of virus outbreaks because of hospital overcrowding and the existence of asymptomatic cases of the virus (21). After this first wave of pandemic, which ended in May 2020, the Italian government implemented significant changes to the structure of the health system in order to stem the second wave (22). However, the effects were different in different regions. The severity and the mortality of COVID-19 infection in Lombardy (which was the Italian epicenter) and Veneto were higher during this first wave of pandemic than during the second wave (between October 2020 and January 2021). For instance, in Lombardy there were 16,362 deaths (47.7% of deaths in Italy) during the first wave and 15,515 deaths (18.9% of deaths in Italy) during the second and the third wave combined (23, 24). But this does not apply to the rest of Italy, where the trend in mortality was reversed: 34,260 and 38,535 deaths in the first and second wave, respectively (23, 24).

To date, COVID-19 studies in Italy have reported the disruption of services and substantial changes in the way clinical care is delivered for mental health (25), oncology (26), surgical arthroplasty (27), pediatrics (28) and many other specialist healthcare systems. However, at the time of writing, the status of the perinatal healthcare system has not yet been comprehensively or extensively investigated. Therefore, we sought to evaluate the impact of the COVID-19 outbreak and the containment measures on maternal and perinatal healthcare services in Italy.

TABLE 1 | Timeline of the COVID-19 pandemic in Italy.

December 31, 2019	The Wuhan Municipal Health Commission in Wuhan City, Hubei province, China, reports a cluster of pneumonia cases (including seven severe cases) of unknown etiology.
January 9, 2020	China CDC reports that a novel coronavirus (later named SARS-CoV-2, the virus causing COVID-19) had been detected as the causative agent for 15 of the 59 cases of pneumonia.
January 17, 2020	ECDC publishes its first risk assessment on the novel coronavirus.
January 22, 2020	The Italian Ministry of Health instructs a task force to coordinate a surveillance system for suspected cases and interventions in national territory.
January 30, 2020	Two Chinese tourists hospitalized for respiratory tract infection are the first confirmed cases of COVID-19 detected in Italy. The WHO declares this first outbreak of novel coronavirus a "public health emergency of international concern."
January 31, 2020	The Italian Council of Ministers declares a national public health emergency condition.
February 21, 2020	The Italian National Institute of Health confirms the first case of local transmission of COVID-19 infection. Over the following days, the Italian authorities reported clusters of cases in several regions (Lombardy, Piedmont, Veneto etc.).
March 8–9, 2020	The Italian Council of Ministers issues a decree to install strict public health measures starting in the most affected regions (i.e., Lombardy and Veneto). These measures include social distancing and restricting movements of people within and outside the hometown, with permitted travel limited to shopping for food, going to work (only for essential services to remain operating; work from home is encouraged), or seeking medical care. All planned surgeries are postponed in order to give over intensive care beds to the treatment of COVID-19 patients.
March 11, 2020	The Director General of the WHO declares COVID-19 a "global pandemic." The Italian Council of Ministers extends the strict containment measures at national level.
March 13, 2020	The WHO declares Europe is becoming the new epicenter of COVID-19 pandemic.
March 31, 2020	Official reports indicated 7,593 COVID-19–associated deaths and 44,773 infected individuals. The Italian Ministry of Health issues recommendations for pregnant women, women in labor, puerperal women, newborns and breastfeeding mothers.
April, 2020	Italian scientific associations in the field of perinatal medicine (e.g., FIGO and SIN) start to publish interim recommendations for management of pregnant-woman in labor, puerperal women, newborns and breastfeeding mothers during the COVID-19 pandemic.
May 4, 2020	The Italian Council of Ministers restores the freedom of movement, and other non-essential activities re-open later in the month.
May 31, 2020	The Istituto Superiore di Sanità (in collaboration with ACP, AGUI, AOGOI, FNOPO, SIAARTI, SIGO, SIMP, SIN, SIP, and TAS) publishes interim indications for pregnancy, childbirth, breastfeeding and the care of very young children 0-2 years in response to the COVID-19 emergency.

Table adapted from the Timeline of ECDC's response to COVID-19 (available on-line at www.ecdc.europa.eu/en/covid-19/timeline-ecdc-response).
ACP, Associazione Culturale Pediatri; AOGOI, Associazione Ostetrici Ginecologi Ospedalieri Italiani; AGUI, Associazione Ginecologi Universitari Italiani; China CDC, Chinese Center for Disease Control and Prevention; ECDC, European Center for Disease Prevention and Control; FIGO, International Federation of Gynecology and Obstetrics; FNOPO, Federazione Nazionale degli Ordini della Professione di Ostetrica; SIAARTI, Società Italiana di Anestesia Analgesia Rianimazione e Terapia Intensiva; SIGO, Società Italiana di Ginecologia e Ostetricia; SIMP, Società Italiana di Medicina Perinatale; SIN, Società Italiana di Neonatologia; SIP, Società Italiana di Pediatria; TAS, Tavolo Tecnico Allattamento del Ministero della Salute; WHO, World Health Organization.

METHODS

Study Design and Participants

A cross-sectional survey was conducted using an online questionnaire accessible on the University of Brescia website. The questionnaire was distributed *via* an electronic link to the coordinators or representatives of 1,428 public and private maternal and perinatal healthcare centers located throughout Italy. A brief explanation of the study purpose and assurance of anonymity was outlined in the body of the email as well as on the first page of the questionnaire. Informed written consent was obtained from all respondents before data collection. The research was approved by the Ethics Committee of ASST Spedali Civili Hospital Brescia, Italy (Approval number: NP4221 24.06.2020). The questionnaire was made available for completion from June 30 to October 7, 2020. Data were collected using LimeSurvey.

Survey Description

The survey questionnaire was specifically created for this study: to evaluate the COVID-19 impact on both antenatal and postnatal healthcare facilities and their activities and provision of services. It was designed and trialed by a team of perinatal experts who work in maternal and perinatal clinics or are regularly involved in research in this area and in the training of healthcare workers. All the experts are members of the Observatory of Perinatal Clinical Psychology (https://www.unibs.it/it/node/988), Section of Neuroscience of the Department of Clinical and Experimental Sciences (University of Brescia, Italy). Possible misinterpretations or difficulties with wording or comprehension were discussed and resolved within the core research group. The final version of the survey questionnaire included 60 general questions, 4 additional specific questions for antenatal services and 13 for intrapartum, postnatal services. Most of the questions were closed-ended, but some optional open-ended questions were used to allow respondents to express their subjective perceptions. An example of the survey questions is "How many healthcare professionals are employed in your facility?" or "Was your facility converted into COVID-19 units during the period of health emergency (March–May 2020)?" For the latter question there were three closed-ended responses: "Yes, completely," "Yes, but only partially," "No".

Statistical Analysis

Descriptive analyses were performed. Categorical variables were recorded in terms of frequency and compared across groups using the chi-square test or the Fisher's exact test, as appropriate. Analyses were performed using R version 4.0.2 (R Foundation for statistical computing, Vienna, Austria).

RESULTS

Sample Characteristics

Seventy-seven Italian perinatal healthcare facilities completed the survey (response rate 5.4%). Of these, 46 were prenatal facilities, whereas 31 were intrapartum/postnatal or maternal facilities. Thirty-nine were located in Lombardy or Veneto (the most affected Italian regions), and the remaining were from the other ten regions. Twenty-five were hospital-based, whereas the remaining were community-based. The median of healthcare professionals working in the facilities was 10 (inter-quartile range = 37.7).

All the results, unless otherwise specified, did not yield significant differences between hospital- and community-based facilities, geographical areas, or antenatal and intrapartum/postnatal care.

Services

Seventy percent of all facilities reported that the first wave of the COVID-19 pandemic negatively influenced the functioning of one or more aspects of the maternal and perinatal services. The impact of the measures taken to prevent the spread of the virus on specific activities and services provided by Italian perinatal healthcare facilities is reported in **Table 2**.

Visits and Examinations

From March to May 2020, only 28.4% of facilities all over the country continued to provide outpatient routine visits and examinations as usual, 59.4% provided visits but to a limited extent, while 12.2% ceased their activities. However, the majority of maternal and perinatal facilities were available for emergencies, either completely (68.8%) or to a limited extent (19.7%). All the facilities in which emergency visits were ceased were community-based and, except one, were located in Lombardy or Veneto. Regarding the waiting time for first visits and control visits, most centers reported that it was not extended (61.2 and 55.4%, respectively) or only partially (29.3 and 33.8%, respectively). Most of the facilities (68.8%; 78.3% prenatal vs. 54.8% postnatal, $p = 0.03$) had always or almost always kept fathers out of their partners' visits and exams.

Overall, at 24.7% of the facilities a part of the staff, and at 6.5% of the facilities, all the staff, continued their job in smart working mode. Most facilities continued to provide always, or almost always, in-person visits with physicians (82%), obstetricians (82.6%), and nurses (77.1%) during the pandemic. On the other hand, only 32.8% of facilities always or almost always provided in-person psychological visits. The facilities located in Lombardy or Veneto significantly more frequent in-person visits with physicians, compared to those located in the other regions, (91.3 and 74.1%, respectively, $p = 0.04$) and by psychologists (38.9 and 25.0%, respectively, $p = 0.02$). At the same time, obstetrician and nurse visits were significantly more frequently used by hospital-based professionals than by community-based colleagues (90.5 vs. 79.2%, $p = 0.02$ for obstetricians; 88.2 vs. 66.7%, $p = 0.02$ for nurses).

Transformation Into a Dedicated COVID Facility

About a quarter of maternal or perinatal healthcare facilities (23.4%) were partially converted or transformed into COVID-19 units (16 out of 18 of these facilities were hospital-based) to provide care and support to the large number of patients infected by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2). Further, two facilities (2.6%), that is, a hospital-based

TABLE 2 | Impact on activities and services provided by perinatal healthcare facilities in the Italian national territory.

	Outpatients care												Inpatients care						Outpatients care			
	Pregnancy and antenatal care												Postnatal & newborn care									
Has the COVID-19 pandemic adversely affected specific activity and service?	**Preconception interventions and infertility treatments**	**Procreative and contraceptive counseling**	**Voluntary termination of pregnancy**	**Physiological pregnancy monitoring**	**High risk or pathological pregnancy diagnostics and monitoring**	**Twin pregnancy**	**Prevention of preterm birth**	**Cesarean section planning**	**Prenatal diagnosis**	**Assisted reproductive technology**	**Psychological counseling and support**	**Birth preparation classes**	**Delivery room**	**Postpartum obstetrical ward**	**Neonatology**	**Neonatal intensive care**	**Neonatal pathology**	**Newborn postnatal health checks**	**Psychological counseling and support**	**Home visits**	**Parenting support**	**Breastfeeding support**
Yes	21.9% ($n = 7$)	18.2% ($n = 6$)	77.4% ($n = 24$)	76.2% ($n = 32$)	75.0% ($n = 24$)	61.9% ($n = 13$)	66.7% ($n = 12$)	72.7% ($n = 16$)	63.6% ($n = 14$)	11.2% ($n = 1$)	35.9% ($n = 14$)	16.3% ($n = 7$)	64.3% ($n = 9$)	46.7% ($n = 7$)	57.1% ($n = 8$)	70.0% ($n = 7$)	53.8% ($n = 7$)	42.9% ($n = 9$)	32.0% ($n = 8$)	21.0% ($n = 4$)	22.2% ($n = 6$)	33.3% ($n = 9$)
Partially	43.7% ($n = 14$)	51.5% ($n = 17$)	19.4% ($n = 6$)	21.4% ($n = 9$)	21.9% ($n = 7$)	33.3% ($n = 7$)	33.3% ($n = 6$)	27.3% ($n = 6$)	31.8% ($n = 7$)	44.4% ($n = 4$)	61.5% ($n = 24$)	60.4% ($n = 26$)	35.7% ($n = 5$)	53.3% ($n = 8$)	42.9% ($n = 6$)	30.0% ($n = 3$)	38.5% ($n = 5$)	57.1% ($n = 12$)	64.0% ($n = 16$)	58.0% ($n = 11$)	63.0% ($n = 17$)	59.3% ($n = 16$)
No	34.4% ($n = 11$)	30.3% ($n = 10$)	3.2% ($n = 1$)	2.4% ($n = 1$)	3.1% ($n = 1$)	4.8% ($n = 1$)	0.0% ($n = 0$)	0.0% ($n = 0$)	5.6% ($n = 1$)	44.4% ($n = 4$)	2.6% ($n = 1$)	23.3% ($n = 10$)	0.0% ($n = 0$)	0.0% ($n = 0$)	0.0% ($n = 0$)	0.0% ($n = 0$)	7.7% ($n = 1$)	0.0% ($n = 0$)	4.0% ($n = 1$)	21.0% ($n = 4$)	14.8% ($n = 4$)	7.4% ($n = 2$)

Yes, performed; Partially, partially performed; No, not performed.

Due to the characteristics of the data, it was not possible to calculate differences between hospital- and community-based facilities, nor between geographical areas.

obstetrics and gynecology ward and a community-based birth center, were completely converted into COVID-19 facilities.

Staff

Overall, a minority of facilities reported that some or all of the staff members (13 and 3.9%, respectively) were transferred to COVID-19 wards. This occurred significantly more frequently in hospital-based facilities than in community-based facilities. Nevertheless, almost one-fourth (23.4%) of the facilities, both hospital- and community-based, became understaffed during the index period due to various reasons such as ward transfer and sick leave.

About half of the facilities (46.0%) provided the entire staff with specific training on COVID-19 management, whereas a further 28.6% provided it only to select staff members. The remaining 25.4% did not provide any training.

Regarding the use of personal protective equipment (PPE) and the adoption of social/physical distancing, though perceived as essential and health-saving, both were considered very stressful by the staff of 68.2% of the facilities.

DISCUSSION

Our survey provides sobering insights into disruption to care and treatment for peripartum and perinatal patients (i.e., pregnant women, new mothers and their fetus/neonate) in Italy. We analyzed responses from 77 facilities in 11 Italian regions, covering relevant aspects of the activities and services provided in ante-, intra-, and post-partum clinical settings. Our data aligns with similar studies (6, 29) revealing that the pandemic has caused disruptions, with delays, reductions or cancellations in both maternal and neonatal appointments.

Regarding check-ups and examinations, although it is fully understandable that non-urgent services, such as many routine outpatient visits, were canceled in a well-intentioned effort to contain the spread of the new coronavirus (e.g., reports clearly show that, due to the pandemic, fewer women received follow-up care after obstetric anesthesia) (30). This change in access to medical and health services adversely affected the standard of maternal and perinatal care, including the realm of mental health care but particularly that of preventive, routine, and corrective medicine (5, 6, 29). The peripartum/perinatal population is particularly vulnerable, both physically and psychologically, to altered or delayed health care, because patients need and deserve close longitudinal monitoring (31). This is true for all pregnant and postpartum women as well as their babies because, for instance, even in case of a healthy young woman with non-complicated pregnancy (at least for a certain period), a complex maternal condition or fetal anomaly requiring multiple medical subspecialty consultations could occur. We must bear in mind that routine appointments are crucial to enable parents to participate in a shared decision-making process in all the cases in which there is uncertainty about medical conditions (32). Additionally, these consultations may also alleviate unnecessary parental anxiety. All these aspects must be considered when working during disasters such as the ongoing pandemic because, as highlighted by a systematic review on the effects of disaster on pregnancy and the postpartum period, they have an indirect impact on maternal mental health and some perinatal health outcomes (33). Moreover, it has been observed that the well-documented negative influence of mother's mental health on child development (34, 35) may be even greater after a disaster than any direct effect of disaster-related prenatal stress (33).

As regards telehealth (vs in-person check-ups), our data aligns with previous studies showing that it has been rapidly adopted in perinatal care since the onset of the pandemic (36–39). Telehealth offers safe access to consultation and follow-up appointments, saving patients both time and money, but is a complex system that normally requires years of implementation and optimization (40) in order to be an effective tool for providing comprehensive and multidisciplinary perinatal care, mainly in cases where physical examination is not or is rarely necessary. Face-to-face check-ups are still essential in high-risk cases (41). However, in certain cases, such as women with gestational diabetes mellitus, self-care programs *via* telemedicine may be a better choice than face-to-face visits (42).

In terms of healthcare workers, obstacles to effective care appear to include understaffing and additional stress for perinatal healthcare workers, and this aligns with the previously demonstrated increase in stress during the pandemic, stemming from staff shortages, excessive workload and the use of personal protective equipment (43). In terms of the patient's couple relationship, keeping patients (mothers and babies) together with their partner/other parent is crucial for respectful and effective care. However, consistently with other studies (5, 44, 45), our data show that partners/other parents are often excluded from the mother's check-ups and examinations in an effort to protect other patients and staff from infection.

As concerns the regional differences, our results indicate that facilities located in Lombardy or Veneto experienced a greater reduction in the provision of outpatient visits, especially emergency visits, and a statistically significant higher percentage of closures of community-based facilities. This is in line, on the one hand, with the Italian geographical distribution of the infection (northern regions faced disproportionately higher numbers of infections and deaths compared with southern and central Italy) (46), and on the other hand, with other Italian studies showing significant variations across regions in the way COVID-19 has affected medical specialist departments [e.g., radiology has changed during the pandemic with a large variability among different Italian regions; (47)]. With regard to the main difference between antenatal and postnatal services, that is, the degree to which fathers are permitted to attend their partners' visits and exams, one plausible and economical explanation is that different regions adopted different approaches to patient care, for instance different Italian regions implemented different strategies in terms of hospitalization, treatment in ICUs or home care for patients infected with SARS-CoV-2 (48). Here, we point out that Italian health system is regionally decentralized (thus, Italy has twenty regional health services), a situation that is not useful in controlling a pandemic, especially if we take into account the strong political pressure toward the transfer of tax resources from the central (national) government to the regions where income is produced (49).

Taken as a whole, the results of this study suggest that Italy was not entirely prepared to handle such a pandemic; indeed, specialist perinatal healthcare services have been (and still are) disrupted at many levels by this global health emergency. This is in line with other COVID-19 studies that have reported similar situations in other high-income countries (5, 29, 36–41, 43–45, 49–51). Our findings deepen the understanding of how the pandemic has influenced Italian healthcare facilities, and can be crucial in guiding the development and implementation of effective responses and, more broadly, in supporting and strengthening perinatal health systems. From this perspective, crises are also times of opportunity (12). The COVID-19 pandemic has caused us to rethink how to improve access to and implementation of perinatal healthcare services. The improvements forced by the current pandemic will be useful during the next phases as well as during future possible national or global health crises.

Strengths and Limitations

The main strength of this research is that it is the first Italian study, and among very few international studies, that describe the effects of the COVID-19 pandemic on healthcare facilities and their provision of services. Thus, it may be helpful for the formulation of appropriate and evidence-based actions to be taken. However, in interpreting these results, certain limitations must be considered. First, the low response rate (5.4%) and of the fact that certain Italian regions are poorly represented or absent from the study. Thus, the results may not be representative of all perinatal healthcare facilities in Italy. However, it should be kept in mind that low response rates to online surveys in primary care are common and the extent to which results are affected is uncertain (52). Second, there is no information on the geographic location (urban vs. rural), patient volumes, and demographic characteristics of the responding facilities.

CONCLUSION

The COVID-19 pandemic has disrupted maternal and perinatal healthcare activities and services, as well as increasing levels of stress among healthcare providers. This study sheds light on the effects of the COVID-19 pandemic on maternal and perinatal healthcare facilities and provides insights for policymakers. The management, allocation, and training of peripartum/perinatal healthcare workers can and must be improved. Italian policymakers and administrators are urged to work together to improve care for the most vulnerable. Prompt and continuous evaluation, along with timely and effective information on the status of healthcare facilities is fundamental to the development and implementation of contextually relevant guidelines.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the corresponding author upon request.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethics Committee of ASST Spedali Civili Hospital Brescia, Italy (NP4221 24.06.2020). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LC and AS contributed equally to the general study design. LC and AT from the Observatory of Perinatal Clinical Psychology promote and coordinate the study in each health care service. MR, SC, and BM designed the plan of statistical analysis of the study. All authors have critically reviewed and agreed this final version of the article.

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Latent Profiles of Parental Burnout During COVID-19: The Role of Child-Related Perceptions

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The present study examined latent profiles of parental burnout dimensions (e.g., exhaustion in parental role, contrast with previous parental self, feelings of being fed up, and emotional distancing, measured with a shortened version of the parental burnout assessment scale) among Finnish parents of sixth and eighth grade children. In addition, the role of children's strengths and difficulties (e.g., prosocial skills, hyperactivity, somatic problems, conduct problems, and peer problems) and parents' growth mindset in predicting membership in the latent parental burnout profiles was examined. The participants were 1,314 parents (80% mothers) from the Helsinki Metropolitan area who filled in a questionnaire concerning their parenting burnout and child-related perceptions during the fall 2020. The results were analyzed using latent profile analysis (LPA) and three-step procedure. Three latent profiles of parental burnout were identified as: low parental burnout (85.7% of the parents), high parental burnout (8%), and emotionally distanced (6.3%) profiles. Parents who reported their children having some challenges (e.g., hyperactivity, somatic problems, conduct problems, and peer problems) more often belonged to the high burnout or emotionally distanced profiles rather than to the low parental burnout profile. Parents whose children had high prosocial skills and who employed growth mindset more often belonged to the low parental burnout rather than to the distanced profile.

Keywords: parental burnout, strengths and difficulties, latent profile analysis, growth mindset, COVID-19

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INTRODUCTION

For many parents, parenting is a highly rewarding experience with multiple positive consequences, such as increases in the meaning of life, happiness, and wellbeing (Nelson et al., 2013). However, parenting can also be taxing and taking care of children may involve both acute (e.g., conflicts) and chronic stressors (e.g., behavioral problems and health issues; Mikolajczak et al., 2019). Especially, when parents' resources do not meet the parenting demands, and the difficulties to deal with the existing stressors are overwhelming, parents may be at risk for parental burnout (Mikolajczak et al., 2019, 2020). A completely new and unexpected environmental stressor occurred in 2020, when the COVID-19 pandemic spread across the world. The pandemic resulted in lockdowns and quarantines across countries, causing severe turmoil in many families' lives. Due to the COVID-19 outbreak, concerns and fears about the virus increased which may have led to altered levels of stress, anxiety, and parental burnout among many families (Prikhidko et al., 2020). As the schools and workplaces were closing, many parents had to

supervise their children's schooling at home while simultaneously managing their own work remotely. In Finland, most schools were closed nearly 2 months during the initial phase of COVID-19 in spring 2020. However, they were again opened during the fall 2020, the time when the current data were collected. At the same time, lockdowns caused severe financial strain in many families' lives, and while parents needed to multitask and balance with their work and family duties, challenges related to these unexpected changes in work and family life may have resulted in altered parental burnout symptoms (see also Griffith, 2020).

The field studying parental burnout is relatively new; however, it is clear that parental burnout is a serious condition which would deserve heightened attention (Mikolajczak et al., 2019). Parental burnout can be highly damaging, and can manifest as suicidal and escape ideations (Mikolajczak et al., 2019), and as child neglect or abuse (Mikolajczak et al., 2018). Another concern parental burnout rises is its prevalence, as a study examining parents from 42 countries showed that parents across the world, especially in individualistic Western cultures, such as Finland, United Kingdom, Belgium, and United States, report symptoms of parental burnout (Roskam et al., 2021). Thus, it is of great importance to examine in more detail what percentage of parents experiences high or altered levels of parental burnout, and what factors precede it. However, even several studies have examined the different subdimensions of parental burnout, their antecedents and outcomes (Roskam et al., 2018), person-oriented research examining latent profiles of parental burnout is still sparse (see Hansotte et al., 2021; Lebert-Charron et al., 2021 for exceptions). It is possible that parents report different levels of burnout symptoms and that distinct latent homogeneous profiles can be identified reflecting high, average, and low levels of parental burnout. These profiles can be examined using person-oriented research, such as latent profile analysis (LPA; Muthén and Muthén, 2021). Consequently, the present study was among the first examining latent profiles of parental burnout (e.g., exhaustion in parental role, contrast with previous parental self, feelings of being fed up, and emotional distancing) by means of LPA during the pandemic. In addition, the role of parental perceptions (e.g., strengths and difficulties and growth mindset) in predicting membership in the latent profiles was examined.

Parental Burnout

Parental burnout develops as a prolonged response to overwhelming parental stress, when parents' own resources do not meet the parenting demands (Mikolajczak and Roskam, 2018). Parental burnout has been distinguished from job burnout, as one can simultaneously be drained by one's job and not by parenting, and *vice versa* (Mikolajczak et al., 2019), and even parental burnout literature shares some similar aspects (e.g., exhaustion) with job burnout literature, and parental burnout is mildly correlated with job burnout, it loads to separate factors from job burnout (Roskam et al., 2017, 2018). Parental burnout was initially researched using similar constructs to job burnout (e.g., exhaustion, depersonalization, and inefficacy) using the parental burnout inventory (PBI; Roskam et al., 2017); however, further research among burned out parents indicated the existence of four separate dimensions specific to parental burnout, each of which describes different aspects of parents' experiences. These four dimensions are measured with parental burnout assessment (PBA; Roskam et al., 2018). The most important dimension of parental burnout is *exhaustion*, which describes parents' feelings of tiredness in parental role, so that it reaches the level of exhaustion (Roskam et al., 2018). The second dimensions are called as *contrast with previous parental self*, which describes parents' feelings of not being able to be as good parent as before (Mikolajczak et al., 2019). As a diagnostic criterion of parental burnout, contrast with previous self-distinguishes exhausted parents from permanently dismissive ones (Roskam et al., 2018). The third dimension, described as parents' *feelings of being fed up*, characterizes parents' loss of pleasure and feelings of fulfillment in parental role (Roskam et al., 2018). The fourth dimension is characterized as parents' *emotional distancing from one's children*, when parents are so exhausted they disengage emotionally rather than physically from their children (which is often not possible), and provide only the necessary practical care, such as taking care of everyday tasks, but become emotionally less involved and responsive to their children (Roskam et al., 2018). It can be further assumed that different crisis situations alter burnout symptoms among parents. The present study examined parental burnout profiles during the COVID-19 pandemic.

It is also possible that experiences of parental burnout are not similar for all parents. For example, some parents may experience generalized exhaustion in parental role, whereas other parents feel increased emotional distance from their children. These differences can be captured using person-oriented methods, such as LPA, which was employed in the present study. The structure of parental burnout dimensions has been examined to some extent (Roskam et al., 2018; Aunola et al., 2020), however, so far two studies have previously sought to examine parental burnout profiles using LPA or cluster analysis as a method (Hansotte et al., 2021; Lebert-Charron et al., 2021). In their study, using the PBA, Lebert-Charron et al. (2021) examined over one thousand French mothers and were able to identify five clusters on the basis of parental burnout symptoms. The largest cluster (49% of the mothers) was called as "absence of parental burnout," characterized by very low scores on all burnout dimensions. The second largest group (18%), "middle manifestations of parental burnout" cluster, described low levels of exhaustion and saturation, and very low levels of contrast and emotional distancing. The third (11%) cluster described altered emotional distancing, and the fourth (12%) and fifth (10%) clusters described high and very high manifestations of parental burnout. Group differences were found between the clusters concerning affective variables, such as anxiety, burden, and depressive symptoms, which were altered in clusters reflecting higher levels of parental burnout (Lebert-Charron et al., 2021). Similarly, using the earlier measure of PBI and an online survey, Hansotte et al. (2021) were able to identify five latent parental burnout profiles: not in parental burnout (59%), inefficient (9%), at risk of parental burnout (20%), emotionally exhausted and distant (8%), and burned

out (3%) profiles. The results further showed that profiles with high levels of exhaustion and emotional distancing were associated with higher levels of neglect and violence (Hansotte et al., 2021). The present study continues this line of person-oriented research on parental burnout, using LPA as a method. The advantage of LPA over traditional cluster analysis used in the previous study is that it is model-based and provides fit indices for different latent profile solutions, which can then be compared in order to determine the final number of profiles. Moreover, the present study examines parental burnout profiles both among mothers and fathers.

Parental Burnout and Parental Perceptions Concerning Their Children

Research on parental burnout has often focused on examining various factors that may make parents vulnerable for burning out in parenting (Mikolajczak et al., 2019). One major factor contributing to parental burnout is parents' concern about their children, such as worries about behavioral or health problems and educational difficulties (Griffith, 2020). Parents of children with chronic illnesses or special needs score higher for burnout than parents of control group (Lindström et al., 2011; Gérain and Zech, 2018). Similarly, parents' concerns about their children's behavioral and emotional problems may increase symptoms of parental burnout. The COVID-19 pandemic might have increased also children's concern about the virus, and as new social distancing recommendations took place and children could spend less time with their friends, which might have shown as problems in their behavior and emotional state. This might have increased parents' concerns about their children and further manifest in their perceptions of their children. As a result, parents' perceptions of their children's strengths and difficulties, such as prosocial skills, hyperactivity, somatic problems, conduct problems, and peer problems (e.g., loneliness), might have amplified during the pandemic's school closures when parents spent more time with their children at home.

In addition to strengths and difficulties, parents' perceptions of growth mindset (Dweck and Yeager, 2019) may affect their parenting stress. Growth mindset refers to a belief that one's capacities are not fixed but can be developed over time, whereas fixed mindset refers to a belief that capacities cannot be shaped or developed (Dweck and Yeager, 2019). Such beliefs can shape one's experiences and show in their attitudes toward others or learning (Dweck and Yeager, 2019). Some parents emphasize more the possibilities of growth and malleability of abilities (e.g., growth mindset; Dweck and Yeager, 2019), which might have helped parents to feel less stressed about their children's skill development while homeschooling their children (see also Mosanya, 2020), and result as lesser parental burnout. Contrary to fixed mindset, parents who employ growth mindset believe that children's capacities are not fixed but can develop over time (Dweck and Yeager, 2019). Parents growth mindset is often associated with parents' behavior, children's mindsets (Dweck and Yeager, 2019), and skill development (Andersen and Nielsen, 2016). Recent results have shown, that growth mindset shows as reduced academic stress among university students, and may enhance one's resilience during times of crisis, such as COVID-19 (Mosanya, 2020). Similarly, parents' growth mindset might act as a resilience factor and protect parents against severe stress (e.g., parental burnout). However, no previous studies have examined the associations between parents' perceptions of their children's strength and difficulties, their own growth mindset, and parental burnout. The present study is the first to examine these associations.

Previous studies have also shown that mothers often experience higher parental burnout than fathers (Aunola et al., 2020; Roskam and Mikolajczak, 2020). Mothers are often more involved in taking care of children than fathers (Mikolajczak et al., 2018) which makes them prone to parental stress and burnout (Aunola et al., 2020). Parents' educational level is often unassociated with parental burnout (Mikolajczak et al., 2018; Roskam et al., 2018; Aunola et al., 2020); however, less is known about the extent to which parents' educational level is associated with parenting burnout profiles. The present study examined the role of parents' gender and educational level in predicting their membership in parental burnout profiles during the pandemic.

Aims

The following research questions were examined in the present study:

1. What kind of distinct latent profiles (e.g., groups of homogeneous subjects) can be identified according to parental burnout symptoms (e.g., exhaustion in parenting, contrast with previous parental self, feelings of being fed up, and emotional distancing) among Finnish parents during fall 2020?
2. To what extent parents' perceptions of their children's strengths and difficulties (e.g., prosocial skills, hyperactivity, somatic problems, conduct problems, and peer problems) predict parents' belonging to different parental burnout profiles?
3. To what extent parents' growth mindset predicts them belonging to different parental burnout profiles?
4. To what extent parents' gender and educational level predict them belonging to different parental burnout profiles?

MATERIALS AND METHODS

Participants

The participants of the present study came from the longitudinal growing mind study. During the fall 2020, during the COVID-19 pandemic, 1,314 parents (80% mothers, 19% fathers, and 1% else) from the Helsinki Metropolitan area filled in a questionnaire concerning their parental burnout and perceptions concerning their sixth and eighth grade children. Finnish children typically start their sixth and eighth grades when they are 12 and 14 years old. The parents' educational level was as follows: elementary education (2%), high school degree (3%), vocational degree (13%), double degree (4%), polytechnic degree (22%), bachelor's degree (6%), master's degree (40%), doctoral degree (7%), and other (3%). Most families (77%) had two parents, and 5% consisted of single parents. Altogether 22% of the parents were divorced, and some (8%) lived in blended families.

Measures

Parental burnout was examined with a shortened version of the PBA scale (Roskam et al., 2018). The scale consisted of eight items (e.g., two items concerning each subdimension) measuring parents' exhaustion in parenting (e.g., "I feel completely run down by my role as a parent"), contrast with previous parental self (e.g., "I tell myself that I'm no longer the parent I used to be"), feelings of being fed up (e.g., "I cannot stand my role as father/mother any more"), and emotional distancing from one's children (e.g., "I do what I'm supposed to do for my child(ren), but nothing more"). Parents' answered to each item using a 7-point Likert scale (1 = completely disagree; 7 = completely agree). Sum scores were constructed separately for each parental burnout dimension. The Cronbach's alpha reliabilities for exhaustion, contrast, feelings of fed up, and distancing were 0.79, 0.70, 0.51, and 0.51, respectively, indicating a moderate to high reliability of the variables (e.g., values between 0.50 and 0.70 considered as moderate reliability; Perry et al., 2004).

Strengths and difficulties questionnaire (SDQ, Goodman, 2001) was used to measure parents' perceptions concerning their children, which is a widely used short tool for emotional and behavioral screening. The questionnaire maps five different dimensions of children's strengths and weaknesses: prosocial skills (e.g., *"Considers other people's feelings."*), hyperactivity (e.g., "*Restless, over-active, unable to be quiet and still for a long time."*), somatic problems (e.g., *"Often complains about headaches, stomach ache or nausea."*), conduct problems (e.g., *"Generously shares his/her items with other children."*), and peer problems (e.g., *"He/she is picked on or bullied by other children."*). Each subdimension was measured with five items, and parents responded to them with a 3-point scale (1 = false; 3 = entirely true). Sum scores were constructed for each dimension. The Cronbach's alpha reliabilities for prosocial skills, hyperactivity, somatic problems, conduct problems, and peer problems were 0.72, 0.78, 0.72, 0.56, and 0.60.

Parents' growth mindset was examined with a four questions (Dweck, 2006; e.g., *"A person can learn new things, but he/she cannot change his/her intelligence."*). Parents answered to the questions with a 6-point Likert scale (1 = completely agree; 6 = completely disagree). The Cronbach's α for the sum score was 0.92.

Parents' gender was coded 1 = mother; 2 = father.

Parents' educational level was coded 1 = basic education; 2 = secondary education; and 3 = tertiary education.

Analysis Strategy

To be able to identify the homogeneous latent groups of parents with different levels of exhaustion in parental role, contrast with previous parental self, feelings of being fed up, and emotional distancing, the results were analyzed by means of LPA (Muthén and Muthén, 2021), which is a type of finite mixture analysis that assesses heterogeneity through the identification of homogeneous subgroups (i.e., latent profiles) of participants with similar indicator means (e.g., parental burnout dimensions) within the latent profiles. The advantage of LPA over traditional cluster analysis is that it is model-based and provides fit indices for different latent profile solutions, which can then be compared in order to determine the best fitting final solution.

No control variables were used in defining the latent profiles. The latent profile analyses were carried out in two phases. As we were interested in examining what kind of naturally occurring latent profiles of parental burnout indicators could be identified, latent profile analyses for different latent groups were carried out first, and the fit indices and class frequencies were compared. The variances were estimated equal between the classes. The estimation was performed step by step, starting from one-class solution to estimate the parameters for 2, 3, …, *k*-class solutions. The solution that best fitted the data in accordance with the indicators and that was also deemed reasonable in terms of interpretation was chosen as the final latent profile model. Second, in order to identify the possible antecedents of parental burnout profiles, parents' perceptions of their children's strengths and difficulties (prosocial skills, hyperactivity, somatic problems, conduct problems, and peer problems), mindset, and parents' gender and educational level were added into the final model as covariates using the three-step procedure (Asparouhov and Muthén, 2014). In the three-step procedure, after determining the number of latent profiles (step 1, as described above), the profile probabilities were saved in a new data set with the covariates (step 2), and using the new data set, the role of the antecedents was examined further (step 3; see Asparouhov and Muthén, 2014 for further details of the analyses). The benefit of the three-step procedure is that the forming of the latent profiles is free from the effect of the covariates. Each covariate was added in the model separately (see **Table 1** for means, variances, and correlations).

All the analyses for the LPAs were performed with the Mplus statistical package (version 8; Muthén and Muthén, 2021). Missing data were deleted listwise, which was the default for this type of analysis (Muthén and Muthén, 2021). There were 4–6% random missingness in the examined variables. The model parameters were estimated by means of maximum likelihood robust (MLR) estimator, which is robust to the non-normality of the observed variables. Maximum likelihood robust produces standard errors and a chi-square test statistic for missing data with non-normal outcomes by means of a sandwich estimator and the Yuan-Bentler T2 test statistic (Muthén and Muthén, 2021).

RESULTS

The purpose of the mixture analyses was to find out whether distinct latent profiles (e.g., groups of homogeneous subjects) could be identified (Muthén, 2001; Muthén and Muthén, 2021). Five criteria were used to decide the final number of classes: (a) the Bayesian information criterion (BIC) and (b) the Akaike information criterion (AIC), according to which the model with the smallest value is considered the

TABLE 1 | Pearson correlation coefficients, means, and variances for all the examined variables.

S. No.		1	2	3	4	5	6	7	8	9	10	11	12
1.	Parental exhaustion												
2.	Contrast	0.49***											
3.	Feelings of fed up	0.57***	0.46***										
4.	Emotional Distancing	0.37***	0.42***	0.38***									
5.	SDQ prosocial	−0.22***	−0.18***	−0.20***	−0.18***								
6.	SDQ hyperactive	0.31***	0.24***	0.29***	0.18***	−0.30***							
7.	SDQ somatic	0.27***	0.22***	0.22***	0.12***	−0.16***	0.28***						
8.	SDQ conduct problems	0.32***	0.26***	0.29***	0.15***	−0.45***	0.51***	0.31***					
9.	SDQ peer problems	0.21***	0.21***	0.18***	0.15***	−0.27***	0.18***	0.36***	0.19***				
10.	Growth mindset	−0.09***	−0.07**	−0.09**	−0.14***	0.10***	−0.10***	−0.01	0.12***	−0.08			
11.	Gender	−0.03	0.02	−0.03	0.11***	−0.04	−0.04	−0.03	−0.05	0.00	−0.06*		
12.	Educational level	−0.01	−0.03	−0.01	−0.05	0.05	−0.09***	0.00	−0.01	−0.04	0.05	0.03	
M		1.94	1.75	1.30	1.39	2.44	1.44	1.25	1.28	1.36	4.45	1.19	2.75
Var		1.42	1.21	0.42	0.58	0.16	0.18	0.11	0.08	0.10	1.46	0.16	0.22

***$p<0.001$; **$p<0.01$; *$p<0.05$.

best model; (c) the Vuong-Lo-Mendell-Rubin (VLMR) test of fit, which compares solutions with different numbers of profiles (a low value of p indicates that the k model has to be rejected in favor of a model with at least $k+1$ profiles); (d) entropy values, which determine classification quality (values close to 1 indicate clear classification; Celeux and Soromenho, 1996); and (e) the clarity and interpretation of the profiles.

Table 2 shows the different fit indices for the compared latent profile solutions. Comparison of the fit indices and profile frequencies showed that when a third group was included in the analyses, the BIC, aBIC, and AIC slightly decreased and entropy value slightly increased compared to the two profile solution, and the profile sizes were acceptable. Also the VLMR test suggested that including a third profile would better fit the data. Thus, because the three profile solution was theoretically meaningful and the goodness-of-fit indices indicated that the third latent group was necessary, the three-latent-group solution was considered the best model. The final three profile solution is presented in **Figure 1**.

The first latent profile (85.7% of the parents) was characterized by a low level of all parental burnout components (**Figure 1**). The second latent profile (8% of the parents) was characterized by a relatively high parental exhaustion, contrast with previous parental self, and feelings of fed up, but a low level of emotional distancing. The third latent profile (6.3% of the parents) was characterized by an average level of parental exhaustion, contrast with previous self, and feelings of fed up, and a high level of emotional distancing from one's children. The latent profiles were labeled as *low parental burnout (*e.g., *low PB), high parental burnout (*e.g., *high PB),* and *emotionally distanced* profiles.

Next, to investigate the role of covariates in predicting the three latent profiles of parental burnout, parents' perceptions of their children's strengths and difficulties (prosocial skills, hyperactivity, somatic problems, conduct problems, and peer problems) and parents' gender and educational level were added in the final model separately as covariates using the three-step procedure (Asparouhov and Muthén, 2014). The results for the covariates showed that parents who perceived their children as having high prosocial skills, and who emphasized growth mindset, were more likely to belong to the low PB profile than to the distanced profile (**Table 3**). Moreover, parents who perceived their children were hyperactive or had problems with peers, more often belonged to the distanced or high PB profiles rather than to the low PB profile. Parents who perceived their children had somatic or conduct problems more often belonged to the distanced or high PB profiles rather than to the low PB profile or to the high PB rather than to the distanced profile. Further, mothers more often belonged to the high PB rather than to the distanced profile, whereas fathers more of the belonged to the distanced rather than to the low PB profile (**Table 3**). Parents with higher educational level rather belonged to the low PB than to the high PB profile. Further, parents with higher educational level more often belonged to the distanced rather than to the low PB profile.

TABLE 2 | Fit indices for the compared latent profiles.

Number of profiles	BIC	aBIC	AIC	Entropy	VLMR	Difference in the number of parameters	Value of *p*	Latent class proportion %
1.	13784.77	13759.35	13743.32	–	–	–		
2.	11757.69	11725.92	11705.89	0.96	−7083.16	4	0.01	85/15
3.	11496.68	11439.50	11403.43	0.97	−5977.94	5	0.03	86/6/8
4.	11008.11	10935.05	10888.95	0.97	−5683.71	5	0.20	81/11/4/4

BIC, Bayes information criteria; aBIC, Adjusted Bayes information criteria; AIC, Akaike information criteria; and VLMR, Vuong-Lo-Mendell-Rubin.

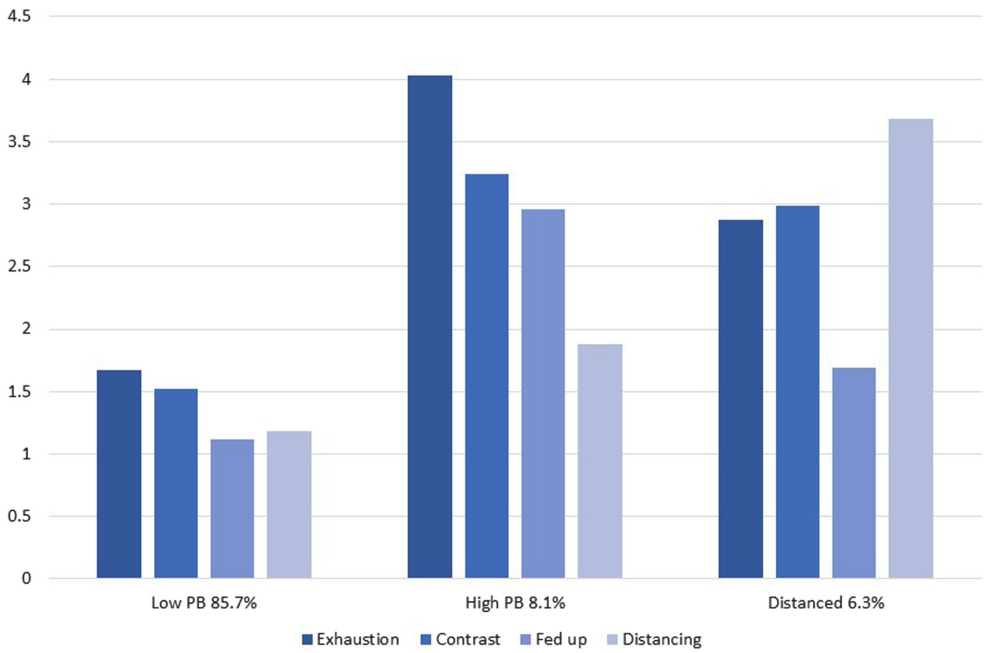

FIGURE 1 | Latent profiles of parental burnout.

DISCUSSION

The present study was one of the first person-oriented studies which examined parental burnout profiles using sophisticated statistical methods, i.e., LPA. Parental burnout profiles were examined during an unprecedented time of global COVID-19 pandemic, when in many countries, new regulations and lockdowns took place. The pandemic caused changes in almost every aspect of life, causing severe psychological, social, and financial strain for many families. Due to the pandemic, social contacts have reduced, and the availability of social support and help in child rearing have decreased, which might have increased risk for parental burnout. Because of the pandemic, parents had to balance between work and taking care of their children, and they might have to extent their work beyond regular working hours. Parents have also had fewer places to go for their own leisure activities which typically help in creating a better work and family life balance. All these strains might have increased parental stress, concern about their children, and parental burnout. The present study examined associations between parents' child-related perceptions and parental burnout profiles among Finnish parents.

Latent Profiles of Parental Burnout

Although the structure of parental burnout dimensions has been examined to some extent (for examples, see Roskam et al., 2018; Aunola et al., 2020), only two studies so far have examined parental burnout profiles using cluster analysis (Lebert-Charron et al., 2021) or LPA (Hansotte et al., 2021). To the authors' knowledge, the present study was the first examining the latent profiles of parental burnout measured with the PBA using LPA. The advantage of LPA over traditional cluster analysis is that it provides fit indices for different latent profile solutions, which helps in determining the best fitting final solution for the data. Three latent profiles of parental burnout were identified among Finnish parents, namely, high PB, low PB, and distanced profiles. The largest profile was the low PB profile to which 85.7% of the parents belonged. It was characterized by a low level of all components

TABLE 3 | Antecedents of parental burnout profiles.

	Distanced vs. low PB	High PB vs. low PB	High PB vs. distanced
SDQ prosocial	−1.06***	0.31	−0.31
SDQ hyperactive	1.18***	1.49***	0.31
SDQ somatic	0.91**	1.55***	0.64*
SDQ conduct problems	1.44***	2.54***	1.10*
SDQ peer problems	1.25***	1.55***	0.30
Growth mindset	−0.31***	−0.15	0.16
Gender	0.53*	−0.48	−1.01*
Educational level	−0.51*	0.26	0.78*

***$p < 0.001$; **$p < 0.01$; *$p < 0.05$.

of parental burnout (e.g., parental exhaustion, contrast with previous parental self, feelings of being fed up, and emotional distancing). The second largest profile was the high PB profile to which 8% of the parents belonged, and it was characterized by a relatively high parental exhaustion, contrast with previous parental self, and feelings of fed up, but a low level of emotional distancing. The third latent profile (6.3% of the parents) was called distanced profile, as it was characterized by a high level of emotional distancing from one's children, and an average level of parental exhaustion, contrast with previous self, and feelings of fed up. These results are partially in line with previous research showing that approximately 67% of French mothers reported absent or low scores, and 22% reported high scores on parental burnout (Lebert-Charron et al., 2021). In our study, 8% of the parents reported high parental burnout. These differences may be due to also fathers participated in the present study. Previously, it has been find that mothers often report higher parental burnout (Aunola et al., 2020; Furutani et al., 2020; Roskam and Mikolajczak, 2020).

In the present study, emotionally distanced parents separated out as their own profile. These results suggest that small populations (6%) of exhausted parents use emotional distancing as their "reserve" to escape otherwise overwhelming tasks of parenting during the pandemic (see also Cullati et al., 2018). Similarly, Hansotte et al. (2021) found in their study one small (8%) profile in which parents reported high emotional exhaustion and distancing. The results further showed that especially fathers belonged to the emotionally distanced profile. Fathers often spend more time at work than mothers (Nomaguchi et al., 2005), which might make them prone to emotional distancing from their families. Previous studies have also suggested that profiles of emotionally distanced parents are composed of a very specific group of parents who might suffer from other mental disorders (Lebert-Charron et al., 2021). Future studies should examine the characteristics of this profile further.

Importantly, the results showed that different profiles of parental burnout can be identified. Similar to previous studies which have shown that smaller proportions of parents (approximately 20% of mothers) suffer from parental burnout (Séjourné et al., 2018), the results indicated that 14.3% of the parents reported parental burnout symptoms. However, different from most previous studies, 8% of the parents reported high levels of all four burnout symptoms, whereas 6.3% of the parents reported high emotional distancing and altered levels of exhaustion, contrast with previous self, and feelings of fed up. These are important results which show that parental burnout symptoms can manifest in multiple ways among parents. Further interventions to prevent and treat parental burnout could be designed based on these results. For example, parents who suffer from overall high parental burnout may benefit more from directive treatment interventions which target the discrepancy between parenting demands and resources, whereas emotionally distanced parents may benefit from nondirective treatment interventions focusing on active listening, encouragement, and feelings of worth and ability (see also Brianda et al., 2020). However, when compared to the previous studies (Séjourné et al., 2018; Lebert-Charron et al., 2021), in the present study the percentages of parents suffering from burnout during the COVID-19 pandemic were not higher. However, the above mentioned studies targeted only mothers' experiences, among who parental burnout is often higher (Aunola et al., 2020; Furutani et al., 2020), which may partly explain the results.

Associations Between Parental Burnout and Parental Beliefs and Perceptions

The role of parental perceptions concerning children's strengths and difficulties, and growth mindset in determining parents' belonging to one of the three parental burnout profiles was examined. The results clearly indicated that parents' concerns about their children's difficulties (e.g., hyperactivity, somatic, conduct, and peer problems) were associated with parents belonging to one of the burnout profiles, whereas parents whose children had high prosocial skills (e.g., strength) or who emphasized growth mindset were more likely to experience low parental burnout. Previous research examining self-, parent-, and teacher-reports of strengths and difficulties questionnaire has proven its validity as a tool for identifying emotional and behavioral problems in children and adolescents (Tobia and Marzocchi, 2018; Theunissen et al., 2019). Thus, it is possible that parents' concerns about their children's difficulties were accurate and manifested as increases in parental burnout. Similarly, previously it has been found that parents whose children have externalized disorders, such as conduct disorders or antisocial behavior, often experience higher levels of parental burnout (Sorkkila and Aunola, 2020) and disengage emotionally from their children (Roskam et al., 2018). Due to the ongoing pandemic, most parents were spending more time at home with their children, and parents were also able to observe their children's learning and possible related problems much more frequently than before, which might have increased parents' concerns. Also other fears, worries, and life changes related to the COVID-19 pandemic might have triggered more child-related concerns among parents. On a positive note, children's strengths and parents' growth mindset manifested as low parental burnout. Beliefs about mindsets can shape parents' experiences and attitudes toward their children's learning (see also

Dweck and Yeager, 2019). Parents who employ growth mindset, believe their children's capacities can be developed over time (Dweck and Yeager), and are often more involved in their children's education and engage with their children in more constructive ways than parents who employ fixed mindsets (Mueller et al., 2017), which may also reduce parental stress. Growth mindset can reduce stress and enhance resilience among university students (Mosanya, 2020). Similarly, among parents, growth mindset might act as a sign of resilience and protect parents from parental burnout. In future studies, it would be possible to design growth mindset interventions to help reducing parental burnout (see also Rowe and Leech, 2019). Moreover, mothers more often belonged to the high PB rather than to the distanced profile, whereas fathers more of the belonged to the distanced rather than to the low PB profile. These results partly align with findings of some previous studies showing that mothers often score higher in the global parental burnout scale (Aunola et al., 2020). Contrary some previous findings showing that educational level is not associated with parental burnout (Mikolajczak et al., 2018; Roskam et al., 2018; Aunola et al., 2020), the present results showed that parents with higher educational level suffered less from parental burnout. One reason for these differences in the findings may be methodological differences, i.e., the present study being person-oriented compared to previous variable-oriented studies.

Limitations

This study has some limitations which should be taken into account when generalizing the findings of the present study. First, the study design was cross-sectional, which made it not possible to examine the order of the associations (e.g., whether parental perceptions predict parental burnout profiles or *vice versa*). Similar associations should be examined in future studies using longitudinal designs. Second, the parental burnout assessment used in the present study was a shortened version of the original 23-item PBA scale (Roskam et al., 2018) which may have affected the results. More studies would be needed examining latent profiles of parental burnout using the original PBA scale. Third, some variables used in the present study showed only moderate reliability, and even values between 0.50 and 0.70 are considered as moderate reliability (Perry et al., 2004), more studies in the future would be needed to explore similar constructs further. Fourth, other variables which were not examined in the present study might have affected the results. For example, parental burnout is often associated with depressive symptoms, lower self-esteem, and sleep disruptions (Lindström et al., 2011; Mikolajczak et al., 2019; Aunola et al., 2020). More studies would be needed in the future to examine whether these variables are associated with latent profiles of parental burnout.

CONCLUSION

The present study showed importantly that by using person-oriented research (LPA), it is possible to identify distinct homogenous profiles of parents who suffer from parental burnout. The results indicated that most parents (85.7%) typically show low parental burnout, whereas smaller percentages of parents belong to high (8%) or distanced (6.3%) parental burnout profiles. Similarly, previous studies have shown that the majority of parents (between 60 to 80%) typically reports low or nonexistent parental burnout symptoms (Roskam et al., 2018; Séjourné et al., 2018; Lebert-Charron et al., 2021). Unlike burned out employees, burned out parents cannot take sick leave or take extended breaks from parenting (Mikolajczak et al., 2019). The COVID-19 pandemic also decreased normal social interactions and families are spending more time among themselves. Having no escape from parenting may prompt some burned out parents to emotionally distance from their children, as our results showed. Worries and fears about the virus spreading, and other social, psychological, and financial strains that the pandemic caused might have increased parents' concerns about their children's behavioral and emotional difficulties. In future studies and intervention designs, it would be important to take into account the type of parental burnout profiles each parent belongs to. For example, some parents might benefit from reducing the discrepancy between parenting-related demands and resources, whereas other parents may benefit more from active listening and encouragement (see also Brianda et al., 2020). Moreover, the present study examined antecedents of parental burnout profiles, using a shortened version of PBA. Recently, the outcomes of parental burnout (measured with the original PBI) profiles were examined, showing different profiles of parental burnout were associated with different consequences in terms of neglect and violence toward children (Hansotte et al., 2021). More studies would be needed to examine the outcomes of parental burnout profiles using the PBA scale. In addition, the notion that some parents suffer from parental burnout is relatively new, and more information and public discussion concerning the topic would be needed. Increasing discussion about parental burnout and related factors would help parents to better understand their symptoms and, if necessary, seek for help. Moreover, brief instruments could be develop to be used at places, such as maternity clinics and healthcare centers, to screen and prevent possible symptoms of parental burnout, and to identify possible risk groups of parents prone to such symptoms (see also Aunola et al., 2020). Such screenings could be conducted, for example, in regular intervals at the same time when parents take children to their regular checkups in order to enhance families wellbeing.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the University of Helsinki Ethical Review Board.

The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

KU contributed to the writing of the manuscript and performed the statistical analyses. KS-A contributed to the design of the study and writing of the manuscript. All authors contributed to the article and approved the submitted version.

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Mental Health of Parents and Preschool-Aged Children During the COVID-19 Pandemic: The Mediating Role of Harsh Parenting and Child Sleep Disturbances

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In the context of the coronavirus disease-2019 (COVID-19) pandemic, mental health problems of parents and children have become a public issue. Herein, we explored the association between parental well-being index and child mental health problems during the pandemic and the mediating role of harsh parenting and child sleep disturbances. An online survey was conducted among 16,398 parents of children aged 3–6 years (48.1% girls, M_{age} = 4.69 years, SD_{age} = 0.75 years) from March 15 to 29, 2020. Child mental health (Strengths and Difficulties Questionnaire, SDQ), sleep problems (Children's Sleep Habits Questionnaire, CSHQ), and parental well-being index (World Health Organization-Five Well-Being Index, WHO-5), and harsh parenting were reported by parents. The results revealed that a higher parental well-being index was associated with lower child mental health problems. Harsh parenting and child sleep problems were significant mediators within the association. This study indicates the association between parental well-being index and child mental health during the pandemic and underlying mechanism, and has important implications for reducing parental and child mental health problems.

Keywords: parental well-being index, child mental health problems, childhood adversity experience, child sleep problems, COVID-19 pandemic, preschoolers

INTRODUCTION

The coronavirus disease-2019 (COVID-19) has spread across the world rapidly. Currently, the pandemic is still ongoing and even deteriorating in some regions and countries. China has effectively controlled the pandemic by implementing measures such as nationwide home confinement and school closure. Approximately 180 million primary and secondary students and 47 million preschool children who were confined at home during the pandemic experienced a sudden change in lifestyle in China (1). Although guidelines, resources, and interventions have been promptly provided (2), increasing concerns are emerging regarding the mental health of children during the pandemic. Thus, exploring the factors influencing child mental health to ensure the healthy growth of children during the pandemic becomes especially important. Mental health is recognized as the primary factor in having a good

quality of life, and happy and confident children are more likely to maintain it into adulthood, thus providing resilience in the face of adversity (3). It is an important factor that affects physical health. For example, studies have demonstrated associations between emotional and behavioral problems and diet quality (4). Consequently, considering the important role of child mental health and the negative impact of the COVID-19 pandemic, it is of critical importance to focus on the factors affecting child mental health during the pandemic.

The strike of the COVID-19 outbreak accompanied by home confinement, social isolation, unhealthy lifestyle, and unfavorable family environment factors have been regarded as an adverse experience that could impair the child mental health (5). Does this mean that lower well-being index of parents and worse parenting style and unhealthy lifestyle, such as child sleep hygiene problems act on child mental health? However, their unique roles during the pandemic have attracted limited attention. Therefore, this study examined the association between parental well-being index and child mental health by using a sample of isolated Chinese preschool-aged children during the COVID-19 pandemic. Furthermore, we examined the internal mechanism of the above relationship.

Parental Well-Being Index and Child Mental Health Problems

The effect of home confinement on parental and child mental health is of great concern. Epidemiological studies have shown that children exposed to pandemics are particularly vulnerable to behavioral problems, including hyperactivity, conduct disorders, externalizing problems, and general psychological distress (1, 6, 7). Significant disruptions in family lifestyle during the home confinement, combined with heightened stress and anxiety can lead to psychological difficulties in preschoolers.

In the meantime, just like their children, adults face all kinds of stress. In particular, parents have to cope with social distancing and changes in their daily routine, such as working remotely or facing unemployment, combined with additional caring for their children during school hours. In some cases, the changes brought about by the confinement were accompanied by reduced income and new responsibilities, which likely exacerbated the pre-existing difficulties and pressures (8, 9). Yet, despite a growing focus on the impact of COVID-19 on adults' and children's mental health, few studies have explored the association between parental well-being index and child mental health problems in the context of the pandemic. Therefore, based on previous evidence, we propose the following hypothesis in the pandemic:

> Hypothesis 1: parental well-being index would be associated with child mental health problems.

The Mediating Roles of Harsh Parenting and Child Sleep Disturbances

Parenting style refers to a series of practices that create an emotional environment and influence child development and well-being (10). Previous studies have reported that parents' mental health likely affects their parenting behaviors, with harsh parenting style, in turn, leading to child mental health problems (11). In the context of the COVID-19 pandemic, parents experiencing elevated levels of cumulative stress are even more likely to display more rigid and abusive parenting behaviors (12). Ineffective parenting practices are positively associated with child behavioral problems (13). In particular, parental verbal aggression alone as separate and distinct from physical punishment contributes to lower self-esteem in children (14). Concerning parenting strategies, the American Academy of Pediatrics recommends against physical and verbal punishment of children in favor of more effective disciplines for raising healthy children (15). Therefore, increased attention should be paid to investigating the mediating role of parenting style within the parent-child mental health association. Thus, the following hypothesis is developed in relation to the pandemic:

> Hypothesis 2: harsh parenting would mediate the relationship between parental well-being index and child mental health problems.

Sleep disturbances frequently occur in preschool children and are associated with a range of adverse health outcomes (16). During the pandemic, the confined preschoolers were reported to demonstrate changes in sleep patterns characterized by later bedtimes and wake times, longer nocturnal, and shorter nap sleep durations (17). Increasing research has indicated the impact of parental psychological functioning on sleep quality in young children. For example, parental depression and stress were linked to child sleep disturbances (18). Moderate/severe maternal depression symptoms were associated with increased odds of children aged 4–5 years sleeping <10 h/day (19). Meanwhile, it has been well-documented that sleep disturbances are associated with poor mental health in children. For example, children with sleep disturbances show more maladaptive emotional generation and regulation processes, more inattention, aggressive and hyperactivity-related problems, more peer problems and school readiness problems (20). Based on these findings, it can be inferred that sleep problems may increase child mental health problems. Thus, we propose the following:

> Hypothesis 3: child sleep problems would mediate the relationship between parental well-being index and child mental health problems.

In summary, harsh parenting and child sleep problems are important links that connect parental well-being index and child mental health problems. Environmental and lifestyle factors can affect sleep quality and quantity and lead to sleep disorders (21). Children who live in families with harsh parenting are significantly associated with lower verbal skills and increased behavioral problems, including internalization, externalization, and sleep problems (22). A prospective study demonstrated that hostile parenting predicts child sleep problems (23). Thus, harsh parenting style may be positively contributed to child sleep disturbances. Based on the above, parents with a low well-being index may implement rigid parenting behaviors, which further increase the odds of child sleep disturbances and enhance their mental health problems, a serial link demanding a systematic investigation. Thus, the following hypothesis is proposed:

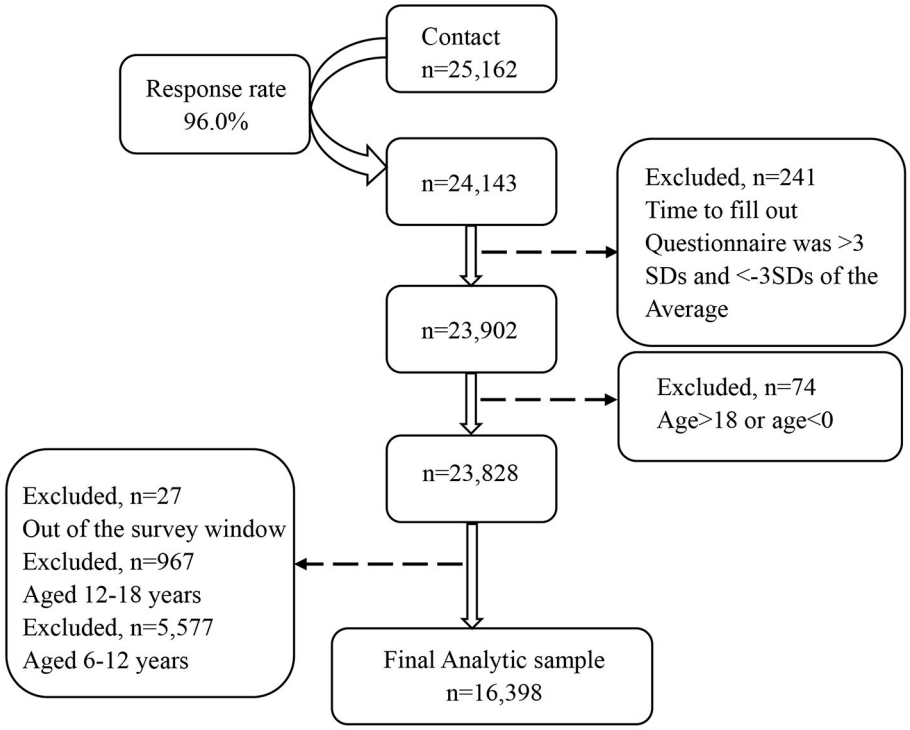

FIGURE 1 | Flow-chart for participants.

Hypothesis 4: parental well-being index would be associated with child mental health problems through the serial mediating roles of harsh parenting and child sleep problems.

MATERIALS AND METHODS

Participants and Procedures

The current study used data from a population-based online survey that included parents (including other caregivers) of children aged 3–6 years from 28 provinces across mainland China. Specifically, 25.7% of the questionnaires came from East China (Shanghai, Zhejiang, Jiangsu, and so on), 73.3% from southwest China (Chongqing, Sichuan, Guizhou, and so on), and 1% from other regions (Guangdong, Shanxi, Henan, and so on). The survey was conducted through the WeChat-based survey program, Questionnaire Star (https://www.wjx.cn/), a frequently used online survey platform in China, from March 15 to 29, 2020 when the families were on mandatory home confinement while filling the survey (24). The survey was administered through a combination of non-probabilistic convenience and snowball sampling. The scan code and link for the survey were posted to the public. The parents who agreed to participate were encouraged to forward the survey link to other parents. Participants endorsed their consent before moving on to the survey questions. To promote participation and data quality, a free online workshop entitled "how to help your child get sound sleep during COVID-19?" was delivered to the participants by a psychologist and sleep specialist (GW). We also used a series of logical algorisms in the program to maximize the accuracy and quality of the online survey, such as restricting responses range and de-identity. The participant could submit the questionnaire only after all items were completed to reduce the possibility of accidentally skipping items. According to the logged-in WeChat account, each participant was only allowed to participate once. Since the self-report questionnaires might be affected by participants' response bias, all participants remained anonymous and participated voluntarily.

Among 25,162 initial contacts, parents of 24,143 children consented to participate, yielding a 96.0% response rate (**Figure 1**). As we aimed to recruit a general and representative sample of the general population for assessment of child mental health problems during the pandemic, we did not screen and exclude those with suspected COVID-19 infection. We excluded 241 questionnaires with a completion time outside three standard deviations ($M = 18.87$ min, $SD = 10.56$ min) and 7,504 questionnaires outside the age range of 3–6 years old.

Measures

The survey consisted of a set of sociodemographic questions investigating children's age, gender, presence of siblings, family type (e.g., nuclear family, extended family, etc.), primary caregivers, and parental education level. The primary caregiver was defined as the child's main caretaker and was dichotomized into parental care vs. non-parental care. Parental education level was self-reported on four levels (undergraduate and above, junior college, high school or technical secondary school, and middle school and below). Following this, a series of standardized measures on child mental health, parental well-being index, and

sleep problems were presented. Measures on physical activity and screen exposure were also included.

Child mental health problems were evaluated using the Strengths and Difficulties Questionnaire (SDQ). Parents were asked to rate their child's behaviors over the past 2 months on 25 items, compositing five subscales: peer problems, conduct disorders, hyperactivity, emotional problems, and prosocial behavior. We used the SDQ total difficulty score (excluding the prosocial behavior items), with a score of ≥14 indicating mental health problems (25). The Cronbach's α for SDQ was 0.73 and the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was 0.89 ($p < 0.001$, Bartlett's test of sphericity) in the current sample.

The World Health Organization-Five Well-Being Index (WHO-5) was used to assess the parental well-being index over the past 2 weeks (26). On five mental health-related statements, parents were asked to rate the frequency on a six-point Likert scale (0 = Never to 5 = All the time). A total score was calculated, with a score of <13 indicating mental health problems (27). The Cronbach's α was 0.92 and the KMO measure of sampling adequacy was 0.89 ($p < 0.001$, Bartlett's test of sphericity) in the current sample.

Harsh parenting was evaluated by two questions: (1) to discipline and regulate a child's behavior, how many times have you physically punished your child (spanking or hitting) without hurting him/her or leaving bruises or marks? (2) To discipline and regulate a child's behavior, how many times have you scolded your child (yelling, shouting, or using words to humiliate him or her)? Parents were required to report the frequency of each statement on a 5-point scale (never, 1 or 2 times per week, 3 or 4 times per week, 5 or 6 times per week, almost every day).

The Children's Sleep Habits Questionnaire (CSHQ), which was used to assess child sleep disturbances over the past week (28), is a standardized and internationally recognized instrument consisting of 33 items covering eight domains: bedtime resistance, sleep anxiety, sleep onset delay, sleep duration, night waking, parasomnia, daytime sleepiness, and sleep-disordered breathing. Parents rated the frequency of each item occurring in their children over the past week on a 3-point scale (usually, sometimes, rarely). A total score >41 indicates global sleep disturbances. The Cronbach's α was 0.73 and the KMO measure of sampling adequacy was 0.84 ($p < 0.001$, Bartlett's test of sphericity) in the current sample.

Daily time spent on physical activity over the past week was reported as <30 min, 30–60 min, >60 min. Daily exposure to media over the past month was reported on weekdays and weekends. The average daily screen exposure time = (screen exposure time on weekdays*5 + screen exposure time on weekends*2)/7. As previous studies have linked physical activity and screen exposure time to child mental health problems (29–31), they were considered as covariates in the current study.

Data Analysis

Missing data for all key variables were <1% ($n = 154$) and were handled by listwise deletion. Descriptive analyses were used for sociodemographic data. The multicollinearity test was conducted to exclude multicollinearity problems among the variables. We used Harman's single-factor test to verify the presence of common method bias. We also used Spearman correlations to investigate associations between parental well-being index, harsh parenting, child sleep problems, and child mental health problems. We calculated the Cronbach's alpha to show the reliability of the measures and used the Kaiser-Meyer-Olkin (KMO) test to show its validity. Data analysis was conducted using SPSS 26.0. Finally, we employed PROCESS Model 6 in SPSS 26.0 to examine Hypotheses 1 to 4. In addition, a 95% bias-corrected confidence interval with 5,000 bootstrap samples was applied to determine the significance of the mediational effect.

TABLE 1 | Descriptive characteristics of the sample ($n = 16,398$).

Variables	Total sample
Child age (years)	
Mean (SD)	4.69 ± 0.75
Child gender, *n* (%)	
Male	8,512 (51.9)
Female	7,886 (48.1)
Child siblings, *n* (%)	
One or more	9,503 (58.0)
None	6,895 (42.0)
Child family type, *n* (%)	
Nuclear family	6,850 (42.4)
Extended family	8,944 (54.5)
Single-parent family	324 (2.0)
Others	180 (1.1)
Child primary caregiver, *n* (%)	
Parental care	11,659 (71.1)
Grandparents or others	4,739 (28.9)
Child physical activity, *n* (%)	
<30 min	9,266 (56.5)
30–60 min	5,868 (35.8)
>60 min	1,264 (7.7)
Child screen exposure time (hours)	
Mean (SD)	2.05 ± 1.87
Parental education, *n* (%)	
Middle school and below	3,982 (24.3)
High school or technical secondary school	4,375 (26.7)
Junior college	3,657 (22.3)
Undergraduate and above	4,056 (36.7)
Others	328 (2.0)

RESULTS

Sample Characteristics

Descriptive data are summarized in **Table 1**. A total of 16,398 children aged 3–6 years ($M = 4.69$ years, $SD = 0.75$ years) were finally included in the study. The demographic survey results showed that participants comprised 8,512 boys (51.9%) and 7,886 girls (48.1%). Of the children, 58.0% had at least one sibling. Family type distribution was 42.4% with a nuclear family, 54.5% with extended family, 2% with single-parent family, and 1.1%

TABLE 2 | Means, standard deviations, correlations, and reliabilities (in brackets).

	M	SD	1	2	3	4	5	6
1 Physical activity	1.51	0.64	-					
2 Screen exposure time	2.05	1.87	0.06**	-				
3 Parental well-being index	15.99	5.56	0.08**	−0.10**	-			
4 Harsh parenting	3.73	1.75	0.03**	0.10**	−0.25**	-		
5 Child sleep problems	43.34	6.52	−0.04**	0.12**	−0.26**	0.20**	-	
6 Child mental health problems	18.66	4.79	0.03**	0.11**	−0.23**	0.27**	0.34**	-

*$p < 0.05$, **$p < 0.01$, $N = 16{,}398$ for preschool children, physical activity ("1" <30 min; "2" 30–60 min; "3" > 60 min), The average daily screen exposure time = (screen exposure time on weekdays*5+ screen exposure time on weekends*2)/7.

with other family types. The primary caregiver of the children was mostly the parent (71.1%), while for the remaining 28.9% of children, it was a grandparent or others. There were 36.7% parents with the highest level of undergraduate education and above, 22.3% with junior college, 26.7% with high school or technical secondary school, and 24.3% with the lowest level of middle school or below. In 56.5% of the preschoolers, physical activity was <30 min/day, in 35.8%, it was 30–60 min/day, and in 7.7%, it was more than 60 min/day. The average screen time among preschoolers was 2.05 ± 1.87 h/day.

Multicollinearity Test and Common-Method Bias Test

The multicollinearity test revealed that the tolerance of each variable was between 0.90 and 0.92, and the variance expansion factor ranged between 1.09 and 1.11. These findings revealed no multicollinearity problem among the variables.

The results of Harman's single-factor examination showed that eight factors had eigenvalues >1, and the first factor explained 11.89% of the total variance. This result did not exceed the critical value of 40% (32). The above methods indicate an absence of serious common method bias in the current study.

Correlations Among Primary Variables

The Spearman correlations (**Table 2**) showed that significant but moderate positive relationships between child mental health problems with harsh parenting ($r = 0.27$, $p < 0.01$) and child sleep problems ($r = 0.34$, $p < 0.01$), as well as between harsh parenting and child sleep problems ($r = 0.20$, $p < 0.01$). There were significant but moderate negative relationships between parental well-being index and harsh parenting ($r = -0.25$, $p < 0.01$), child sleep problems ($r = -0.26$, $p < 0.01$), and child mental health problems ($r = -0.23$, $p < 0.01$).

Serial Mediation Model

Table 3 and **Figure 2** show that the direct effect of parental well-being index on child mental health problems was significant and negative ($\beta = -0.10$, $p < 0.001$). In the path of "parental well-being index → harsh parenting → child mental health problems," parental well-being index had a significant negative impact on harsh parenting ($\beta = -0.08$, $p < 0.001$), which in turn had a significant positive impact on child mental health problems ($\beta = 0.49$, $p < 0.001$). In other words, the parental well-being index enhanced the children's psychological health by reducing harsh parenting. In the path of "parental well-being index → child sleep problems → child mental health problems," parental well-being index had a significant negative impact on child sleep problems ($\beta = -0.24$, $p < 0.001$), which in turn had a significant positive impact on child mental health problems ($\beta = 0.20$, $p < 0.001$). Thus, the parental well-being index improved child psychological health problems by weakening child sleep problems. Finally, serial mediation analysis revealed that in the path of "parental well-being index → harsh parenting → child sleep problems → child mental health problems," harsh parenting had a significant positive impact on child sleep problems ($\beta = 0.52$, $p < 0.001$). This indicated that the parental well-being index reduced child sleep problems by alleviating the harsh parenting, which in turn improved child mental health problems.

Table 4 shows that the direct and total indirect effect of parental well-being on child mental health was −0.10 (95% CI −0.11, −0.08; $p < 0.001$) and −0.09 (95% CI −0.10, −0.09; $p < 0.001$), respectively, with a total effect of −0.19. The mediating effect of parental well-being index on harsh parenting was −0.04, $p < 0.001$, with an effect size of 19.76 percent. The mediating effect of parental well-being index on child mental health problems through sleep problems was −0.05, $p < 0.001$, with an effect size of 24.84 percent. The mediating effect of parental well-being index on child mental health problems through harsh parenting and sleep problems was −0.01, $p < 0.001$, with an effect size of 4.13 percent.

DISCUSSION

To our best knowledge, the current study is among the first to explore the relationship between parental well-being index and child mental health problems, and the mediating role of harsh parenting and child sleep problems in the context of COVID-19 pandemic. Our findings showed that the parental well-being index had an indirect and negative effect on child mental health problems. Additionally, separately, harsh parenting and child sleep problems mediated the relationship between parental well-being index and child mental health problems. More importantly, a significant serial mediation was identified: parents with low well-being index tended to exert more toward harsh parenting, which further increased child sleep problems and, subsequently, resulted in mental health problems in children.

The current study corroborated the negative association between parental well-being index and child mental health

TABLE 3 | Model coefficients for the serial mediation analysis.

Variables	Model 1			Model 2			Model 3		
	Harsh parenting			Child sleep problems			Child mental health problems		
	B	SE	T	B	SE	t	B	SE	T
Screen exposure time	0.06	0.01	7.98***	0.28	0.03	10.49***	0.09	0.02	5.02***
Physical activity	0.15	0.02	7.00***	−0.23	0.08	−3.03**	0.28	0.05	5.11***
Parental well-being index	−0.08	0.00	−31.48***	−0.24	0.01	−26.02***	−0.10	0.01	−14.84***
Harsh parenting				0.52	0.03	18.01***	0.49	0.02	24.06***
Child sleep problem							0.20	0.01	35.93***
R^2		0.06			0.09			0.17	
F		374.55***			377.59***			648.61***	

*$p < 0.05$, **$p < 0.01$, ***$p < 0.001$, N = 16,398 for preschool children, physical activity ("1" <30 min; "2" 30–60 min; "3" > 60 min), The average daily screen exposure time = (screen exposure time on weekdays*5+ screen exposure time on weekends*2)/7.

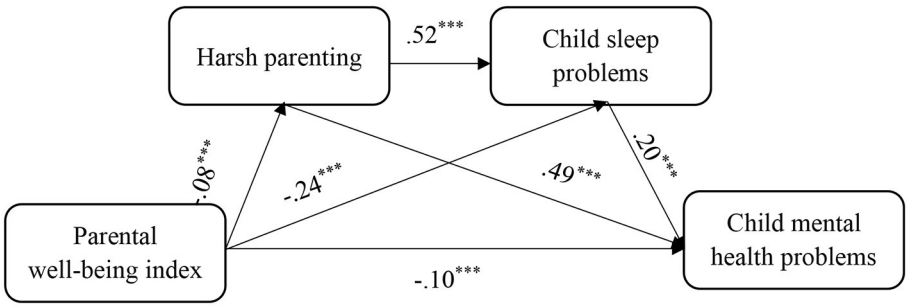

FIGURE 2 | Roadmap of the influence of parental mental health on child mental health. ***p < 0.001.

TABLE 4 | Breakdown table of the total, direct, and mediating effects.

Parental mental health	Effect	Boot SE	Boot LLCI	Boot ULCI	Effect ratio %
Direct effects	−0.10	0.01	−0.11	−0.08	51.32
Total indirect effects	−0.09	0.00	−0.10	−0.09	48.68
Indirect effect 1	−0.04	0.00	−0.04	−0.03	19.76
Indirect effect 2	−0.05	0.00	−0.05	−0.04	24.84
Indirect effect 3	−0.01	0.00	−0.01	−0.01	4.13

The path of indirect effect 1 is "parental well-being index → harsh parenting → child mental health problems," the path of indirect effect 2 is "parental well-being index → child sleep problems → child mental health problems," and the path of indirect effect 3 is "parental well-being index → harsh parenting → child sleep problems → child mental health problems."

problems in the context of the COVID-19 pandemic. This finding is consistent with a previous study reporting that mental distress among caregivers was associated with an increased risk of child health issues during the pandemic (33). It is well-known that, due to their cognitive and psychological immaturity, children are particularly vulnerable to stress, in the incidence of natural disasters (34). An emotionally and physically stable parent is more capable of helping children buffering their stress and managing their negative feeling (35). However, in parents who increasingly experience a reduction in income, changes in daily routine, and new responsibilities during the pandemic, their ability to comfort children inevitably diminishes over time, thus increasing the risk of trauma to the pandemic in children and youth, resulting in enduring emotional consequences. Research shows that children as young as 2 years are aware of the changes around them (36). Therefore, observing poor well-being in parents, such as high anxiety and depressive symptoms may lead to a higher likelihood of children suffering from mental health problems.

The current results revealed the mediating roles of harsh parenting and child sleep problems between parental well-being index and child mental health problems during the pandemic. Indeed, as parental stress levels rise over the pandemic period, parents may be more likely to exert harsh parenting (11). Specifically, previous studies have shown that the rates of child abuse, neglect, and exploitation are likely to exacerbate during such stressful periods (37). Our findings are consistent with recent research showing that parental distress and social isolation

are important risk factors contributing to child abuse and neglect, domestic violence, and a deterioration of the parent-child relationship (38–40). Additionally, children whose parents were, in general, more pessimistic displayed worse emotion regulation and were more likely to show externalizing behaviors than children whose parents were warmer and more frequently expressed positive emotions (41). Verbal abuse during childhood has been associated with the externalization and internalization of various disorders in adulthood (42, 43). Therefore, our findings have significant implications for promoting a positive family environment during the pandemic.

Our results further revealed that sleep problems might constitute a pathway for the relationship between parental well-being index and child mental health. Child sleep problems were responsible for more than 20 percent of the parental well-being index related to child mental health problems, which was stronger than the other two indirect effects, indicating that parental well-being index affected child mental health problems severity mainly through sleep. Excessive parental involvement at bedtime were associated with increased child nocturnal awakenings (44). During the lockdown, mothers may be excessively vigilant to their children's health and sleep, and thus overestimating the children's sleep problems. Whereas, Gregory and Sadeh (45) have proposed that the association between sleep and mental health may be bidirectional (46), it is also possible that changes in sleep during the COVID-19 pandemic contribute to or even exacerbate psychological health (5). Since sleep problems in children potentially have a significant impact on certain aspects of the child's psychological health, including cognitive development and emotional/behavioral development, prioritizing interventions to maintain the child's quality of sleep are strongly encouraged.

In the present study, we also examined the association between harsh parenting and child sleep problems during home confinement, thus accounting for the lack of evidence on this topic. The impact of COVID-19 and lockdown measures can increase parenting stress, which in turn could increase the use of harsh parenting and harm the relationship between parents and their children (47). Previous studies reported that adverse childhood experiences like child abuse, neglect, and poor family environment experienced before age 18 were positively associated with a variety of sleep problems in adults, including insufficient sleep, insomnia, and nightmares (48). The proposed underlying mechanisms include childhood adversities that may increase corticotropin-releasing hormone (CRH) reactivity and subsequently hypothalamic-pituitary-adrenal (HPA) axis, which in turn affect sleep quality (48). Previous studies have shown that poor sleep quality can induce consequences ranging from inattentiveness, reduction in executive functioning to mood disturbances (49). Insufficient sleep duration in children was associated with mental health disorders (50). Some studies also suggested that the rapid-eye-movement sleep involved in emotional memory processing may be impaired among subjects who were exposed to trauma (51). Therefore, measures could be undertaken to elevate the parental well-being index, which in turn could weaken the mediating role of harsh parenting and child sleep problems, thus reducing child mental health problems.

Our findings have important implications for prioritizing prevention and intervention efforts to reduce and eliminate the influence of poor parental well-being on child mental health problems during and following the pandemic, particularly by promoting positive parenting style and reducing child sleep disturbances. For example, positive parenting, such as effective parent-child communication about pandemics is critical for child mental health and can have short- and long-term protective effects (52, 53). Schools can also actively promote a health-conscious schedule, good personal hygiene, encourage physical activities, appropriate diet, and good sleep habits, and incorporate such health promotion materials into the school curriculum (54). This can not only develop children's self-discipline skills but also reduce the burden of parents. It is the responsibility of all stakeholders to minimize the negative impact during this sudden public health event.

LIMITATIONS, STRENGTHS, AND FUTURE DIRECTIONS

The current study has several strengths. First, as few studies on the effects of parental well-being index on child mental health problems during the COVID-19 epidemic were available at the time of the investigation, the current study furthered our understanding of their association and mediating factors. Second, the online survey in a large-scale and sociodemographic-diverse sample of young Chinese children, and the use of validated measures maximized the generalizability and accuracy of our findings. The present study also has several limitations that should be considered. First, our data did not allow us to differentiate the findings between urban and suburban areas. Second, several exposure variables were measured with one or two self-made items, and future studies would better use standardized measures. Third, no information about previous diagnosis or difficulties of both parents and children was retrospectively collected, and parental reports on the time of data collection might be biased. The potential self-selection bias in the study should also be noted. Parents who were more concerned about their children's mental health were more likely to participate in the study. Finally, although the use of a cross-sectional online survey was considered the optimal way to obtain timely information on the national level, it prevented us from detecting the direction of causality. Future studies should further investigate the mental health of parents and preschoolers after home confinement.

CONCLUSION

The current study showed that the parental well-being index was associated with child mental health problems, and the association was mediated by harsh parenting and child sleep problems. Our findings highlight the importance of comprehensive strategies regarding both the parental well-being index and child mental health problems in the context of the COVID-19 pandemic. To promote optimal mental health in young children during the pandemic and thereafter, parental well-being index, positive parenting skills, and

healthy sleep habits should be prioritized. The current study inspires further research and discussion concerning parental or child psychological health during adversity such as the COVID-19 pandemic.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Institutional Review Board of Shanghai Children's Medical Center, Shanghai Jiao Tong University School of Medicine (SCMCIRB-W2020042). Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

AUTHOR CONTRIBUTIONS

PW, GW, FJ, and JC contributed to the concept and the design of the research project. WL, ZW, SH, FZ, YX, and LP contributed to the administration of online surveys and the acquisition of data. PW, XS, WL, GW, FJ, and JC contributed to the analysis, interpretation, and description of data. PW, XS, WL, ZW, GW, FJ, and JC participated in drafting the article and revising it critically for important intellectual content. All authors contributed to the article and approved the submitted version.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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REVIEW
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Becoming a Mother During COVID-19 Pandemic: How to Protect Maternal Mental Health Against Stress Factors

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During the COVID-19 pandemic, there were an increasing prevalence of perinatal psychiatric symptoms, such as perinatal anxiety, depression, and post-traumatic stress disorders. This growth could be caused by a range of direct and indirect stress factors related to the virus and changes in health, social and economic organization. In this review, we explore the impact of COVID-19 pandemic on perinatal mental health, and propose a range of hypothesis about their etiological mechanisms. We suggest first that the fear of being infected or infected others (intrauterine transmission, passage of the virus from mother to baby during childbirth, infection through breast milk), and the uncertainty about the effect of the virus on the fetuses and infants may have played a key-role to weakening the mental health of mothers. We also highlight that public health policies such as lockdown, limiting prenatal visits, social distancing measures, and their many associated socio-economic consequences (unemployment, loss of income, and domestic violence) may have been an additional challenge for perinatal mental health. Ground on these hypotheses, we finally purpose some recommendations to protect perinatal mental health during a pandemic, including a range of specific support based on digital technologies (video consultations, phone applications) during pregnancy and the postpartum period.

Keywords: perinatality, perinatal psychiatry, COVID-19, SARS-CoV-2, mental health, maternal health, neonatal health, postpartum depression

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INTRODUCTION

The COVID-19 pandemic has caused an unprecedented health, social, and economic crisis across the world. Although most biomedical research initially focused on the epidemiology of the disease, the respiratory symptoms caused by Sars-Cov-2 in the adult population, or even potential therapies, new interest has gradually focused on the collateral effects of the pandemic on mental health (1–3). Initial studies have shown an increasing prevalence of mental disorders in the general population during the pandemic (4). Among them, pregnant women and new mothers constitute a specific, vulnerable population, affected in the foreground by the dramatic consequences of the pandemic (5).

Pregnancy and the postpartum period involve profound physiological (somatic and hormonal), psychological (process of motherhood) and social changes in future mothers. Apart from the disorders caused by infection, the impact of policies to fight the pandemic could have affected maternal health, modifying the organization of perinatal care, intra-family relations, or even living conditions (5). Previous studies have shown that patients in the prenatal and postnatal periods are particularly at risk of developing mental disorders during health or social disasters (6). These mental disorders represent major challenges for public health because of their negative impact on the mother and on the subsequent growth and development of the child (1). For example, depression and perinatal anxiety are associated with risks of miscarriage, pre-eclampsia, gestational hypertension, premature birth, lower Apgar scores, low birth weight, postnatal depression, higher and early attachment disorders (7, 8). Knowing the risk of these prenatal and postnatal mental disorders on mothers, fetuses and infants, it is imperative to offer responses to the mental health needs of this population (9).

Maternal fear about the effects of the virus on pregnancy and the fetus adds to the general psychological difficulties encountered during pregnancy, especially fear of birth (10). A large number of mothers, mostly first-time mothers, are terrified by the physiological stages of pregnancy and the prospect of childbirth, dreading each obstretrical follow-up consultation (11). In these mothers, prenatal stress constitutes a major risk factor for postpartum depression and perinatal mental disorders in general (12). For this at-risk population, the consequences of COVID on maternal mental health are even greater.

In this review, we offer an update comparing our clinical experience with the current literature on perinatal mental health during the COVID-19 pandemic. We suggest that a better understanding of the effect of the pandemic on the mental health of pregnant and postpartum women will allow the implementation of early and adapted interventions to deal with it, in order to protect maternal mental health from the stress induced by the pandemic. We offer a series of advice that can be delivered to patients during the perinatal period in order to reduce the stress associated with the pandemic, and improve the coping skills for these mothers. Finally, we suggest several public health measures that can be applied to these specific clinical situations, in order to improve their management.

INCREASED PREVALENCE OF PSYCHIATRIC DISORDERS

Perinatal and Postpartum Anxiety

The perinatal period, including pregnancy through childbirth and the first year postpartum, is a time of high vulnerability for mental health. This rise is particularly crucial for prenatal anxiety, defined as the presence of anxiety symptoms during pregnancy, and postpartum anxiety, defined as the presence of anxiety symptoms within 1 year of childbirth.

These perinatal anxiety symptoms lead to a deterioration in quality of life, insomnia, and can cause subsequent depressive disorders, including postpartum depression. Before the pandemic, previous studies suggested a prevalence of prenatal and postnatal anxiety around 15.2% (13), and 45.7% for associated insomnia (14). This risk was even higher in women who experiences a high medical risk pregnancy, or lives in disadvantaged socio-economic conditions.

Thus, the prevalence of perinatal anxiety has significantly rised during the pandemic. A systematic review including 11,187 participants in China evaluated the impact of COVID-19 on anxiety and depression amoung pregnant women. The results showed that the prevalence of anxiety was 34% (95% CI: 0.26–0.43), and prevalence of both anxiety and depression was 18% (95% CI: 0.09–0.29) (15).

In a meta-analysis reviewing the effect of COVID-19 on maternal mental health the overall pooled State-Trait Anxiety Inventory (STAI) score was significantly higher during pandemic (16). Besides, the COVID-19 pandemic is a unique stressor, with potentially wide-ranging consequences for pregnancy and beyond. The stress induced by the pandemic may have been a major factor in the rise in anxiety symptoms in the perinatal population.

Others studies using different tools to evaluate anxiety showed similar results. Another has compared the mean total Inventory of Depression and Anxiety Symptoms (IDAS II) and Beck Anxiety Inventory (BAI) scores for patients included before COVID-19 and re-evaluated during the outbreak. Interestingly, the mean total IDAS II score have significantly increase during the SARS-CoV-2 pandemic, but with a specific pattern concerning the intensity of the symptoms: the number of patients without anxiety, or with mild anxiety (according to the BAI score), decreased, whereas patients with moderate and severe anxiety increased (17). Few hypotheses have been proposed to explain these specifics of the evolution of anxiety symptoms during the pandemic, and these results need to be clarified.

Studies also report a time effect regarding these symptoms. In a meta-analysis of the worldwide prevalence of depression and anxiety among pregnant women during the COVID-19 pandemic through a systematic search of the literature from December 2019 to February 2021, moderation by time showed that prevalence of anxiety was higher in studies conducted later in the pandemic (18).

Crucially, this increase of anxiety was shown to be directly associated with the pandemic: a study evaluating the basal anxiety (STAI-T) and the state anxiety related to the ongoing pandemic (STAI-S) amoung the same pregnant women in Italy showed that there was a positive association between STAI-T and STAI-S (Pearson $= 0.59$; $p \leq 0.0001$) (19). These results suggest that the impact of the pandemic, evaluated at different times in the past months, tended to increase with time.

Additionnaly, a prospective cohort study with 1,367 participants accros USA found an associationbetween high prenatal maternal stress and preterm delivery during COVID-19 pandemic (20). According to the Anglo-Saxon theory of "Prenatal early Life Stress," there is an increase in Corticotrophin Releasing Hormon (CRH) and cortisol in stressed or depressed mothers (21).

However, cortisol has a deleterious effect on obstetric parameters (prematurity, modification of fetal activity,

intrauterine growth retardation) (21). It crosses the placental barrier influencing the development of the fetal nervous system and modifying the programming of the hypothalamic-corticotropic axis of the child which may later be responsible for attention and behavioral disturbances.

After birth, prenatal stress is also associated with disruptions in early dyadic relationships, especially mother-child attachment relationships (22). These direct consequences of prenatal stress during the COVID-19 pandemic are therefore a public health priority, in order to protect maternal mental health and child development.

Perinatal and Postpartum Depression

This requirement is also valid for perinatal depression, differentiated into prenatal depression (depressive symptoms, for more than 15 days, during pregnancy) and postpartum depression (depressive symptoms, for more than 15 days, in the year following childbirth). These depressive symptoms, defined by DSM5, combine sadness or anhedonia, and four following symptoms including: asthenia, cognitive impairment, negative cognitions, suicidal ideation, psychomotor disturbances, appetite disturbances, and impaired functioning (23). In the general population, outside of a pandemic period, the rate of postpartum depression (PPD) is around 15–20%, and several studies have highlighted an increase in the prevalence of postpartum depression during the pandemic with an estimated prevalence around 22% (24).

A longitudinal study comparing 102 pregnant women and a control group of 102 non-pregnant women showed a significant increase in depression and anxiety in parturients, and an increase in negative affects and a decrease in positive affects greater than in the control group (25). Another study of 1,754 pregnant women in Canada found that women recruited after the onset of the pandemic were almost twice as likely to report symptoms of depression, anxiety disorder, or substance use disorder (26). Finally, a subsequent meta-analysis of 23 studies involving 20,569 participants (16,797 pregnant women and 3,772 postpartum women) during the COVID-19 pandemic shows that 70% of patients present with psychological distress, 31% with depressive symptoms, and 49% with insomnia (24).

The studies suggest that the prevalence of depression appears to be particularly higher in the first and third trimester of pregnancy, with a U-shaped curve (24). The increase in the prevalence rate of depression in the third trimester may be correlated with the proximity of childbirth, and major hormonal changes (27, 28). These initial alarming data were however moderated by the results of a meta-analysis comparing the scores of the Edinburgh Postnatal Depression Survey (EPDS) before and after the pandemic, and finding no significant difference, although the prevalence of postpartum depression tends to be numerically higher during the pandemic (16).

Although these early studies suggest that anxiety-depressive symptoms may have been exacerbated during the COVID-pandemic, results deserve to be considered with caution. The majority of these studies suffer from methodological weaknesses, because of the difficulty in performing screening and prolonged postpartum follow-up. During the perinatal period, patients generally have regular obstetric follow-up, but after childbirth and return home they are mostly isolated, with little medico-social supervision.

Consequently, most of these studies are cross-sectional, and there are few prospective longitudinal studies with prolonged follow-up. In addition, most of the data presented comes from Western countries and China. This characteristic is a limit for their generalization to the whole world. More longitudinal studies, from different countries, are needed to explore these variables during the COVID-19 pandemic.

At any rate, the urgency of appropriate management of these perinatal disorders is justified by their associed morbidity. Perinatal disorders, especially PPD, are associated with a multitude of direct and indirect consequences on mother, infant, siblings, and family. Public Health France and Inserm, two major public health organisms, published on January 6, 2021 the results of the 6th report of the confidential national survey on maternal deaths (ENCMM). It reveals that suicide is the second cause of maternal death (13.4%) for the period 2013–2015 after cardiovascular diseases (13.7%). There is no data regarding the rate of perinatal suicide during the COVID-19 period, but this critical dimension will need to be carefully explored in order to prevent a possible worsening of this dramatic consequence of PPD.

Acute and Post-traumatic Perinatal Stress Disorder

The notion that childbirth can be traumatic for a third of women and lead to acute stress has been documented in pre-COVID-19 samples. These initial traumatic symptoms are strong predictors of post-childbirth-related post-traumatic stress disorder (CB-PTSD), which is the most chronic manifestation of trauma and has a prevalence of 6–19% (29). This disorder is defined by the presence of traumatic symptoms (nightmares, reliving, avoidance, anxiety) focused on childbirth and pregnancy, and continuing within 1 month after childbirth.

The pandemic has created a more stressful climate in the delivery room during labor and delivery. Factors such as fear of maternal and newborn exposure to the virus during hospital stay, suboptimal preparation for childbirth, feeling of lack of support during childbirth, the limitation of visits to the post-childbirth service and the discrepancy between the expectations in terms of birth before the pandemic and the real experience of childbirth during the pandemic have contributed to a more anxiety-provoking, even traumatic, experience of childbirth (30).

Many studies have evaluated, through web questionnaires mainly, the mother's state of mind the first weeks of post partum to estimate the prevalence of symptoms of PTSD. In one of them, Out of 1,015 pregnant women reached, 737 (72.6%) fully answered the questionnaire and clinically significant PTSD symptoms were present in 75 women (10.2%, NSESSS cutoff 24) (9). Another one showed even higher scores: PTSS rate was 42.9% (IES-R cut-off score $\geq$ 24). Dismissive and fearful avoidant attachment styles were significantly associated with the risk of depression and PTSS, respectively. Perceived support provided by healthcare staff was a protective factor against depression and

PTSS. Another protective factor against PTSS was quiet on the ward due to the absence of hospital visitors (31).

In addition of this increased risk of PTSD after birth, we must take into account the fact that, at the beginning of the pandemic, when little was know about the mother-fetus transmission, some abortions were associated with the infection status of the mothers. In a longitudinal single-arm cohort study conducted in China between May 1 and July 31, 2020 seventy-two pregnant patients with COVID-19 participated in follow-up surveys until 3 months after giving birth (57 cases) or having abortion (15 cases). All cases infected in the first trimester and 1/3 of cases infected in the second trimester had an abortion to terminate the pregnancy, and 22.2% of pregnant patients were suffering from post-traumatic stress disorder or depression at 3 months after delivery or induced abortion (26).

Several characteristics appear to be associated with the risks of developing perinatal mental disorders during a pandemic. First, women from lower socioeconomic categories generally present with more severe anxiety-depressive symptoms, possibly related to increased environmental stressors. Second, multiparous women have a higher prevalence of anxiety and depression than first-time women during the pandemic (24). Pre-existing parenting challenges for multiparous women may play a mediating role here, particularly school closures, increased parenting responsibilities, lost wages, and socioeconomic fragility.

Finally, the presence of previous mental disorders appears to be associated with higher psychiatric symptoms during the pandemic (9). This population of vulnerable women suffering from pre-existing psychiatric disorders is particularly at risk of decompensating their disorder, or of developing psychiatric comorbidities, and as such must be the subject of targeted prevention and support strategies (32).

STRESS FACTORS ASSOCIATE WITH THE FEAR OF THE VIRUS

Fear of Infection During Pregnancy

The COVID-19 pandemic has generated a wave of fear. The main reaction to this fear has been to avoid places with high risk of contamination, including hospitals. But for pregnant woman, avoiding care facilities was impossible. A dilemma occurred between the need for monthly follow up and the risk of contamination that generated a lot of unanswered questions for mothers:

- "Can I go to antenatal visits?";
- "Is it better for my fetus that I stay locked up at home?";
- "Can I keep my plan to deliver the baby in the hospital?."

Other source of anxiety for pregnant woman was the unknown related to the impact of COVID-19 infection on the fetus, the pregnancy or the mother:

- "Am I more likely to get infected with COVID-19?";
- "Can the virus be passed to my fetus?";
- "Am I more likely to develop pregnancy-related complications if I am infected?";
- "Does Being Pregnant Increase my Risk of Pregnancy Complications?."

An online study reported that 93% of pregnant women participants reported suffering of an increased source of stress related to COVID-19 infection (33). A number of factors linked to the pandemic may have contributed to the stress during perinatal period, including the perceived vulnerability of parturients to SARS-Cov-2. During perinatal psychiatric consultations, several patients questionned their doctor about the individual risks of contamination. The uncertainty about the potential effects of the virus may have contributed to increase the anxiety of parturients. In previous epidemics such as Severe Acute Respiratory Syndrome (SARS) in 2003, pregnancy may have worsened the clinical course of the infection (34). Current studies point out an increase in ICU admissions and mechanical ventilation for COVID-19 infected pregnant women (35). Moreover, a case study from July 2020 report the presence of coronavirus in both amiotic fluid collected prior to the rupture of menbranes, and in blood drawn early in life (36). A proposed explanation from this study was the lower expression of the angiotensin-converting enzyme 2 receptor and the serine protease TMPRSS2, both necessary for the cell entry and the spread of COVID-19 (37).

Howewer, the first clinical data are reassuring: several newborns that have been tested positive for SARS-CoV-2 or that presented IgM antibodies even when they were delivered by cesarean section or despite an immediate separation from the mother at time of birth didn't have serious complications (38, 39). Moreover, although meta-analysis shows that maternal infection leads to an increased risk of prematurity (19–47% of cases), fetal distress (43% of cases), premature rupture of membranes (19% of cases) and miscarriage (7% of cases), it's hard to know if these complications are produced by the virus itself or caused by the iatrogenic treatment of the infection (40). Finally, the first data in pregnant women rather support a moderate increase in the risk of complications due to COVID-19 infection (41). Taken together, these preliminary studies provide evidence to reassure patients about the direct risks of Sars-Cov-2 infection for pregnancy.

Vulnerability of Newborn

The second stress factor occurres after childbirth and is related to the vulnerability of the newborn to the unknown virus or about the ways of transmission:

- "Am I at risk of infecting my infant?";
- "How do I take my baby without risking of infecting him?"
- "Is the virus transmitted through breast milk?";
- "Can I breastfeed if I have a fever and fear I may have the virus?."

In the USA, the Centers for Disease Control and Prevention (CDC) initially recommended temporarily separating infected women from their newborns, but the low prevalence of mother-to-newborn transmission lead to new recommendations in December 2020 by the American Academy of Pediatrics (AAP) in support of maintaining the mother and child contact with measures of hand hygiene and wearing of masks.

Regarding the risk of transmission during breastfeeding, first studies were reassuring but did not result in clear recommendations. The American Academic of Pediatrics recommends continuing to promote breastfeeding even with suspected or confirmed COVID-19 (42). Parturients can be reassured about the possibility of breastfeeding their infants, even if they are infected with COVID-19 after birth. Women who develop COVID-19 can be encouraged to breastfeed while applying appropriate respiratory hygiene measures (wearing a mask) and following standard hygiene precautions (disinfecting hands and objects affected).

Fear of Fear Itself

The third stress factor is related to negatively anticipating consequences of perinatal stress itself for pregnant women. In perinatal clinical practice, women can ask their obstetrician, midwife, or psychiatrist these questions:

- "Will my anxiety disturb my baby's brain?"
- "Will my anxiety interfere with my baby's growth?"
- "Will my child be anxious because I was anxious during my pregnancy?"

This anticipation is associated with a set of biomedical health beliefs in the general population about the impact of the emotions experienced during pregnancy on the development of the fetus, including the theory of the developmental origin of health and disease (DOHaD) (43). This theory suggests that mental (such as emotions or beliefs) and physiological (such as blood sugar or cortisol) states experienced during pregnancy cause similar disorders in children. It assumes that if the mother is anxious, the children will be.

These patients excessively project the consequences of their current anxiety on their baby, imagining for example that their level of stress will cause an anxiety disorder in their child, or will deteriorate its future health. Although there are complex links between mental health during pregnancy and a large number of neurodevelopmental variables, these excessive causal assumptions often play a role in exacerbating anxiety, and cause depressive cognitions such as guilt or shame.

STRESS FACTORS ASSOCIATED WITH *PUBLIC HEALTH POLICIES*

Social Isolation and Care Restriction

The COVID pandemic has profoundly shaken the daily lives of millions of people: the practices surrounding social rituals such as birth and death were also upset by the the public health policies to minimize the spread of the virus, and have generated social isolation among all the population. The limitation of visits to maternity decided in many countries has caused an increase in social isolation, a reduction in obstetric follow-up, and psychic suffering in many mothers. These situations were associated with several maternal questions:

- "How can I participate to preparation classes with all the restriction?";
- "Could my partner attend the delivery?";
- "Can my partner visit me in maternity?";
- "Will my mother and father be able to see the baby in the maternity?."

The limitation to access maternity care restrains the preparation for childbirth. Many prenatal interview and preparation sessions for childbirth were canceled or reduced during the pandemic, not allowing a good psychic anticipation (example:).

Also, at the beginning of the pandemic, some maternities decided to deny attendants from going to delivery rooms to support mothers during labor, such as the New York-Presbyterian and Mount Sinai Hospital in the US. These maternities have chosen to minimize family contact with the hospital system to limit the risk of interpersonal transmission, when virus was still new, contamination modes poorly known, and incidence of dramatic infections.

Some maternities have even prohibited visits or the presence of spouses after childbirth and during postpartum hospitalization. Fathers were thus obliged to stay at home during the first days of the child, and mothers found themselves without conjugal support during the immediate postpartum period. This situation was all the more unpleasant as the symptoms of Baby Blues occur during this period of postpartum: the presence of the spouse is important when these transient symptoms occur in order to support mothers in the face of these difficulties. The restriction of postpartum visit have contributed to greater psychological vulnerability and an increased risk of postpartum depression in these patients, as well as consequences for couples (44). Indeed, participating in childbirth and early parenting is associated with immediate and long-term effects for parent and child: this strengthens marital ties, early mother-infant relations, and promotes the harmonious neurodevelopment of the child (45).

In addition, recommended health measures in maternity hospitals (wearing mask, respect social isolation) has sometimes been associated with real obstetric violence: encouragement to wear a mask during expulsion efforts for several women increased the anxiety-provoking climate around childbirth, and could be associated with post-traumatic stress disorder persisting months after the maternity exit (44).

Social support, especially from the spouse, is a major protective factor against postpartum depression (31). For future fathers, meeting their baby several days after birth could also be an important issue. The remoteness of the fathers was able to promote the risks of paternal perinatal depression, designating the prenatal or postpartum depression affecting fathers, in addition to the risk of postpartum depression in mothers (44). In response to the new restriction formulated by several American hospitals on the presence of the spouse during childbirth, a decree of March 28, 2020, following a petition that quickly collected more than 600,000 signatures, finally authorized the presence of a support person in USA.

Lockdown's Consequences

Second, the generalized lockdown instaured by several countries during the pandemic has been experienced as an extremely uncomfortable experience due to the separation from their

loved ones, lack of freedom, and emotional isolation. Studies in the general population have shown a higher prevalence of psychological distress and anxiety-depressive symptoms during lockdown (46, 47).

There were frequently two types of stress factors associated with confinement. The first one is the loss of social resources, coupled with the fear of physical and emotional isolation:

- "What am I going to do if my loved ones cannot come and help me?";
- "My parents will be able to see the first months of my newborn?";
- "How can I take care of my oldest child if school is closed?."

The second one was the loss of physical resources, associated with the anticipation of a food shortage, domestic, or an economic fragility of the household:

- "What will I do if I do not find enough diapers?";
- "How can I feed this child if I am unemployed?"
- "Will my spouse meet the family's needs?"

The effects of the pandemic on perinatal mental health is also associated with the consequences of confinement among those who have the least social support (48). In an online study in USA, parturients associated their stress primarily with fear of lack of food reserves (59.2%), loss of household income (63.7%), loss of childcare services (56.3%), and conflict between household members (37.5%) (33).

With the closure of school and the isolation of grandparents, many parents have also additional tasks such as babysitting and helping with homeschooling. In this context, single mothers are even more severely affected (22). Single pregnancies, especially for immigrant mothers without immediate family support, were particularly at risk of psychiatric decompensation (44). These mothers who have sometimes already dependent children found themselves isolated at home, without the possibility that the family can come and help them, with all tasksrelated to newborn and siblings.

Violence against women is also an important issue. Although public health guidelines recommend staying at home for safety, the home is the least safe place for these patients. Generalized confinement has been associated with an upsurge in domestic violence, often even appearing in homes where it had not previously taken place. In Canada, calls for violence support services have tripled (49), and these preliminary data are probably underestimated because many victims fear reprisals or are deprived of all contact with the outside world. We can underline the strong entanglement between the decrease in social resources (for both partners), the stress induced by the prospect of loss of economic resources, and domestic violence (49).

On the other side, the lockdown has also caused a redefinition of family life, fundamentally changing its systemic organization. For some, lockdown was an opportunity to forge a new family cohesion based on values perceived as priorities for the household. Because of the lockdown period, fathers had to stay home longer than their paternity leave. This situation has been an opportunity for families to develop strong triadic relationships, to deepen interpersonal relationships, and to develop new partnership skills in the couple. Some couples have also expressed their positive feelings associated with these first postpartum weeks in a period of confinement, with a tightening of the family cocoon around the triad (44) (**Figure 1**).

The Vaccination Dilemma

Despite its effectiveness, vaccination no longer enjoys universal support from the population around the world. Indeed, in the Western world, many anti-vaccine groups have emerged, fighting against the recommended vaccines (50, 51). In France, during the 2016 Health Barometer, up to 25% of the population was unfavorable to general vaccination (52). During the pandemic, anti-vaccine positions have increased dramatically, alongside lingering doubt about vaccine safety. These doubts were particularly important for pregnant women fearing effects on their fetus. The following questions were frequently asked related to vaccines:

- "Can I have a miscarriage if I am vaccinated during my pregnancy?"
- "Will my child have congenital malformation if I am vaccinated during my pregnancy?";
- "Will my child have autisitic spectrum disorder if I am vaccinated during my pregnancy?";

Since the influenza A (H1N1) pandemic, many debates have taken place on the usefulness, efficacy and safety of a vaccine developed for short-time epidemic (53). This considered short period has been explained by a virus not totally unknown, technologies in development for 30 years, colossal investments and a vaccine tested by a very large panel of population. Many uncertainties appear in connection with the fear of unknown side effects due to the lack of time to carry out long and systematic pharmacovigilance. However, faced with the rapid spread of Covid-19, the paucity of proposed therapeutic strategies and the lack of knowledge obtained on this new virus, a major issue in this pandemic is the rapid development of a safe and effective vaccine. This race against time has generated many doubts about safety and the absence of long-term side effects in the general population. These uncertainties are exacerbated in pregnant women because no data have been available in the beginning of the pandemic, because pregnant women were excluded from clinical studies.

The current data are however reassuring for the vaccination of pregnant women: mRNA vaccines consist of a lipid nanoparticle in which mRNA is encapsulated, allowing it to enter human cells. The vaccine then provides the host cells with the information to make only the S-glycoprotein, a protein that normally allows the virus to attach to human receptors. Our immune system therefore recognizes this S-glycoprotein as a foreign antigen, triggers the immune response and the production of antibodies. MRNA does not enter the cell nucleus, so it cannot modify human DNA and is rapidly degraded in the cell cytoplasm. The first results on animal studies of these vaccines are also reassuring as to the teratogenic risks.

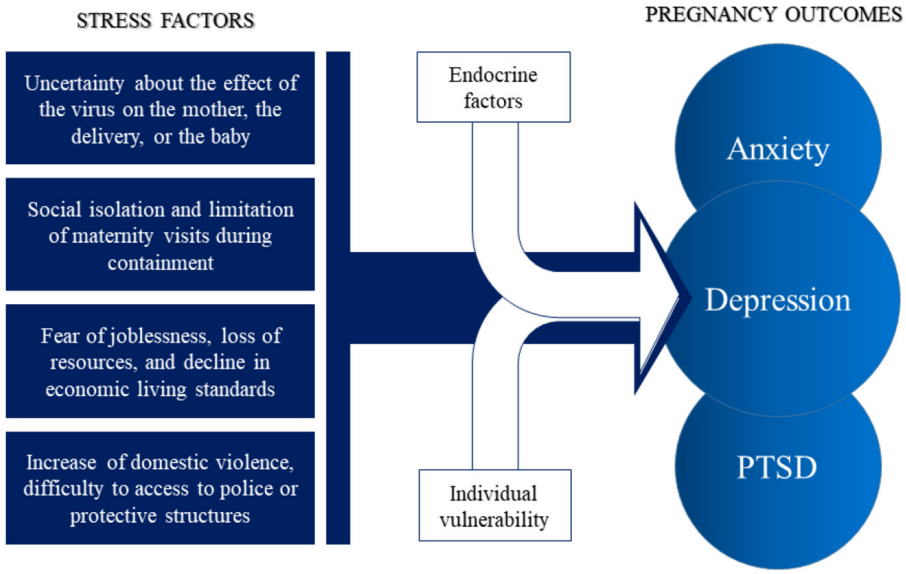

FIGURE 1 | Maternal stress factors and psychiatric outcomes during the COVID-19 pandemic. These stress factors associated with perinatal endocrine factors (variation in cortisol, progesterone, and neurosteroid) and individual vulnerability (domestic violence, social insecurity) may lead to a range of psychiatric symptoms and psychiatric disorder, including anxiety, depression, and post-traumatic stress disorder (PTSD).

Faced with its data, American College of Obstetrical and Gynecology (ACOG) and the Society for Maternal-Fetal Medicine (SMFM), state that pregnant women who meet criteria for receiving COVID-19 vaccine may be vaccinated (52). The National College of French Gynecologists and Obstetricians (CNGOF) and the French National Authority of Health (HAS) has pleaded for an extension of the anti-COVID-19 vaccination to pregnant women and recommend mRNA vaccines for pregnant women; however the injection during the first trimester should be avoided in principle (54).

PROTECT PERINATAL MENTAL HEALTH FACE TO THE PANDEMIC

Preventive Specific Support During Pregnancy

The COVID pandemic is forcing us to adapt the organization of perinatal care in order to protect this fragile population against the direct or indirect consequences of the pandemic. It is crucial to prevent the appearance of mental disorders before they can disrupt the behavior of patients: studies have pointed out that anxiety predicted the cancellation of routine obstetrical appointments during lockdown, degrading medical and perinatal follow-up for these women, and restricting the management of their anxiety (55).

We suggest that the implementation of specific perinatal psychiatric care programs during pregnancy is essential to reduce symptoms of anxiety and depression, and prevent the fetal and maternal consequences of these disorders. These strategies should promote close collaboration between midwives, obstetric care, Maternal and Child Health Protection team, and perinatal psychiatric care. This networking between various professionals seems essential to avoid losing sight of suffering women (especially when they are in situations of precariousness, isolation or recent migration), often in difficulty in seeking help from professionals.

Maintaining perinatal follow-up during pregnancy can provide a barrier against the development of pre-partum psychiatric complications (44). The pandemic has drastically reduced access to mental health services, leading to an impoverishment of usual follow-up strategies (56). The early detection of clinical symptoms of anxiety or perinatal depression is a public health objective during this troubled time (17). Overall, the direct and indirect stressors associated with the pandemic that we have discussed are difficult to assess with conventional psychometric tools. The clinical scales are used to screen symptoms of anxiety or depression once they set in, and the disorder has already manifested itself. There is a lack of predictive instruments that can be used during the perinatal period (31).

The PREPS (Pandemic-Related Pregnancy Stress Scale) is a scale that can be used to assess stress factors dimensions related to pandemic: (1) Perinatal Infection Stress, 5 items related to the risk of infection; (2) Preparedness Stress, 7 items related to the stress of preparing for childbirth and postpartum; (3) Positive Appraisal, 3 items related to the favorable experience associated with the pandemic (57). This tool focused on stressors could be systematically used during pre-partum consultations, to early detect situations at risk of developing perinatal psychiatric disorders, before the onset of symptoms (44).

The use of these tools would also make it possible to offer women at risk behavioral strategies for preventing stress, before it becomes overwhelming. Studies pointed out the protective effect of pre-partum physical exercise against anxiety and depressive symptoms (58). Maintaining regular physical activity in the absence of obstetric contraindications is a useful and easy strategy for parturients during the pandemic. Women with proven risk factors should be encouraged to maintain regular physical activity during prenatal period.

Postpartum Follow-Up and Vulnerable Patients

After childbirth, the need for a specific organization of care is also a challenge during a pandemic. The main problem encountered is the isolation of patients after leaving the maternity ward, increased by lockdown. Continuity of care must be maintained between pediatricians, obstetricians, nurses, midwives and perinatal psychiatry teams, and sometimes in connection with adult psychiatry services. However, the destabilization of the health system during the pandemic weakened this course of common care and perinatal interdisciplinarity.

Most mother-baby psychiatric units in France and Europa had to temporarily suspend their admissions during the crisis, due to uncertainty about the risks of transmission (44). The disorganization of psychiatric care may have been an additional factor in the aggravation of pre-existing clinical pictures, or in the increase in the prevalence of disorders. In the absence of a mother-baby hospitalization unit, severe postpartum depression or puerperal psychosis caused a systematic separation of the mother and the infant: the mother was hospitalized in general psychiatric hospital, and the infant generally kept in nursery. Knowing the serious consequences of perinatal anxiety and postpartum depression on the health of mothers and newborns, responding to this issue during the pandemic presents a real challenge.

During the 2020 lockdown, the Sorbonne University maternities in Paris set up a new care system offering the possibility for women giving birth a 30 min telephone interview with a psychologist at 2 weeks postpartum, and 6 weeks later (59). About 80% of patients benefited from this follow-up during lockdown. The first interview focused on the mother's experience of childbirth and the conditions of discharge at home, associated with screening for perinatal post-traumatic stress disorder (PTSD) using the Perinatal PTSD Questionnaire (PPQ). The second interview more accurately assessed early dyadic relationships [using the New Mother-to-Infant Bonding Scale and Dyadic Adjustment Scale (60)] and symptoms of postpartum depression (using

TABLE 1 | Questions frequently asked by mothers during COVID-19 pandemic.

Mother's questions	Caution evidence	Reassuring evidence	Potential medical advise
Does Being Pregnant Increase my Risk of Pregnancy Complications?	Some report have found an increased risk of prematurity, fetal distress, premature rupture of membranes and miscarriage for infected mothers	There are no evidence to conclude if pregnancy complications are due to the effect of the virus itself or to the iatrogenic treatment of the infection	The risks associated with the virus for pregnant women are limited when patients have regular perinatal follow-up
Can the virus be passed from me to my fetus?	The first studies are reassuring with a low rate of transplacental passage, but this question requires further evidence to confirm transmission hypothesis	When cases of suspected transmission during pregnancy have been reported, newborn tested positive to COVID-19 didn't had serious complication	The risk associated with transplacental transmission or contamination at birth is low, and mothers can be reassured about the risks to their infants
Can I breastfeed if I have fever and fear I have the virus?	There are still few studies on the transmission of the virus from mother to child during breastfeeding, and more scientific work should be done on this topic	The American Academic of Pediatrics is very reassuring and recommends breastfeeding even if infected by COVID-19	During breastfeeding, women have to applying appropriate respiratory hygiene measures (wearing a mask) and following standard hygiene precautions (disinfecting the hands and objects affected)
Can I get vaccinated during my pregnancy?	Pregnant individuals were excluding from the clinical trials for Pfizer and Moderna vaccines but results of animal studies on these two vaccines are reassuring	The American college of Obstetricians and Gynecologists state that pregnant women can be vaccinated	Mothers should give priority to vaccination in front of the risk-benefit balance in favor of its implementation, and can be reassured about the associated thromboembolic risks
What are my options to cope with my perinatal stress during the pandemic?	Studies have shown an increase of anxiety and depression during the pandemic, and its symptoms have been experienced by many women during the perinatal period. It's more difficult to deal with these symptoms in countries with precarious health systems	In many country, new tools have been developed to protect and support mothers in the face of stressors linked to the pandemic, such as regular teleconsultations and the use of online applications after maternity discharge	Mothers can be encouraged to contact perinatal psychiatric services when these exist in the structures where they are taken care of. When they are not available, a quick contact with a psychiatrist or the general practitioner should be organized in order to intervene early on the emerging symptoms.

We describe here questions frequently asked by pregnant women or mothers who have just given birth, and summarize the data currently available in the scientific literature, and medical advice that can be given in response. Its recommendations are based on the current state of the literature, and are likely to change over time.

the EPDS scale). These type of protocols have participated in the early detection of risk situations for postpartum depression, allowing targeted intervention during the COVID-19 pandemic (59).

Digital Platforms in Perinatality

The use of new technologies such as digital platforms (e.g., online phone applications) is an effective way to maintain the contact with patients, and implement early screaning strategies. These tools assess and identify patients with risk factors for psychiatric symptoms, and refer them to teams specializing in perinatal mental health. These digital medical technologies are growing in the medical world, but are still fewly used in perinatal care. This gap was able to be reduced during the pandemic, under the effect of the pressure induced by the lockdown. The need to find perennial tools to assess maternal mental health in postpartum has encouraged an expansion of the use of these digital technologies.

Otherwise, teleconsultation is essential to evaluate the first dyadic interactions and to see the family environment. These home video consultations can be carried out with the dyad, the father, and even the immediate family surrounding the baby, involving the pediatric team and the Child, Maternal and Child Health Protection team if necessary. However, the use of this video technology is only possible in the most developed countries, and in the regions best equipped with digital technology and computer networks. Speaking another language or not having easy access to these technologies can hamper this care. When possible, perinatal team could propose, in conjunction with all early childhood professionals, to set up home visits for the most vulnerable dyads who do not have access to these digital technologies. Regular teleconsultations offered for at-risk patients would be beneficial to ensure this perinatal follow-up.

Morevoer, online application with real-time screening of psychiatric symptoms and regular intervals in the patient's usual environment (home) would be useful. An innovative project currently underway at Sorbonne University proposes an application to strengthen the screening and care of women in the postpartum period. On this platform, patients benefit from practical advice on the primary care (feeding, daily care such as baths and sleep), and medical care (vaccination schedule, and postpartum follow-up interviews).

The application also proposes early, graduated intervention and a connection, if necessary, with a care service. Several levels of therapeutic response are offered on the platform depending on the score of the questionnaires: if no symptoms, regular psycho-educational support; if mild to moderate symptomatology, greater support with psychotherapy exercises (cardiac coherence, cognitive behavioral therapy); if severe symptomatology, contact with a perinatal psychiatry unit. This type of protocol could be systematically offered to patients, and extended on a national level (**Table 1**).

CONCLUSION

The COVID-19 pandemic causes harm consequences for perinatal mental health, and special attention should be paid to parturients and mothers during this time. Pregnant and postpartum women are particularly at risk of developing psychiatric symptoms during the pandemic. Social support appears to be a major protective factor against these disorders, and could be promoted by the use of new digital technologies, video teleconsultations, andconnected applications. Targeted prevention strategies should be systematically offered to women in order to detect clinical symptoms early, and to offer rapid therapeutic interventions.

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HB and LJ: conceptualization, methodology, supervision, project administration, and funding acquisition. HB, BV, CJ, and LJ: resources. HB: writing—original draft preparation. HB, BV, CJ, RT, and LJ: writing—review and editing. All authors have read and agreed to the published version of the manuscript.

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REVIEW
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COVID-19 Pandemic-Related Restrictions: Factors That May Affect Perinatal Maternal Mental Health and Implications for Infant Development

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This review aims to discuss the factors that may affect maternal mental health and infant development in COVID-19 pandemic condition. Toward this direction, the two objectives of this review are the following: (a) to discuss possible factors that may have affected negatively perinatal mental health through the pandemic-related restrictions; and (b) to present the implications of adversely affected maternal emotional wellbeing on infant development. We conclude that the pandemic may has affected maternal mental health with possible detrimental effects for the infants of the COVID-19 generation. We highlight the need for evidence-based interventions to be integrated within the health system for prenatal and postpartum care in an effort to promote maternal mental health and infant development.

Keywords: COVID-19 pandemic, maternal mental health, neonate/infant development, family functioning, maternal health care policy, birth experience, NICU, breastfeeding

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INTRODUCTION

COVID-19 pandemic constitutes a major threat to global human health and a worldwide traumatic experience (1, 2). During the 2 years of the COVID-19 pandemic, million infants were born to mothers and families who have experienced tremendous stress and change in their daily lives and environments due to the pandemic (3–5)].

According to the World Health Organization (WHO), maternal mental health is defined as "a state of wellbeing in which a mother realizes her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her community" [as cited in Engle (6)]. Perinatal mental disorders constitute the commonest complications of child-bearing, and they are associated with high levels of maternal and fetal/infant morbidity and mortality (7). For women in the perinatal period, research has identified two major-pandemic–related stress domains: stress associated with feeling unprepared for birth and stress related to fears of perinatal infection (8). What is more, in the first months of COVID-19 pandemic, evidence from around the world[1] indicated that pregnant women suffer from high prevalence of anxiety (ranging from 21.7 to 78.4%), depression (ranging from 17 to 56.3%) and post-traumatic stress disorder (9–13). During COVID-19, the overall prevalence of anxiety and depression among pregnant women was 40 and 27%, respectively. Though the levels of anxiety and

[1]These studies compared mental health between pregnant and non-pregnant women, or mental health of pregnant women during the pandemic with pre-pandemic period, or they provided quantitative evidence of anxiety and depression symptomatology of pregnant women in different countries.

depression during pregnancy vary across different countries, in general prenatal depression is estimated to affect 9–18% of pregnant women at any given time during pregnancy (14, 15) while 5–13% of pregnant women suffer from anxiety symptoms (10, 11). Thus, evidence suggests that symptoms of maternal mental disorders have become more common during the pandemic (9–13). In the meanwhile, prenatal psychopathological diagnoses have been rarely investigated (13) and only a limited number of studies analyzed longitudinally anxiety and depression symptoms of pregnant women in the course of the lockdown. Despite contrasting results, findings show that ongoing COVID-19 pandemic may aggravate anxiety and depression symptoms of pregnant women (9, 12, 16).

COVID-19 pandemic coincides with sensitive time windows of heightened plasticity, such as pregnancy and neonatal life (1, 2). The significance of adversely affected perinatal maternal mental health as a potential risk factor for infant development has been emphasized (17). Prenatal stress affects the development of fetal systems (14, 15, 18–21). These fetal systems are also potentially related factors and causes of neuropsychiatric disorders (depression, anxiety, behavioral dysfunction, attention-deficit hyperactivity disorder, autism spectrum disorder) in children (21). Further, symptoms of maternal mental disorders have been linked with delays and poor infant motor, social, cognitive, and language development and difficulties in emotional self-regulation [see (22, 23) for reviews].

In addition, face mask wearing by caregivers in daily interactions with their infants may affect negatively: (a) infants' abilities related to social and emotional reciprocity and interpersonal engagement (24, 25) and (b) infant speech perception by interfering in the way basic features of infant-directed speech are expressed and transferred to infants and by obscuring, or reducing infant perception of intersensory coherence, speech intelligibility and maintainance of infant attention [(26), as cited in (27, 28)].

On this ground, as the pandemic continues, the adverse impact on maternal mental health may has long-term effects and powerful influence not only for the generation of infants born during the pandemic, but also for future generations to come (5). We are seriously concerned on this issue because the results of a limited number of the first relevant studies confirm the impact of negatively affected perinatal maternal stress on infant development in the pandemic condition (2, 29–32).

The WHO considers maternal mental health as a global health priority (33). Despite that, in this unprecedented time, mental health issues may have been overshadowed by more pressing issues in health care (34). What is more, relevant literature has mainly focused on the impact as an outcome of the pandemic on postpartum maternal emotional wellbeing. A growing body of research investigates women's mental health also during pregnancy (35). In the meanwhile, the factors that may affect perinatal maternal mental health and their connection with infant development have been discussed only in fragments. From an holistic perspective, this review comes to fill in this gap in the literature by discussing the possible factors that may affect perinatal maternal mental health through pandemic-related restrictions, and by highlighting the adverse implications of negatively affected maternal emotional wellbeing on infant development of the COVID-19 generation (see **Figure 1**).

Search Strategy

A strategy was formulated and literature searches were conducted from March 2020 to March 2022. The following electronic databases were searched: Web of Science, APA PsycINFO, Academic Search Ultimate, and JSTOR. Search was restricted to papers published in English language, with no restriction on the year of publication. Editorials, opinion papers, empirical studies, reviews, systematic reviews, and meta-analyses were eligible. In this review, we excluded publications which investigated: (a) the way the pandemic may has affected maternal mental health of preschoolers, school-aged children and adolescents and (b) research with a focus on maternal mental health of children, or adolescents with atypical development. Thus, we included only articles with a focus on the way the pandemic has affected perinatal maternal mental health of typically developing neonates and infants. For the first five subsections of the first objective of this review, literature search included the combined use of the keywords: "COVID-19 or coronavirus or 2019-ncov or sars-cov-2 or cov-19" with each of the following terms: "maternal mental health or postnatal mental health or perinatal mental health," "family environment family relationships or family dynamics or family functioning"/"family cohesion," "maternal care or maternal health or reproductive health," "maternal health or pregnancy or perinatal," "breastfeeding or breast-feeding or infant feeding or lactation or lactating," "birth experience or womens' feelings about birth or birth satisfaction," and "neonatal intensive care unit or nicu or baby unit or newborn intensive care." For the sixth subsection of the first objective of this review, literature search included the combined use of "COVID-19 or coronavirus or 2019-ncov or sars-cov-2 or cov-19" with "maternal mental health or postnatal mental health or perinatal mental health" and "infant development." Thus, for the coherence of this review, we restricted the presentation of these studies only to those that provided evidence on infant developmental outcomes in relation to perinatal maternal mental health in the first months of life. For the second objective of this review, search terms included the combined use of "maternal depression or postpartum depression or perinatal depression" or "maternal anxiety or postnatal anxiety or perinatal anxiety" or "maternal stress during pregnancy" with each of the following terms: "infant development," "fetal systems," "fetal physiology," "mother-infant interaction or early interaction," "mother-infant attachment," "maternal sensitivity or parental sensitivity or caregiver sensitivity."

POSSIBLE FACTORS THAT MAY HAVE AFFECTED NEGATIVELY PERINATAL MENTAL HEALTH THROUGH THE PANDEMIC-RELATED RESTRICTIONS

Family Environment and Parental Mental Health

The lockdowns and shutdown policies related to COVID-19 have led to economic difficulties, instability or loss

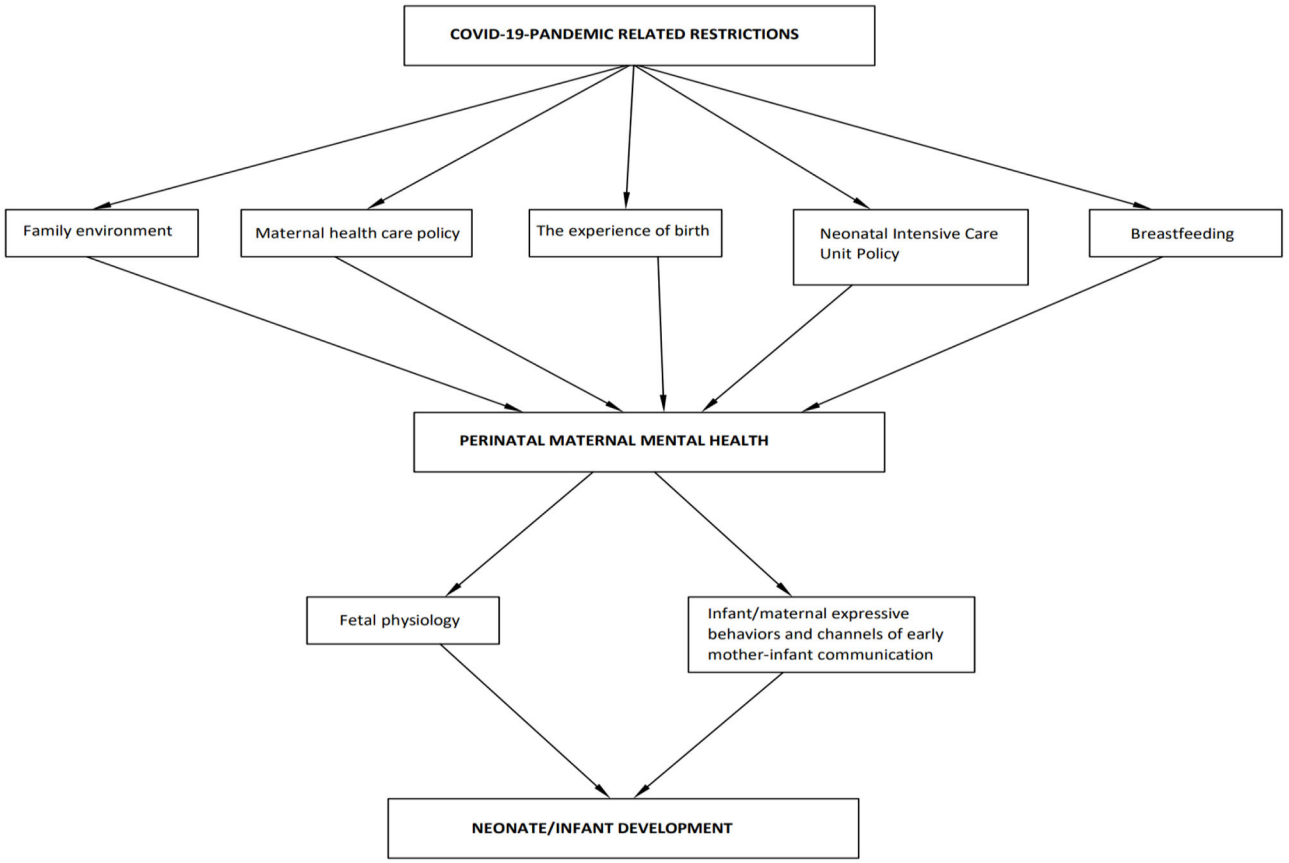

FIGURE 1 | Factors that may affect perinatal maternal mental health through pandemic-related restrictions and implications for neonate and infant development.

of job and uncertainty for the future economic status. The introduction of strict measures changed considerably the daily routine of citizen. Further, COVID-19 has been posing a threat to interpersonal interactions and relationships due to both a limited physical proximity with one's not cohabiting family members/friends, and at the same time, a forced and prolonged cohabitation with members of one's family (1, 36). Family environment/function has a significant impact on the mental health of its members. Under a crisis condition, the family environment may affect the interaction of negative emotion among its members (37). The unusual family environment has been associated with mental disorders among pregnant women. The mother's perinatal mental health is influenced by her family environment and compatibility between them is very important (38). Parental depression can be passed on to children through poor family function (39).

In connection to these, findings coming from limited studies in different regions provide evidence of a negative impact of the COVID-19 pandemic on the *family environment* and *parental (maternal and paternal) mental health* (1, 38, 40–46).

In particular, in China, Xie et al. (38) showed that, compared to the pre-pandemic period, the scores of cohesion[2] and independence in families were much lower during the pandemic. The scores for family cohesion were negatively related with depression, anxiety, and hostility symptoms. Similarly, Li et al. (45) confirmed negative correlations between depressive symptoms and family cohesion/adaptability. In Singapore, parents with greater COVID-19-related concerns reported higher stress and less closeness to their children (41). In USA, Feinberg

[2]The Olson Circumplex Model explains family function and the way family systems will change in response to a crisis. It includes two dimensions: family cohesion and family adaptability. "Family cohesion is defined as the emotional bond that family members have toward one another" [(37), p.145]. "Family adaptability is the amount of change in its leadership, role relationships and relationship rules" [(37), p. 147]. The four levels of cohesion range from disengaged (very low) to separated (low to moderate) to connected (moderate to high) to enmeshed (very high). The four levels of adaptability range from rigid (very low) to structured (low to moderate) to flexible (moderate to high) to chaotic (very high). The balanced levels of cohesion (separated and connected) and adaptability (structured and flexible) are considered as optimal family functioning while the unbalanced (disengaged or enmeshed/ rigid or chaotic) are seen as problematic for relationships in the long-term. Balanced types of couples and families will have more positive communication compared to unbalanced systems) (37).

et al. (42) reported deteriorations in family wellbeing and parent depression in the first months of the pandemic, compared to the period preceding it, and a moderate decline in co-parenting quality. Bate et al. (40) confirmed increased levels of parents' self-reported depression and anxiety symptoms during the pandemic. Higher conflict in the parent-child relationship strengthened the positive links between parent and child emotional health issues. In Canada, since the onset of the COVID-19, compared to respondents without children (35.6%), a significantly higher proportion of parents reported worse mental health (44.3%) with high levels of anxiety, worry, stress and boredom. 28.3% of parents reported being stressed while facing challenges in the relationship with their partner. Regarding sources of support, 47.6% of parents reported connecting with those in the household (43). In the same cultural context, COVID-19 health anxiety was found to impair family engagement because of the increased emotion suppression and the lack of psychological need fulfillment (47). In Spain (one of the worst affected European countries), Gunther-Bel's et al. qualitative analysis (44) confirmed elevated levels of state anxiety during lockdown and provide mixed results on perceived changes in family dynamics. In particular, prevalence of improvement themes (61.7%) outnumbered deterioration themes (41.0%). For parents with children at home, *family (re)connection* was cited most often among the improvement themes while *unbalanced needs* were most frequent among deterioration themes. Despite the fact that marital functioning for couples with children systematically improved with days in lockdown, this was not the case for parenting functions. In Australia, Westrupp et al. (46) showed that, compared to estimates in the pre-pandemic period, during the COVID-19 parents reported higher levels of depression, anxiety and stress, higher parenting irritability and lower levels of family positive expressiveness. In Italy, Donato et al. (1) confirmed that COVID-19 concerns threaten individuals' psychological wellbeing and showed that explicit stress communication[3] in the couple and responses in dyadic coping mediated the link between COVID-19-related concerns and parents' mental health.

Health Maternity Care Policy

Basic health services worldwide have been heterogeneously affected by the COVID-19 pandemic. There is a variation in strategies adopted to maintain continuity of maternal health services (49). There is a complex organizational response to COVID-19 in maternal services. In some cases these responses are in direct contraversion of COVID-19 recommendations from relevant organizations. These practices may affect negatively, both physically and psychologically, mothers along with their infants as well as medical staff caring for childbearing women and their families (50–53).

[3]According to Bodenmann's Systemic-Transactional Model of dyadic coping (48), dyadic stress is observed when partners are affected by a stressor and the source of stress is defined as common. In order to cope against dyadic stress, partners initiate a dyadic coping process. A dyadic coping process is the interplay between both partners' stress, their coping reactions along with proper common responses to the dyadic stressor. Stress communication is constitutes the first step in the dyadic coping process (1).

In particular, as a response to COVID-19 crisis, limits have been placed on antenatal classes' attendance by pregnant women, decrease of presentations of obstetric-related conditions to the emergency departments, restrictions on health care tests and treatments availability, in both ante- and postnatal care while companionship for birth and postnatal visiting have been prohibited. Giving birth in hospitals full of SARS-CoV-2 infected patients increase further maternal worries for the possibility of their and their infants' infection with adverse physical and psychological implications for both of them. Expectant mothers' reluctance to attend and delay in seeking treatment, due to the fear of being exposed to the virus, may result in poorer outcomes. Moreover, in cases of maternal SARS-CoV-2 infection, forced separation of mothers and infants for up to 14 days has been reported. This prohibited immediate and uninterrupted skin-to-skin contact. Further, a lack of opportunity to support mothers to initiate breastfeeding in the first hour after birth along with non-acceptance of breastmilk donation have been evidenced. These restrictions have a negative effect on mother's mood, self-esteem, self-confidence and confidence in their abilities related to their infant's care. Standard precautions (such as hand hygiene, use of medical mask, routine disinfection) applied by mothers with suspected, or confirmed COVID-19, who must take care of their infants by themselves, may impose psychological demands on new mothers and may complicate the early mother-infant relationship (51–56).

The Experience of Birth

During the pandemic, and especially during the lockdown period, limited access to formal, and informal support network along with medical conditions and risk factors may have shaped adversely the experience of birth (35).

In connection to these, limitations set by the pandemic may cause a shift in the way mothers and fathers experience birth. Thus, birth experience may shift from being a "couple event"—based on "togetherness"—to being in "singleness," placing a barrier within the couple and within the newly born family. Father's stress combined with that of mother in the perinatal period may has implications for infant development (36).

Pregnant mental health is at the core of the following interrelated factors that have been identified as affecting the subjective childbirth experience: pregnant psychological wellbeing, personal history of maternal mental illness, pregnancy complications, fear of childbirth, support and relationship with the partner, fear of health, the first moments with the baby/mother-infant bond (skin-to-skin contact, breastfeeding), previous birth experiences, perceived control, birth plan compliance and medical-obstetric dimensions (33, 35, 57, 58).

In particular, COVID-19 pandemic has *affected adversely all above interconnected factors* that contribute to the subjective childbirth experience (33, 35, 57, 58). Women who gave birth, or pregnant women during the current pandemic, are at greater risk of reporting *general stress*, isolation and frustration at all phases of pregnancy, birthing and infant care. They are also at greater risk of manifesting *depressive, anxiety, or post-traumatic symptoms* (59, 60). In the pandemic condition, depression and anxiety

have been negatively related to birth satisfaction (61). New-mothers with *earlier psychological disorders* and *complications during pregnancy* were more likely to suffer from trait anxiety and postpartum depression, to develop a postpartum post-traumatic stress disorder and to have perceived childbirth as a negative experience (35). In the period preceding the pandemic, *the fear of childbirth* was associated with anticipation, impatience, joy and encounter. However, during the pandemic fear was correlated with sadness, loneliness, inability, sense of isolation and constriction (58). For more than half of expectant mothers, fear of childbirth is above the cutoff value while 32% of women reported a negative childbirth experience (35). *Lack of support* from the partner has arisen as a major issue affecting adversely women's pregnancy and childbirth experience under the restrictions imposed due to the pandemic. Pregnant women were more likely to suffer from state anxiety and to have intense fear of childbirth if they believed that their partner could not be present at childbirth, or had not been present during delivery (35). During the earliest months of the pandemic, higher birth satisfaction has been associated with having a birth partner present (61). COVID-19 has intensified *the protective response of women for those around them* (13, 16, 62). This shift of focus to others' health may increase the risk of maternal mental health problems (13). Regarding the first moments with their infants, Del Rio et al. (50) showed that 43.5% of infants did not receive maternal *skin-to-skin contact after birth*. After the quarantine termination, 49.1% of SARS-CoV-2 infected mothers chose to prolong mother-baby separation. In the first months of the pandemic, separation from the infant has been negatively associated with birth satisfaction (61). The combined impact of isolation with the feeling of the newborn as "fragile" caused tension and mistrust (59). Ravaldi et al. (58) showed that before the pandemic, *previous birth experiences* were associated with positive expectations for birth but during the pandemic the same experiences changed to feelings of danger, anxiety and loneliness. Pandemic situation has been associated with *birth plan* changes (e.g., place of birth, presence of birth partner) (63) which may negatively affect their birth experience and the sense of personal achievement and control (33). Regarding *medical-obstetric dimensions*, pandemic-related health care policy and maternity care practices have a negative impact on birthing women's perceptions of safety and support (64). Women who gave birth during the pandemic gave a worse rating of the quality of care they received (65).

Neonatal Intensive Care Unit Policy

The pandemic-related restrictions in NICU vary widely depending on local infection rates, availability of personal protective equipment and the structure and layout of the NICU (66). In the meanwhile, restrictions in NICU parental presence have been widely adopted (67). COVID-19-related policies that impose restrictions on components of parent presence in NICU (e.g., who can be present, how many people can be present, when they can be present) may inhibit the concept of parents as "partners in care" against the Family Centered Care (FCC)/Family Integrated Care (FIC) model concepts (66, 68–70) with adverse effects on the components of FCC, on infants, new parents and stress-related consequences in health professionals (68).

FCC/FIC—the gold standard in healthcare—has been incorporated into neonatal intensive care units. This kind of care encourages and empowers parents to play an active role in the caregiving of their child, while cooperating with staff and taking part in the decision making for their infants. Providing parents with the opportunity to exercise their role of primary caregivers brings benefits in their emotional health with short- and long-term positive implications for infant development such as: improved weight gain, increase in the incidence of breastfeeding, decreased parental stress and increased parental satisfaction rates, improved neurodevelopmental outcomes (through parent-infant skin-to-skin contact) and the development of parent-infant bonding. Further, promoting parental mental health will also support health professional's wellbeing. In this context, FCC requires that parents are not labeled as "visitors" but rather as "partners in care," or they provide most of the care for their infant (66, 68–70).

Limiting parent presence may contribute in additionally aggravating the psychological distress of NICU family, a vulnerable population due to trauma of separation from the infant along with stress for their medical condition (54, 67, 71). The experience of parenthood in NICU has been negatively affected by the restrictions in parental presence time and physical contact of parents with their infant and additional concerns for their child's health. Parent presence due to isolation recommendations are connected with restrictions on parent-newborn contact, loss of opportunities for interaction and for provision of parental care. Restrictions may impact adversely breastfeeding and may cause additional emotional disturbance on parental pandemic-related preexisting heightened anxiety with adverse effects on parent-infant bonding and infant neurodevelopment. What is more, the restriction to fathers' access to the NICU acted as a significant obstacle to early infant-father bonding and led to loneliness and isolation by the mothers (66, 68, 71–73).

Travel restrictions due to the pandemic constituted an obstacle for family members' presence to provide postpartum social support. Thus, many women are left feeling isolated and alone, a condition that potentially contributes to risk of developing perinatal anxiety and mood disorders (74). Less support from family and friends and loneliness have been frequently reported by parents in NICU (71).

The majority of the newborns born by SARS-CoV-2 infected mothers were followed in isolation rooms in the NICU, others were monitored with a distance of 2 m away from the mother, or cared by family members in a separate room (Yekta 72). Policies that impose limitations in early neonate-mother tactile interaction may disrupt the previously established fetus-mother communication and may have detrimental effects on all domains of infant development, parental mental health and on the quality of spouses' relationship (75–83).

Early skin-to-skin care has been related to positive influences on maternal mental health and sensitivity, oxytocin levels (which facilitates mother-infant bonding with long-term effects), lower pain perception, improved self-efficacy of mothers of

premature infants, growth of parental self-esteem, and higher maternal satisfaction (77, 84–86). Early skin-to-skin care has also beneficial effects for father-infant attachment scores/interactive experiences, for fathers themselves at a biochemical level, and on their mental health which can have an indirect positive impact on maternal domains (exclusive breastfeeding and care-giving-related hormones), and increases spouses' mutual understanding (87–94).

In addition, NICU staff members experience a sudden and continuous environmental stressor since they are further affected by a number of factors that seem to increase even more their psychological stress such as: moral distress when limitations beyond their control make them unable to take decisions according to their own values, the values of the patient's family, or the values of FCC; and difficulties in finding a balance between meeting the emotional needs of hospitalized infants and their families while also safeguarding their own health (52, 54, 68).

Further, it has to be emphasized that personal protection equipment wearing, virtual consultations and online antenatal education cause disruption to interpersonal communication and limit supportive touch between NICU staff and parents (52). Face-to-face psychological support of pregnant and new mothers by mental health professional is equally important as physical checks. A trusting relationship between professionals and families is a prerequisite for good quality maternal and family care. Dynamics of interpersonal communication, such as good eye contact, touch, and tone, are essential elements of care (52). Under conditions of substantial mental health burden of both healthcare workers and new parents, limitation of interpersonal engagement may aggravate even more the risk of emotional exhaustion of pregnant women/new mothers and their families.

Breastfeeding

The nutritional and physical health benefits of breastfeeding for infants and children are well-established. Accumulating research shows the long-term effects of breastfeeding on brain, cognitive and socio-emotional development of children and on mental health of mothers (95).

In the course of COVID-19 pandemic, the main scientific and public institutions (e.g., WHO, UNICEF) advice to facilitate mother-infant interactions and to support breastfeeding initiation even in cases in which a mothers has been virus infected as long as clinical conditions permit it (63, 96, 97). In the meanwhile, other institutions highlight the risk of virus transmission and recommend maternal separation precluding breastfeeding (98). So far, though emerging evidence suggests that vertical transmission is possible, there is not enough scientific evidence to unequivocally state the possibility of SARS-CoV-2 mother-infant transmission via breastmilk. However, infection transmission risk is attributed to close contact between neonate and mother with suspected, or confirmed infection during breastfeeding [see (99–101) for reviews].

Maternal mental health constitutes a core factor related to face-to-face breastfeeding support, skin-to-skin contact after birth and partner's support, all interrelated factors connected to breastfeeding, one aspect of the gold standard infant care (102–104). There is evidence that most of these factors have been affected adversely by the COVID-19 pandemic.

Regarding *maternal mental health*, under the pandemic condition, a limited number of studies shows that breastfeeding mothers reported that they experienced anxiety, depression, isolation, loneliness and distress for not being able to see their family during the lockdown (63, 105–107). Worries about the safety of breastfeeding were commonly mentioned but, at the same time, exclusive breastfeeding was a protective factor to maternal mental health (102, 106). Continued breastfeeding support is a key for breastfeeding success while the quality *of breastfeeding support* is important for both breastfeeding promotion and maternal mental health (63, 103, 108). The *lack of face-to-face health services* and lack/decrease of support for breastfeeding has been mentioned as one of the main concerns of breastfeeding mothers, the most common reason for breastfeeding cessation, a frequent maternal response related to feeding plans changes and as a factor that negatively impacted breastfeeding experience (59, 63, 102, 105). However, the absence of recommendations on breastfeeding support and lack of support has led to reduced compliance to the recommendations of main scientific institutions suggesting breastfeeding initiation. This may has affected adversely both maternal mental health and the rate of breastfeeding (50, 51, 109). However, mothers experience breastfeeding heterogeneously since 41.8% felt that breastfeeding was protected due to the lockdown but 27% of mothers reported a negative impact of lockdown upon their breastfeeding experience. An intense focus on feeding which made them feeling overwhelmed by the breastfeeding experience and a *lack of face-to-face support* were some of the barriers placed in their way (102). As for *partner support*, both women who delivered before and during the lockdown reported that the main source of infant feeding support is the partner (63). Mothers who reported a positive impact of the pandemic on breastfeeding mentioned greater partner support. Shared care was felt to strengthen the new parent relationship and to increase bonds between partner and baby. Mothers who reported an adverse effect of the pandemic on breastfeeding talked about the isolation they felt which had a negative impact on their wellbeing and mental health (102). Regarding the connection of skin-to-skin contact and breastfeeding, in the course of COVID-19 pandemic, there is evidence for a strong negative correlation between exclusive breastfeeding at discharge and mother-newborn separation at birth (50). The implications of early mother-neonate separation have been discussed above.

COVID-19 Pandemic, Maternal Mental Health, and Infant Development: First Results

To our knowledge, the results of a limited number of relevant studies from different regions confirm our concerns on the negative effect of adversely affected perinatal maternal stress on infant development in the pandemic condition.

In Italy, the first longitudinal study (32) that documented the short-term implications of COVID-19 pandemic-related stress

on infant's temperament at 3 months, showed that infant's regulatory capacity was linked with less parenting stress and more mother-infant bonding. In Japan, mother-infant bonding was worse one month after birth among mothers who gave birth during the COVID-19 pandemic compared to those who gave birth in the same period of the previous year (110). Maternal mental health problems have been related to long-term risks for the establishment of mother-infant bonding (30). In Portugal, compared to mothers who gave birth before the pandemic, mothers of 0–12 month-old infants who gave birth during the COVID-19 pandemic presented lower levels of emotional awareness of the child and a more impaired mother-infant bonding. A more impaired mother-infant bonding was associated with higher levels of parenting stress and lower levels of mindful parenting dimensions. Maternal mental health problems may prevent maternal adoption of a mindful parenting practice (30).

An online survey, mainly in European countries, showed an acute decrease in sleep quality (which plays a crucial role in brain maturation) in 0–35-month-old infants and 36–71-month preschool children in April 2020. At two-follow up assessments (May/June 2020), this effect largely disappeared. Caregiver's stress due to the confinement was identified as the dominant factor with a negative impact on children's sleep. In the meanwhile, protective factors influencing children's sleep quality included caregiver's mindful techniques, childcare and the presence of siblings/pets (111). What is more, children (aged 0–4) with parents scoring higher on separation anxiety showed more distress after child care center reopening. There was a positive correlation between concurrent child and parental distress after reopening (29).

In Serbia, Jelicic's et al. follow up study (31) showed medium and high levels of maternal anxiety among 142 third-semester pregnant women during the COVID-19 pandemic, and a high level of perceived social support. The study showed a positive correlation between maternal trait anxiety and child's socio-emotional status at 12 months.

Lastly, there is evidence that COVID-19-related prenatal stress was significantly correlated with higher infants' SLC6A4 methylation (which occurs at the level of stress-related genomic portions). SLC6A4 methylation was negatively associated with the infants' positive affect at 3 months (2).

POSSIBLE EFFECTS OF MATERNAL DEPRESSION AND ANXIETY DURING THE COVID-19 PANDEMIC ON FETAL AND INFANT DEVELOPMENT

There is evidence that maternal stress impacts *fetal central and autonomic nervous system function* (ANS) (15) and both *maternal hypothalamic-pituitary-adrenocortical axis (HPA) activity and fetal HPA development* (19, 20). The early structures of *the developing limbic system (e.g., amygdala and hippocampus)* may also be influenced by the maternal stress (21). What is more, heightened CpG-specific SLC6A4 methylation has been evidenced for infants exposed to prenatal maternal depression and stress. This is important given that heightened SLC6A4 methylation constitutes a potential biomarker of early adverse experiences (2). Prenatal stress exposure has also been related to *physical health-related outcomes* [(14, 18, 112–114), as cited in (20, 115, 116)].

Taken the above evidence together, it is critical that the development of fetal systems [ANS, HPA development and brain structures of the limbic system (amygdala and the hippocampus)] that have been reported to be affected by maternal prenatal stress are also potentially related factors and causes of neuropsychiatric disorders [depression, anxiety, behavioral dysfunction, attention-deficit hyperactivity disorder (ADHD), autism spectrum disorder] in children (21). Though most children are not affected by prenatal stress, partly due to differential genetic susceptibilities (117), we express our concern that the COVID-19 pandemic may contribute into a further increase in the incidence of neuropsychiatric disorders in children, and later in life, as this may be reported in the coming years.

What is more, research provides evidence that maternal depression negatively affects both infant and maternal expressive behaviors. Maternal depression disrupts all channels of early infant-mother communication and parameters of fine-grained interactive temporal coordination along with the dyad's capacity to mutually regulate the interaction (118–125). What is more, maternal depression has a negative effect on mother-infant affective and behavioral synchrony, bonding, attachment, mutual attunement and negatively affects positive enrichment activities and care for the infant, infant health and sleep, breastfeeding and its parameters (e.g., duration, timing exclusivity, satisfaction, confidence and weaning) [(22, 23, 123) for recent reviews]. On this ground, maternal depression has been linked with delays and poor infant motor, social, cognitive and language development and difficulties in emotional self-regulation. Maternal depression has been associated with short and long-term adverse consequences for mothers' physical and psychological health, partner relationships, sexuality and social relationships [see (22, 23) for recent reviews].

Recent evidence on the impact of maternal anxiety on mother-infant interactions shows that high levels of maternal state anxiety significantly predicted a lower score on the sensitivity scale (126), reduced emotional tone and increased level of non-contingent maternal comments during interaction to their infants (127). Anxious mothers present greater intrusiveness (128) and they do not adapt to the infant's moment-by-moment signals (129). Infants of anxious mothers seem less communicative, less emotional during social challenges (130) and they score less optimally on social engagement (129). Maternal anxiety has been positively associated with infant negativity and with mismatches in which infant was in positive affect and mother was in negative affect, or infant expressed negative emotion and mother was in a neutral state (131).

What is more, face masks may aggravate even more the already disrupted channels of early infant-mother face-to-face interaction. In connection to this, in relation to non-depressed mothers, depressed mothers manifest more flat and negative affect, less positive affect and increased gaze focus at the infants (132). Infants of depressed and anxious mothers are likely to

encounter even fewer opportunities to observe and imitate facial expressions of emotion (133). Infants of depressed mothers need more trials and take almost twice as long to habituate to their mother's face and voice compared to infants of non-depressed mothers (134).

DISCUSSION

We reviewed possible factors that may have affected negatively perinatal mental health through the pandemic-related restrictions. We presented the implications of adversely affected maternal emotional wellbeing on infant development.

On the basis of the above review, we would like to note the following:

1. It is our obligation to emphasize that evidence-based promotion of new family mental health during the COVID-19 pandemic is needed to be integrated within the health system at a multi-layered level in the prenatal, intrapartum, postnatal period and in infancy/early parenthood (135, 136). Protective factors, including partner/social support (137) must be taken into consideration. All healthcare providers involved with birth and NICU staff must give even more active support to new families (36, 54). What is more, maternal mental health screening during the pandemic condition has been highlighted as an essential issue (137). It is important for nurses in obstetric units to identify stressors of pregnant women in the course of prenatal care and provide resources to manage/reduce their impact. Providers in outpatient clinics should consider synchronous group prenatal telehealth care visits that may provide support for pregnant women by creating a sense of community (74).
2. High priority should be given to the preservation of family-centered care principles with emphasis on parents' presence in the NICU, parent-infant physical and emotional closeness and parental involvement in the infant's care (54). Toward this direction, while strict restrictions on parental presence were initially adopted to prevent infection spread in the NICU, recently there is a relaxation of such restrictions in favor of parent-infant contact (71). It is the responsibility of hospital systems to ensure that family-infant communication can continue to be supported in the safest manner possible (138). Current recommendations are being modified on a case-by case basis. For mothers in good clinical condition, the separation of the mother-child pair might be not recommended. The recommendations for infected neonates vary from isolated admission without caregivers to strategies adapted to the clinical situation of the infant, but with parental accompaniment (68). When parents cannot be in the NICU, it is crucial that they must be supported to see their baby via video (54). Video-technology interventions showed parental appreciation of being able to see their infant when they could not be in the NICU. Parental ability to visualize their infant reduced stress and anxiety. Videoconferencing seems to be helpful and meaningful to parents [see (72) for a full discussion]. Further, NICU systems should implement evidence-based assessment and treatment for parental distress while providing peer support for parents and voice calls [(54); see in (72) for a discussion on the benefits and the drawbacks of online support groups].
3. We are seriously concerned that the COVID-19 healthcare emergency may be "…a hidden pandemic of developmental psychopathology" [(32), p. 7]. There is an urgent need for more investment to research with the aim to evaluate the way the pandemic is affecting maternal mental health and on the impact of poor maternal mental health on young infants' developing brains. Also, there is a need to follow up these children and their families in order to mitigate the COVID-19 pandemic effects in the long-term. Health authorities and government have to treat this as a public health issue, and not as a condition with short-term effect (34, 139).

CONCLUSION

We highlighted the possible factors that may have affected negatively perinatal mental health through the pandemic-related restrictions. We presented the implications of adversely affected maternal emotional wellbeing on infant development. It is critical to extend with more research our understanding of the way the pandemic is affecting maternal mental health and the impact of poor maternal mental health on infant development. The implications of the adverse maternal wellbeing on infant development under the pandemic condition call for nationwide policies and evidence-based interventions. These interventions have to be integrated within the health system for prenatal and postpartum care in an effort to promote new family wellbeing and infant development. Interventions for improving perinatal maternal mental health is needed to be adapted in the "new normal" of the current situation. Maternal wellbeing and the implications of it on infant development should be priority areas to be included in COVID-19 related policy guidelines.

AUTHOR CONTRIBUTIONS

TK and EH contributed equally to the writing of this review. All authors contributed to the article and approved the submitted version.

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Implementation Evaluation of HUGS/Abrazos During the COVID-19 Pandemic: A Program to Foster Resiliency in Pregnancy and Early Childhood

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Early life adversity can significantly impact child development and health outcomes throughout the life course. With the COVID-19 pandemic exacerbating preexisting and introducing new sources of toxic stress, social programs that foster resilience are more necessary now than ever. The Helping Us Grow Stronger (HUGS/Abrazos) program fills a crucial need for protective buffers during the COVID-19 pandemic, which has escalated toxic stressors affecting pregnant women and families with young children. HUGS/Abrazos combines patient navigation, behavioral health support, and innovative tools to ameliorate these heightened toxic stressors. We used a mixed-methods approach, guided by the Reach, Effectiveness, Adoption, Implementation, and Maintenance (RE-AIM) framework, to evaluate the implementation of the HUGS/Abrazos program at Massachusetts General Hospital from 6/30/2020–8/31/2021. Results of the quality improvement evaluation revealed that the program was widely adopted across the hospital and 392 unique families were referred to the program. The referred patients were representative of the communities in Massachusetts disproportionately affected by the COVID-19 pandemic. Furthermore, 79% of referred patients followed up with the initial referral, with sustained high participation rates throughout the program course; and they were provided with an average of four community resource referrals. Adoption and implementation of the key components in HUGS/Abrazos were found to be appropriate and acceptable. Furthermore, the implemented program remained consistent to the original design. Overall, HUGS/Abrazos was well adopted as an emergency relief program with strong post-COVID-19 applicability to ameliorate continuing toxic stressors while decreasing burden on the health system.

Keywords: toxic stress, patient navigation, resilience, RE-AIM, COVID-19 pandemic, early childhood

INTRODUCTION

Early life adversity, defined as recurrent stressful events that occur during sensitive periods of development, can have profound impact on child development and health outcomes throughout the life course (1–4). Pregnancy and the early childhood years are examples of critical periods of development during which the parent-child dyad is more vulnerable to toxic stressors (5). Adversity during these critical periods of development influences neurodevelopmental processes at the cellular level (6, 7), disrupts normal immunoregulatory scaffolding (8), and results in cumulatively increased risk for disease in adulthood (2, 8, 9). Furthermore, the early life environment can exert intergenerational impact on risk for chronic disease throughout the life course via epigenetic mechanisms (10). Reassuringly, protective buffers can curb the negative impact of toxic stress and build resilience among children and families experiencing adversity (11–14). Therefore, social programs that foster resilience are necessary.

The COVID-19 pandemic exacerbated preexisting and introduced new sources of toxic stress for families with young children. Specifically, the newfound challenges of at-home parenting (15), financial insecurity (16, 17), racial disparities in health outcomes (18–20), and behavioral health burdens have all escalated to critical levels (21–23). This is especially true for marginalized communities such as racially and ethnically diverse populations, immigrants, and families in poverty (18, 19, 24–26). The Helping Us Grow Stronger (HUGS/Abrazos) program fills a crucial need for protective buffers during the COVID-19 pandemic, which has escalated toxic stressors affecting pregnant women and families with young children. The multimodal strategy utilized by HUGS/Abrazos to support patients from communities hardest hit by the COVID-19 pandemic has been previously described (27). Specifically, HUGS/Abrazos supports patients served by Massachusetts General Hospital (MGH), including MGH community health centers in Chelsea and Revere, two communities most severely impacted by the COVID-19 pandemic in Massachusetts.

Given the quickly evolving public health crisis, analytical methods that can assess public health interventions without delaying implementation are crucial. RE-AIM – Reach, Effectiveness, Adoption, Implementation, and Maintenance – provides an evaluation framework that assesses the delivery of public health interventions while bridging the gap between practice and research (28–30). The RE-AIM framework has been especially helpful when used to inform adaptations and dissemination of interventions in low resource settings (31–33). We used a mixed-methods approach, guided by the RE-AIM framework, to evaluate the implementation of the HUGS/Abrazos program to inform future program adaptations, dissemination, and sustainability.

METHODS

Overview of HUGS/Abrazos Program

The design and implementation of the HUGS/Abrazos program has been previously described (27). HUGS/Abrazos aimed to (1) use targeted patient navigation to address unmet health-related social needs; (2) provide short-term, immediate behavioral health support; and (3) create cross-systems linkages among community partners using centralized resource repository and an integrated referral system. The targeted patient population included communities in and surrounding Boston, MA that were heavily impacted by the COVID-19 pandemic. These communities had higher number of immigrants, families living in poverty, and residents of racially and ethnically minoritized groups compared to state average. Eligibility criteria included (1) pregnant women and families with children under 6 years old; (2) demonstration of an unmet socioeconomic or behavioral health need; and (3) had an established provider within MGH system. In a cross-departmental collaboration, providers in Pediatrics, Obstetrics & Gynecology (OB/Gyn), Family Medicine, and other specialties made initial referrals to HUGS/Abrazos. Referrals were triaged and assigned to a community health worker (CHW), who navigated patients toward community resources, or to the behavioral health team, who provided behavioral health support, or to both. During the first encounter, a screening questionnaire was used to assess for specific unmet socioeconomic or behavioral health needs. Referred patients connected with the CHW for up to three touchpoints, and with the behavioral health team for up to four touchpoints. We utilized a centralized resource repository in Aunt Bertha and the Integrated Referral and Intake system (IRIS) to streamline communication and workflow. All patients received a care package that included a $50 gift card for groceries, age-appropriate activity kits, and supplies to encourage healthy practices during the pandemic. At the conclusion of the program, patients were referred to long term services if necessary and available. HUGS/Abrazos conception and design began in April 2020, and program launch occurred in July 2020. Evaluation of implementation included patients referred to the program between 6/30/2020 and 8/31/2021. The Mass General Brigham Institutional Review Board determined the evaluation of the HUGS/Abrazos program to be local program evaluation intended for quality improvement purposes and did not require Institutional Review Board oversight.

Overview of Mixed Methods Evaluation Using the RE-AIM Framework

We used a mixed methods approach, guided by the RE-AIM framework, to evaluate the implementation and delivery of HUGS/Abrazos (30). Quantitative data related to reach, effectiveness, and adoption (R,E,A) were obtained from the electronic health record (EHR) and administrative data. Qualitative data related to implementation and maintenance (I, M) were obtained through focus group sessions, which subsequently underwent rapid qualitative analysis described below. See **Table 1** for the specific measures used to assess each domain of the RE-AIM framework.

Quantitative Evaluation Methods

To evaluate adoption, defined as the representativeness of settings that implement a new program (29), we utilized the EHR and administrative data to determine the characteristics of practices and providers who made referrals to HUGS/Abrazos.

TABLE 1 | Evaluation of the HUGS/Abrazos program using the RE-AIM framework.

RE-AIM Component	Measure	Data source
Reach	Total number of patients seen in practices referring to HUGS	Electronic Health Record (EHR)
	Number of unique referrals made to HUGS	
	Number of families who completed ≥ 1 touchpoint	
	Socio-demographics of referred patients	
Effectiveness	Number of touchpoints with community health, behavioral health, and community health + behavioral health combined	Electronic Health Record (EHR)
	Average number of referrals provided to community resources	
	Reason for referrals to community resources	
Adoption	Characteristics of practices referring to HUGS	Administrative and EHR data
	Characteristics of providers making referrals to HUGS	
Implementation	Appropriateness of HUGS	Qualitative focus groups with community health, behavioral health, and physician champions
	Acceptability of HUGS	
	Penetration of HUGS	
	Fidelity to the program and adaptations made	
Maintenance	Sustainability of HUGS	Qualitative focus groups with community health, behavioral health, and physician champions

RE-AIM, Reach, Effectiveness, Adoption, Implementation, Maintenance.

To evaluate reach, defined as the participation rate and characteristics of the program-eligible population (29), we utilized the EHR to determine the number of patients seen in practices referring to HUGS/Abrazos and the number of unique referrals made to HUGS/Abrazos. Due to the possibility in which multiple referrals were made for the same family or individual for different reasons, we tracked the number of unique families referred. After we identified families, we then selected the first referral made and used that information when reporting. When possible, we linked child and parent data. Of the referrals made, we determined the number of families who completed at least one touchpoint during their HUGS/Abrazos participation. We summarized the socio-demographics of referred patients, which included parent age, child age, sex, race and ethnicity, language, birth country, insurance status, education level, marital status, and employment status, and stratified by those who completed touchpoints and those who did not.

To evaluate the effectiveness, defined as the impact of the program for the participating population (29), we utilized the EHR to determine the number touchpoints patients completed with the CHW, the behavioral health team, or both. Additionally, we determined the reasons for which referrals to community resources were made and the average number of referrals provided to patients for community resources.

We calculated descriptive statistics for the number of referred patients, unique referrals to HUGS/Abrazos, touchpoints completed, and the referrals to community resources. We performed statistical analyses using RStudio 1.4.1717 (R Core Team) (34).

Qualitative Evaluation Methods

We designed and facilitated three focus group sessions with stakeholder groups to elucidate their perspectives on the implementation and maintenance of HUGS/Abrazos. The first focus group session involved all the CHWs who provided patient navigation of community resources appropriate to each patient's health related social needs ($n = 6$). The second focus group session involved all members of the behavioral health team, who provided stress reduction strategies, mindfulness techniques, and cognitive behavioral therapy to alleviate acute behavioral health needs ($n = 3$). Finally, the third focus group session involved primary care physicians (PCP), who were part of the program's initial conception and design team and served as clinician champions heralding the program's launch ($n = 2$). The focus group interview guide was developed according to the sustainability-enhanced RE-AIM framework with questions tailored to evaluate implementation outcomes, which included appropriateness, acceptability, penetration, fidelity to program design, and sustainability (30, 35, 36).

We used rapid qualitative analysis methods that have been successfully used in prior studies to inform implementation when results are needed in a timely manner (37, 38). We recorded and transcribed the focus group sessions for rapid qualitative analysis to determine key findings related to implementation and maintenance of HUGS/Abrazos. First, the evaluation team created a summary table that outlined (1) each implementation outcome with its associated focus group questions; (2) key findings; and (3) related exemplar quotes in the transcript. Next, the analytic team extracted data from one focus group transcript to populate the summary table. The evaluation team then reviewed and modified the summary table based on the initial analysis of one transcript. The analytic team subsequently extracted data from remaining focus group transcripts to populate the newly modified summary tables. A second review of the summary tables by the evaluation team was performed to ensure accuracy and consistency in data extraction. Finally, the summary tables were used to populate a matrix in Microsoft Excel to identify themes and subthemes consistent across stakeholder groups. The evaluation team reviewed and discussed the matrix to finalize the themes. The conception and design team of HUGS/Abrazos performed a final review of the identified themes and subthemes.

TABLE 2 | Characteristics of families referred to the HUGS/Abrazos program ($N = 392$).

	All referred parents	Parents who engaged in HUGS	Parents who did not engage in HUGS	All referred children	Children whose parents engaged in HUGS	Children whose parents did not engage in HUGS
	***N* = 206**	***N* = 164**	***N* = 42**	***N* = 186**	***N* = 146**	***N* = 40**
Age at referral						
Mean (SD)	29.5 (6.7)	29.7 (6.8)	28.6 (6.2)	1.8 (1.8)	1.9 (1.8)	1.6 (1.8)
Range	(16.4, 56.0)	(16.4, 56.0)	(18.7, 42.9)	(0.0, 7.0)	(0.0, 6.6)	(0.0, 7.0)
Age categories of children at initial referral						
0–5.9 mo.	N/A	N/A	N/A	55 (29.6)	42 (28.8)	13 (32.5)
6.0–11.9 mo.	N/A	N/A	N/A	28 (15.1)	21 (14.4)	7 (17.5)
1.0–1.9 yrs.	N/A	N/A	N/A	30 (16.1)	21 (14.4)	9 (22.5)
2.0–3.9 yrs.	N/A	N/A	N/A	41 (22.0)	35 (24.0)	6 (15.0)
≥ 4.0 yrs.	N/A	N/A	N/A	32 (17.2)	27 (18.5)	5 (12.5)
Sex, *n* (%)						
Male	2 (1.0)	2 (1.2)	0 (0)	90 (48.4)	69 (47.3)	21 (52.5)
Female	204 (99.0)	162 (98.8)	42 (100.0)	96 (51.6)	77 (52.7)	19 (47.5)
Race/Ethnicity, *n* (%)		***N* = 201**		***N* = 135**		
White	46 (22.9)	28 (17.5)	18 (43.9)	8 (5.9)	5 (4.7)	3 (10.3)
Hispanic or Latino	129 (64.2)	114 (71.2)	15 (36.6)	108 (80.0)	87 (82.1)	21 (72.4)
Black or African American	17 (8.5)	12 (7.5)	5 (12.2)	12 (8.9)	9 (8.5)	3 (10.3)
Asian or Multiracial	9 (4.5)	6 (3.8)	3 (7.3)	7 (5.2)	5 (4.7)	2 (6.9)
Language, *n* (%)		***N* = 206**		***N* = 185**		
English	121 (58.7)	89 (54.3)	32 (76.2)	72 (38.9)	49 (33.8)	23 (57.5)
Spanish	75 (36.4)	69 (42.1)	6 (14.3)	100 (54.1)	85 (58.6)	15 (37.5)
Other	10 (4.9)	6 (3.7)	4 (9.5)	13 (7.0)	11 (7.6)	2 (5.0)
Birth Country, *n* (%)		***N* = 176**		***N* = 182**		
Foreign Born	119 (67.6)	103 (73.0)	16 (45.7)	12 (6.6)	12 (8.4)	0 (0)
Insurance, *n* (%)						
Public	163 (79.1)	132 (80.5)	31 (73.8)	172 (92.5)	136 (93.2)	36 (90.0)
Private	43 (20.9)	32 (19.5)	11 (26.2)	14 (7.5)	10 (6.8)	4 (10.0)
Education, *n* (%)		***N* = 199**				
Some high school or less	59 (29.6)	52 (32.9)	7 (17.1)	N/A	N/A	N/A
High school graduate	73 (36.7)	59 (37.3)	14 (34.1)	N/A	N/A	N/A
More than high school or other	67 (33.7)	47 (29.7)	20 (48.8)	N/A	N/A	N/A
Marital Status, *n* (%)		***N* = 204**				
Unmarried	123 (60.3)	100 (61.7)	23 (54.8)	N/A	N/A	N/A
Employment, *n* (%)		***N* = 198**				
Unemployed	122 (61.6)	99 (62.7)	23 (57.5)	N/A	N/A	N/A

RESULTS

Adoption

A multidisciplinary cohort of providers from 31 different MGH site specific departments, grouped into 12 overall department categories, referred patients to the HUGS/Abrazos program. Most referrals originated from Pediatrics/Adolescent Health (38.0%), Obstetrics (31.1%), Family Medicine (11.7%), and Behavioral Health/Psychiatry (6.6%) which correlates well with the HUGS/Abrazos intended patient population of pregnant women and families with children under 6 years old. Remaining referrals to HUGS/Abrazos originated from department categories that include but are not limited to emergency medicine, care coordination, social services, and more. Referring providers included physicians, midwives, psychologists, social workers, nurse practitioners, and others.

The MGH HealthCare Centers in Chelsea and Revere were the most common referral sites, making up 42.6 and 23.5%, respectively, of parent referrals and 62.4 and 22.0%, respectively, of child referrals. This correlates well with Chelsea

and Revere being the primary sites of HUGS/Abrazos' initial design and implementation. However, 33.9 and 15.6% for parent and child referrals, respectively, originated from MGH main hospital and other MGH affiliated community-based health centers, suggesting successful widespread multi-site adoption of HUGS/Abrazos in the MGH hospital system.

Reach

A total of 6,267 women and 8,055 children under 6 years old were seen for obstetric and pediatric care, respectively, at practices participating in HUGS/Abrazos since its implementation. A total of 551 referrals were made for HUGS/Abrazos, and of this, 392 referrals were made for unique families during the evaluation period (ex. one family may be referred for both food insecurity and baby supplies). The racial and ethnic demographics of referred patients were comparable to the racial and ethnic demographics of the communities in which we targeted our outreach efforts. For example, the racial and ethnic demographics of parents in the HUGS/Abrazos program included 64.2, 22.9, and 8.5% of Hispanic, non-Hispanic Whites, and non-Hispanic Blacks in comparison to 67.0, 20.6, and 5.4% of the same racial and ethnic groups, respectively, in Chelsea, MA (39). A greater percentage of parents referred to HUGS/Abrazos were foreign-born compared to the percentage of foreign-born residents in Chelsea, MA (67.6 vs. 45.4%) (39). Meanwhile, most children referred to HUGS/Abrazos were born in the United States (93.4%). A majority of referred patients, 41.3% for parent referrals and 61.1% of parents of referred children, spoke a language other than English as their primary language. We also obtained the demographic data for patients who were referred to HUGS/Abrazos but did not participate in any touchpoints for a full scope of our reach. Please see **Table 2** for detailed demographics data of the HUGS/Abrazos patient population.

Effectiveness

A total of 392 unique families were referred to HUGS/Abrazos (see **Figure 1**). Of these families, 310 or 79% of them completed at least one touchpoint with either a CHW or the behavioral health team. Although we did not collect data on reasons for non-participation, possible explanations may include newfound access to another resource, inability to participate due to time constraints and other stressors, access to technology for virtual visits, language and cultural barriers despite availability of interpreters, fear of social stigma, and anxiety around immigration status. Participating families maintained longitudinal relationships through multiple touchpoints with either the CHW, the behavioral health team, or both. Of the 220 families who completed CHW only services, 194 completed at least two touchpoints, and 83 completed three touchpoints. Of the 33 families who completed behavioral health only services, 28 completed at least two touchpoints, 20 completed at least three touchpoints, and 15 completed the maximum four touchpoints. A total of 57 families received both CHW and behavioral health services. Participation rates in either CHW or behavioral health team touchpoints for these families trended similarly to the data for CHW only and behavioral health only families. Families who engaged in patient navigation services with the CHW were referred to an average number of 4.4 community resources and had an average of 3.71 reasons for these referrals (**Supplementary Table 1**). The most common reasons for community resource referrals included but are not limited to infant supplies (60.2%), food security (52.3%), and support with housing and related legal issues (48.5%) (**Supplementary Table 1**).

Implementation and Maintenance

Table 3 summarizes the themes and subthemes related to the implementation and maintenance of HUGS/Abrazos, as well as exemplar quotes, that emerged from rapid qualitative analysis of focus group sessions with CHWs, the behavioral health team, and PCP champions. All focus group participants were females except for two male participants. Professional roles included: CHW, social worker, psychologist, and pediatricians. When assessing appropriateness, or the perceived fit of the program for its intended audience and setting (35), three key subthemes emerged: (1) HUGS/Abrazos successfully targeted its patient outreach toward peripartum women and families with unmet socioeconomic and behavioral health needs, (2) provided them with emergency relief of the most acute issues, and (3) did so in a manner that maximized equity and accessibility. When assessing acceptability, or the perception among stakeholders that the program is agreeable (35), HUGS/Abrazos was perceived as a successful multidisciplinary collaboration that simultaneously reduced the burden on an already overwhelmed behavioral health system and led to positive impacts on patients' lives. When assessing fidelity, or the degree to which the program was implemented as it was designed (35), most stakeholders found that the core components of HUGS/Abrazos – patient navigation, acute behavioral health support, and utilization of a centralized resource repository and integrated referral system – were implemented with high fidelity though flexibility was necessary during individual interactions to fulfill differing needs. In terms of program penetration (35), or the degree to which the program has integrated into the existing infrastructure, HUGS/Abrazos successfully closed the gap among previously siloed resources and care teams to forge new coalitions and relationships within the hospital system and with community partners. From the perspective of the HUGS/Abrazos PCP champions, behavioral health teams, and CHWs, implementation barriers and program limitations included technological challenges in setting of virtual visits, lack of interpreter services at partner organizations, and sensitivity of conversations around immigration status, all of which may directly influence the effectiveness of the program for participants. Finally, stakeholders believe there is value in maintaining HUGS/Abrazos beyond the pandemic as the need for social programs that can foster protective buffers against toxic stressors, such as acute socioeconomic and behavioral health needs, will remain.

DISCUSSION

Several key findings emerged when assessing HUGS/Abrazos program using the RE-AIM framework. First, patients

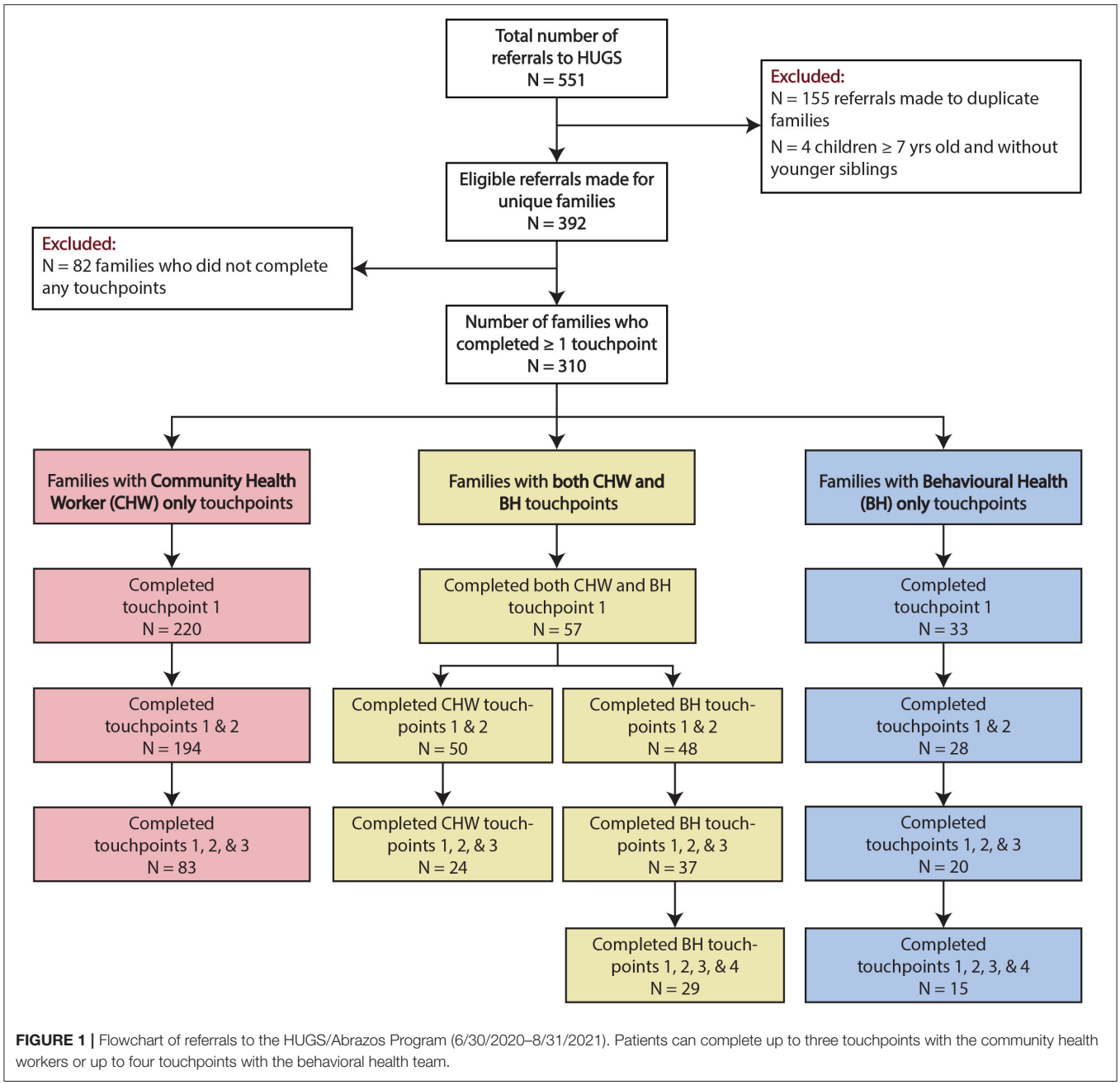

FIGURE 1 | Flowchart of referrals to the HUGS/Abrazos Program (6/30/2020–8/31/2021). Patients can complete up to three touchpoints with the community health workers or up to four touchpoints with the behavioral health team.

referred to HUGS/Abrazos were representative – racially, ethnically, and socioeconomically – of the communities that were disproportionately affected by the COVID-19 pandemic, demonstrating that we are effectively reaching families in need of support. Second, there were high participation rates by referred families throughout the program, illustrating that HUGS/Abrazos filled a crucial need for patient navigation of resources and acute behavioral health support. Third, the adoption and implementation of the key components in HUGS/Abrazos were appropriate and acceptable, and they remained faithful to its original design. Finally, there is overwhelming stakeholder support in maintaining HUGS/Abrazos beyond the COVID-19 pandemic, as it has proved to be an effective delivery model in mitigating acute exacerbations of toxic stress. Taken together, these results suggest that the implementation of HUGS/Abrazos was effective in providing emergency relief to help decrease the burden on the health system.

Short-term behavioral health interventions have been shown to be effective in mitigating mental health needs during the perinatal period and among adolescents (40–44). More

TABLE 3 | Emergent themes and exemplar quotes of the implementation of HUGS.

Themes and Subthemes	Exemplar Quotes
Appropriateness	
HUGS appropriately reaches pregnant women and families with young children who have unmet social and behavioral health needs	Most of the folks have been impacted by the pandemic. There's been a lot of different losses, [ranging] from loss in families, loss of jobs, loss of financial income…[HUGS] has been helpful and useful.
HUGS provides the appropriate short-term supports, including patient navigation to connect patients to community resources, and behavioral health to provide time-sensitive relief	I feel like short-term works. They might be referred back later on, but as a quick intervention…it is beneficial.
HUGS is an accessible and equitable program by offering phone and video visits, services in English and Spanish, and not billing health insurance, but these features are not without known drawbacks and barriers	
Acceptability	
The services provided and connections formed through HUGS have led to positive impacts on patients' lives	HUGS is able to tie this all in a bow, put everything together so that people can talk to each other and deliver the best care for the patients.
HUGS implements effective collaborations among providers (e.g., PCP, community health workers, social workers) and streamlines connections to care	
HUGS provides immediate access to behavioral health supports thereby reducing the time for patients to receive care and the burden on the system	
Fidelity and Adaptations	
The core components of HUGS have remained the same and only minor modifications have been made	Overall, everything has stayed the same: …the gift cards, the books, the community health worker involvement.
Flexibility within the program is important because patients have differing needs	
Penetration	
HUGS has brought together multiple hospital departments to develop new resources to better serve the patient population	Another strength of [HUGS] is that, in medicine … we work in siloes a lot. This forced a deliberate communication with each other …That's one of the strengths of this interdisciplinary collaboration that was very deliberate and eye opening.
HUGS has joined existing coalitions and has formed relationships with community organizations and should continue forging these relationships	
Referrals to HUGS are dependent on providers and their knowledge of the program, talking to families about the program, and other competing demands during the visit	
Sustainability	
HUGS was initially developed as a COVID-19 program to provide time-sensitive relief, but the program should be sustained as socioeconomic and health challenges will remain	I think it has potential to continue because a lot of families are benefitting from it.
Developing a plan to financially sustain HUGS is important to maintain the program	

recently, the availability of telepsychiatry in the ED setting de-escalated mental health crises and limited the burden on an overwhelmed system during the COVID-19 pandemic (45). HUGS/Abrazos utilized similar principles in an emergency relief program to effectively address behavioral health concerns escalated by the pandemic, which were previously not addressed due to limited resources in the mental healthcare system. In terms of our patient population, HUGS/Abrazos served an age group that encompassed the perinatal period to early childhood, which is a particularly sensitive period to external adversity (5), yet few behavioral health programs address. Additionally, HUGS/Abrazos relied on an integrated structure that combined behavioral health support, patient navigation services, and direct relief. Patient navigation has previously been proven to be an effective strategy in addressing the socioeconomic factors underlying complex health needs (46–48). We combined patient navigation strategies with with resource platforms, Aunt Bertha and IRIS, to enhance centralization of resources and closed loop communication among all involve parties.

Several factors contributed to successful reach, adoption, and implementation of the HUGS/Abrazos program. Little is known about factors that support program uptake. By using the RE-AIM framework, we can begin to elucidate these factors and thereby improve the sustainability and diffusion of this innovative program and provide a roadmap for other public health innovations (49, 50). Based on a scoping review that examined factors that influenced implementation, we identified several factors that supported the implementation of HUGS/Abrazos (49). Essential to this program was early stakeholder input from a multidisciplinary team including CHWs, the behavioral health team, and cross-departmental providers on the specific operational processes in HUGS/Abrazos allowing the program to be efficiently implemented across multiple MGH-affiliated sites. This led to the development of strong relationships within the HUGS/ Abrazos team, as well as partnering departments and organizations. We anticipate the stakeholder engagement and relationships will be critical in the maintenance of this program as has been demonstrated in the literature (51). During the inception

of HUGS/ Abrazos, the team had a clear understanding of who the target population was which allowed for focused development and implementation (52). Additionally, effective recruitment of CHWs who were already familiar with the community resources and our targeted patient population ensured readiness to deliver patient navigation services. HUGS/ Abrazos program also had adequate resources to provide the necessary services. The resources included financial, personnel, and dedicated time and were a result of external funding, prioritization from the hospital system reflective of the importance of this program, and the strong relationships developed.

The strengths and limitations of program design has been discussed in detail in a prior publication (27). For our evaluation process, the use of the RE-AIM framework is a key strength that allows us to broadly assess implementation and identify areas for adaptation without disrupting intervention delivery and plan for maintenance and dissemination. One limitation is the scope of data collection, limited to EHR, administrative data, and qualitative data from those delivering the program. We used a pragmatic approach to evaluation to reduce burden and therefore we do not have data from referring providers or from families who were served by the program. As a result, we are unable to make conclusions on direct effectiveness, such as improvement in mental health or alleviation of socioeconomic needs after program participation. Additionally, there remains a perception of HUGS/Abrazos as a pandemic-specific relief program. However, the socioeconomic and behavioral health needs that HUGS/Abrazos address will outlive the pandemic, thus ensuring the program's post-COVID applicability.

In conclusion, the HUGS/Abrazos program is an emergency relief program that provides patient navigation of resources and acute behavioral health services to support vulnerable patient populations while reducing burden on an overwhelmed health system. HUGS/Abrazos serves as a protective buffer for vulnerable pregnant women and families with young children against toxic stressors exacerbated by the COVID-19 pandemic while also fostering resilience. Our evaluation of this quality improvement program, guided by the RE-AIM Framework, demonstrates that HUGS/ Abrazos was successfully adopted, reached its intended population, was effective in sustaining high participation rates and providing needed services, was acceptable, and maintained high fidelity. Next steps should focus on objective assessments of program efficacy, such as usage of validated mental health assessment instruments. Integration of social and behavioral health supports, multidisciplinary collaboration, and use of innovative tools that streamlined workflow are the basic principles that empowered the rapid implementation and effectiveness of HUGS/Abrazos, making the program an exemplary delivery model for future similar programs.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants' legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

MLi, MSi, MPe, and ET contributed to the conceptualization and design of the implementation evaluation process. MLu performed the quantitative statistical analysis and assisted with the interpretation of the data. MLi, MSi, MPe, SP, VC, and S-YTC conducted the qualitative analysis and/or assisted with the interpretation of the data. MSe, AE, CT, GK, AB, MH, MPa, WL, and ET assisted with interpretation of all data and critically reviewed the manuscript for important intellectual content. MLi and MSi drafted the first version of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.862388/full#supplementary-material

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SYSTEMATIC REVIEW
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A Ranking of the Most Common Maternal COVID-19 Symptoms: A Systematic Review

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As the coronavirus disease 2019 (COVID-19) continues to devastate health systems worldwide, there is particular concern over the health and safety of one high-risk group, pregnant women, due to their altered immune systems. Since health workers regularly rely on symptoms to inform clinical treatment, it became critical to maintain a ranked list of COVID-19 symptoms specific to pregnant women. This systematic review investigated the prevalence of common COVID-19 symptoms in pregnant women and compared the ranked list of symptoms to articles of various sizes. Articles were included if they discussed pregnant women diagnosed with COVID-19 using polymerase chain reaction testing, and women present symptoms of COVID-19 and were published between December 1, 2019, and December 1, 2021; while articles were excluded if they did not report on pregnant women with COVID-19 displaying symptoms of COVID-19. Articles were identified on OVID MedLine and Embase in January of 2022. The risk of bias and quality appraisal was assessed using a nine-item modified Scottish Intercollegiate Guidelines Network checklist for case-control studies. The search results included 78 articles that described 41,513 pregnant women with 42 unique COVID-19 symptoms. When ranked, the most common symptoms were found to be cough (10,843 cases, 16.02%), fever (7,653 cases, 11.31%), myalgia (6,505 cases, 9.61%), headache (5,264 cases, 7.78%), and dyspnea (5,184 cases, 7.66%). When compared to other articles in the literature with sample sizes of $n = 23{,}434$, $n = 8{,}207$, and $n = 651$, the ranking largely aligned with those in other articles with large sample sizes and did not align with the results of articles with small sample sizes. The symptom ranking may be used to inform testing for COVID-19 in the clinic. Research is rapidly evolving with the ongoing nature of the pandemic, challenging the generalizability of the results.

Keywords: signs and symptoms, COVID-19 management, screening tools, diagnosis, self-diagnosis, self-check assessment, early diagnosis

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INTRODUCTION

In December 2019, China reported atypical pneumonia cases in Wuhan, Hubei Province, to the World Health Organization (WHO) (1). The viral pathogen responsible was named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) due to its resemblance to an earlier coronavirus (2). The fatal disease was termed coronavirus disease 2019 (COVID-19) and was later characterized as a pandemic due to its rapid worldwide spread (2). As health systems around the world struggled to contain the spread, many systems focused on protecting high-risk groups.

One such high-risk group is pregnant women due to their altered immune systems that make them particularly susceptible to SARS-CoV-2 infection, while clinical identification may be difficult because pregnant women may present different COVID-19 symptoms to their non-pregnant counterparts (3). Since clinicians have been routinely assessing patients for COVID-19 symptoms to inform biochemical testing, and symptoms may vary significantly in pregnant women, it was necessary to develop a list of common COVID-19 symptoms in pregnant women (3).

An early systematic review published in 2020 examined the effects of COVID-19 on maternal, perinatal, and neonatal outcomes of 324 pregnant women. The list of most common symptoms includes fever, cough, dyspnea/shortness of breath, fatigue, and myalgia (4). Another review article on 108 pregnancies with confirmed SARS-CoV-2 indicated that fever was the most common symptom upon admission, while cough was second (5).

Another review of 10,996 patients from 15 countries worldwide, reported that cough and fever were the most prevalent symptoms, with cough present in around half of the eligible cases (6). A more recent systematic review of 11,758 pregnant women found that every fatal case of COVID-19 presented with fever with or without cough. They reported that dyspnea and myalgia were the most common symptoms, presenting in about half of patients, while the sore throat and gastrointestinal symptoms were rare symptoms (7).

Another systematic review compared the symptoms of various severe coronaviruses, finding similar symptoms between coronaviruses. For SARS-CoV-2, symptoms in 17 patients observed that fever, cough, myalgia, and chills were the most common symptoms (8). In 2021, a review article of 30 systematic reviews explored the top 10 most common symptoms. This review of reviews indicated on mothers with COVID-19 indicates the most common symptom is cough, and fever is a close second (9).

This systematic review analyzed the most common COVID-19 symptoms in pregnant women. As well, this systematic review examined the literature that focuses on the COVID-19 symptoms experienced by pregnant women. Based on the literature search, implications for clinical practice were determined and discussed.

METHODS

A systematic review of COVID-19-derived symptoms in pregnant female populations was undertaken in adherence to the guidelines of the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) and the protocol was not registered (10). A systematic review of the literature consisted of four stages: (1) a database and manual search were performed to identify potential articles, (2) articles were reviewed according to the inclusion and exclusion criteria, (3) data was extracted from included eligible articles, and (4) the extracted data was analyzed.

Database Search

Search terms were developed to identify examine that included COVID-19 disease, pregnancy, and maternal COVID-19 symptoms. Search terms to identify articles relating to pregnancy included pregnancy, pregnant women, and pregnant women. The search that reflected COVID-19 included search terms: COVID-19, SARS-CoV-2, and coronavirus pregnancy. Finally, search terms to identify symptoms were most common symptoms, most frequent symptoms, most frequently reported symptoms, most common signs, most frequent signs, and most frequently reported signs. Taken together, the search terms were: ((Pregnancy) OR (pregnant woman) OR (pregnant women)) AND ((COVID-19) OR (SARS-CoV-2) OR (coronavirus pregnancy)) AND ((most common symptoms) OR (most frequent symptoms) OR (most frequently reported symptoms) OR (most common signs) OR (most frequent signs) OR (most frequently reported signs)).

Subsequently, the search terms were deployed in PubMed and Embase databases, collecting articles published between December 1, 2019, and December 1, 2021. Finally, a manual search was performed using the references section of relevant included articles.

Inclusion and Exclusion Criteria

The titles and abstracts were screened to identify eligible articles. The inclusion criteria were as follows: (1) full-text available completely in English; (2) original articles, case reports, select letters to the editor, select commentaries, select communications, or pre-print articles; (3) published between December 1, 2019, and December 1, 2021; (4) included pregnant women diagnosed with COVID-19 using RT-PCR; (5) included pregnant women in any gestational trimester; (6) included pregnant women of any maternal age; and (7) had a relevant topic to COVID-19 symptoms and pregnant women.

The exclusion criteria were as follows: (1) not written in English; (2) subjects were not pregnant women; (3) subjects who were diagnosed with COVID-19 using methods other than RT-PCR; (4) did not report maternal COVID-19 symptoms; (5) incompatible article type, including review articles, guidelines, select communications, select commentaries, and select letters to the editors; and (6) covered an unrelated topic.

Article Review

All identified articles were populated on Microsoft Excel and duplicates were manually removed. Subsequently, the article review phase consisted of three steps: (1) title and abstract screening according to the inclusion and exclusion criteria to assess eligibility, (2) full-text review according to the inclusion and exclusion criteria, (3) data extraction of relevant outcomes of interest according to from included articles. The article review was performed by MC and ME using Microsoft Excel (11).

Data Extraction

During the data extraction phase, the reviewers used Microsoft Excel to capture outcomes of interest as described in the original work and the **Supplementary Material** section (11). Outcomes of interest included maternal COVID-19 status as indicated by a positive RT-PCR test result of any associated maternal COVID-19 symptoms. No data was extracted from individual mothers who were asymptomatic or did not have symptoms for any of the articles.

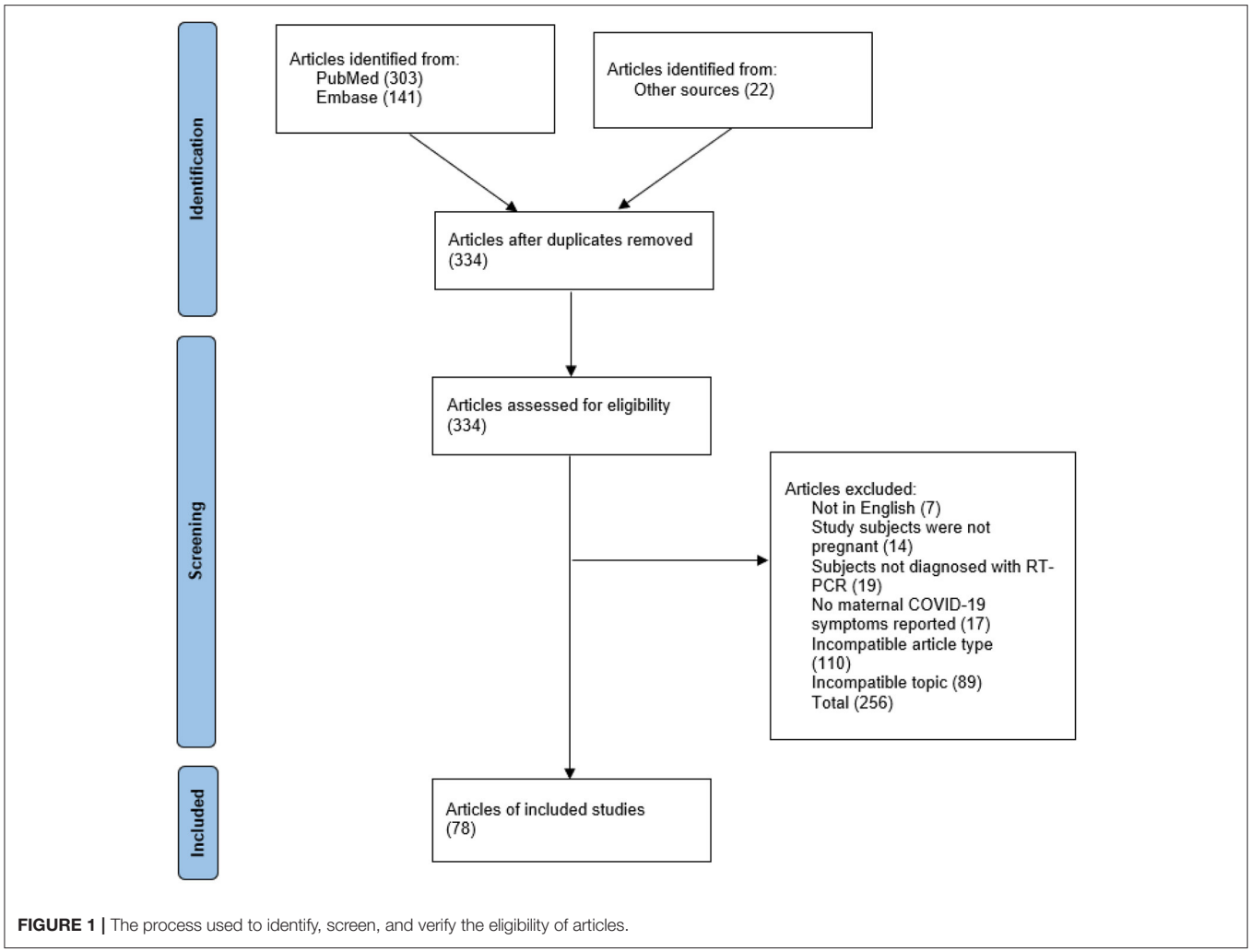

FIGURE 1 | The process used to identify, screen, and verify the eligibility of articles.

Multiple terms were classified under one unified term if the terms reflected the same clinical presentation; for example, "runny nose" and "rhinorrhea" were classified as "rhinorrhea," and "lack of taste" and "ageusia" were both classified as "ageusia." Additionally, multiple symptoms that were classified together in the original work were separated by the reviewers; for example, when an original work reported "lack of taste or smell," the reviewers reported this as both a "lack of taste" and a "lack of smell," and "nausea or vomiting" was reported as both "nausea" and "vomiting." Once data was extracted for each of the included original works, the reviewers calculated the sum of each unique symptom.

Data Analysis

Using Microsoft Excel, reported data on each symptom was aggregated, allowing the total number of symptoms and the confidence intervals to be calculated. Subsequently, the total number of symptoms was aggregated and ranked in order from most frequent to least frequent. For each symptom, the 95% confidence ranges were calculated using the number of women from each included article.

The resulting symptom ranking was presented compared with other relevant articles reporting a ranking of maternal COVID-19 symptoms; a comparison of the rankings was made with articles with sample sizes $n = 23{,}434$, $n = 8{,}207$, and $n = 651$ (12–14).

Risk of Bias Assessment

Two raters rated the included articles, using a modified Scottish Intercollegiate Guidelines Network (SIGN) Checklist for Case-Control studies (15). Based on the question under investigation, the checklist was modified to include nine items for evaluation: Sections 1.1, 1.8, 1.9, 1.10, 1.11, 2.1, 2.2, 2.3, and 2.4.

The rating was performed in three steps. First, raters would evaluate citations and any disagreements were resolved by discussion. Citations were assessed on a three-point scale of "yes," "no," and "can't say" for each of the nine items. Then, for Section Database search, articles that were rated as high quality "++," articles met the majority of criteria met, with little or no risk of bias, while articles rated as acceptable "+" had most criteria met with some flaws in the study design with an associated risk of bias. Articles rated as "0" were of low quality and failed to meet most criteria or had significant flaws relating to key aspects of

TABLE 1 | The top 20 most common COVID-19 symptoms in pregnant women.

Rank	Symptom	Number of cases (%)	95% Confidence range
1	Cough	10,843 (16.02%)	176.90–151.68
2	Fever	7,653 (11.31%)	117.10–98.47
3	Myalgia	6,505 (9.61%)	169.64–140.12
4	Headache	5,264 (7.78%)	233.95–187.17
5	Dyspnea	5,184 (7.66%)	99.50–79.26
6	Chills	3,853 (5.69%)	343.80–298.37
7	Sore throat	3,837 (5.67%)	140.18–107.37
8	Anosmia	3,513 (5.19%)	116.02–90.63
9	Ageusia	3,483 (5.15%)	138.36–110.43
10	Nausea	3,120 (4.61%)	226.25–189.75
11	Vomit	3,112 (4.60%)	200.39–165.73
12	Diarrhea	2,398 (3.54%)	72.96–53.25
13	Rhinorrhea	2,208 (3.26%)	128.60–103.82
14	Fatigue	2,181 (3.22%)	83.18–62.22
15	Abdominal pain	1,269 (1.88%)	110.88–84.35
16	Chest pain	849 (1.25%)	64.32–48.88
17	Nasal congestion	404 (0.60%)	39.02–28.32
18	Expectoration	237 (0.35%)	48.30–30.70
19	Respiratory discomfort	220 (0.33%)	N/A*
20	Respiratory distress	201 (0.30%)	46.58–33.82

N/A indicates no confidence range could be determined from the data.

TABLE 2 | Top 10 most frequent symptoms across articles of different sample sizes.

Symptom	Article 4 (n = 651)	Article 3 (n = 8,207)	Article 2 (n = 23,434)	This review (n = 42,710)
Cough	2	1	1	1
Fever	1	2	2	2
Myalgia	9	3	3	3
Headache	N/A	5	5	4
Dyspnea	3	6	6	5
Sore throat	8	7	7	6
Chills	N/A	4	4	7
Anosmia	7*	12*	12*	8
Ageusia	7*	12*	12*	9
Nausea	12**	9**	9**	10
Vomiting	12**	9**	9**	11
Diarrhea	11	8	8	12
Rhinorrhea	N/A	11	11	13
Fatigue	10	N/A	13	14
Abdominal pain	13	10	10	15
Chest pain	6	N/A	15	16
Nasal congestion	N/A	N/A	N/A	17
Expectoration	N/A	N/A	N/A	18
Respiratory discomfort	N/A	N/A	N/A	19
Respiratory distress	N/A	N/A	N/A	20

*Reported as anosmia or ageusia. **Reported as nausea or vomiting.*

the study design. Finally, studies were filtered according to their ability to minimize risk. Articles that were labeled as high quality or acceptable quality were retained, while those of unacceptable quality were rejected.

RESULTS

Article Review and Selection Process

The flow chart presented in **Figure 1** shows the stages of the article review and selection process. A total of 303 articles were retrieved from PubMed, and 141 were retrieved from Embase, resulting in a pool of 444 articles. Once duplicates were removed, 312 unique articles remained. Then, the 312 articles were filtered according to the exclusion criteria, and 256 articles were excluded. This left 56 articles that met the search criteria. Additionally, 22 articles were manually retrieved from PubMed and Embase. In total, 78 articles met the inclusion criteria.

Ranking of the Top 20 COVID-19 Symptoms

There were 42 unique COVID-19 symptoms identified from 67,665 total COVID-19 symptoms, which were observed in 41,513 RT-PCR-diagnosed pregnant women. The top five aggregated symptoms were found to be cough (10,843 cases, 16.02%), fever (7,653 cases, 11.31%), myalgia (6,505 cases, 9.61%), headache (5,264 cases, 7.78%), and dyspnea (5,184 cases, 7.66%) (**Table 1**).

Comparison of Ranked COVID-19 Symptoms in Pregnant Women

When the symptom ranking was compared to that in articles with different sample sizes, the results varied. In the three articles with large sample sizes, fever was ranked as the second most common symptom, while cough was ranked first in three of the four articles.

The articles included in this comparison were specifically selected to provide variation in sample size to emphasize the impact that sample size has on symptom ranking. The sample sizes were $n = 651$, $n = 8{,}207$, and $n = 23{,}434$ (12–14). As the sample size of the other articles approached that of this systematic review, the order of the COVID-19 symptoms approached the order found in this systematic review (**Table 2**).

DISCUSSION

Review of the Literature

According to a literature search, this is the only systematic review of this size that ranks the frequency of COVID-19 symptoms in pregnant women diagnosed with COVID-19. Furthermore, it encompasses a larger sample size than any other original or type of review article on the frequency of COVID-19 symptoms in pregnant women.

This systematic review builds on the work of a clinical article by updating a list of 42 unique COVID-19 symptoms derived from a larger sample size of 41,513 pregnant women with 67,665 COVID-19 symptoms reported over 24 months (16). The list

of COVID-19 symptoms reported in that clinical article by Ashraf et al. deviated from the ranking of COVID-19 symptoms presented in this systematic review. Here, the cough was the top symptom; however, in the clinical article by Ashraf et al., fever, shortness of breath, and fatigue were more common (16).

Amongst articles of various sample sizes, there is some disagreement, where many articles reported fever as the most common symptom. Some reported cough as the most common symptom, which agrees with the findings of this systematic review (17–23). As the sample size increases, the ranking of COVID-19 symptoms approaches the ranking presented in this paper. However, it should be noted that articles with large sample sizes contributed more to the ranking presented in this systematic review.

Indeed, as more articles report the symptoms of pregnant mothers, the sample size increase and it is anticipated that the ranking will change. This is especially true in the case of new variants, which may increase the prevalence of certain symptoms over others and alter the ranking. As it stands, the list of different symptoms is compressive; however future SARS-CoV-2 variants may cause symptoms not included in this list or alter the ranking of symptoms.

Clinical Assessment Based on Presentation of COVID-19 Symptoms

It has been well-documented in the literature that pregnant women are less likely to manifest typical symptoms of COVID-19 and more likely to be admitted to the intensive care unit compared to non-pregnant women; this indicates that there is a critical need for clinicians to effectively screen pregnant women for COVID-19 (24). Below, clinical considerations for the top five COVID-19 symptoms in pregnant women are described.

1. Cough

The literature agrees that cough is less common in pregnant women than in non-pregnant women (22–24). However, it is one of the most easily identified symptoms in COVID-19 patients since it is not only one of the most common COVID-19 symptoms but also presents early in the pathological timeline (23–26).

As cough may be qualified with various clinical descriptors (e.g., dry cough or non-productive cough), it is important to include all forms of cough, to allow clinicians to quickly screen for it. Therefore, this systematic review clusters various forms of cough as simply "cough" (27).

2. Fever

Although fever is one of the most common symptoms and is considered an early symptom of COVID-19 in pregnant women, there is agreement that fever is less common in pregnant women than in non-pregnant women (22, 23, 26, 28, 29). To complicate matters, unlike in non-pregnant women, fever can be identified both ante- and postpartum in mothers, but both forms are classified broadly as "fever" in this systematic review.

In the clinic, fever is typically identified when a patient presents with a temperature between 37.6 and 39.0 °C via the use of a temperature gun or thermometer (28). Although fever is a common COVID-19 symptom, it may be caused by a variety of factors other than viral infection. Therefore, clinicians should evaluate for fever and symptoms of respiratory infection during screening (4, 5, 30).

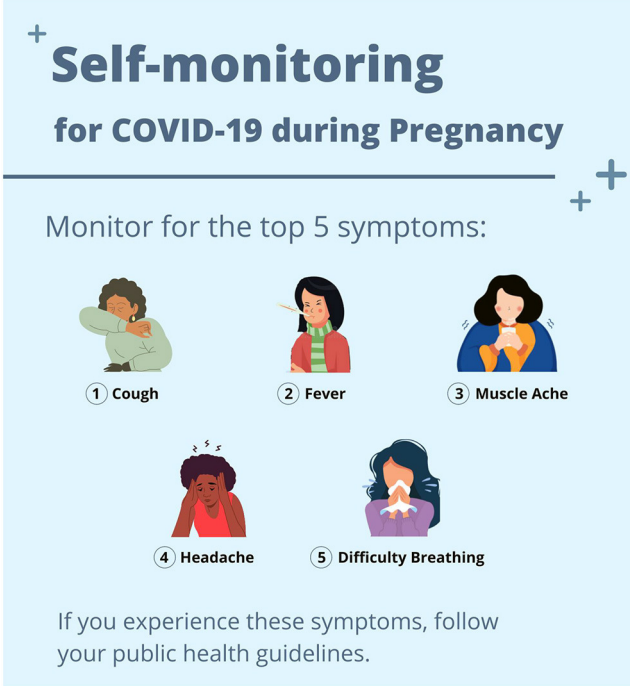

FIGURE 2 | An infographic educates pregnant women to monitor for the top 5 symptoms of COVID-19.

3. Myalgia

This systematic review categorized myalgia, muscle pain, and muscle soreness as "myalgia" due to their clinical similarities. "Chest pain," "abdominal pain," "back pain," and "joint pain" were classified separately due to reporting practices and clinical distinction. Analogous to the situation with other symptoms, pregnant women are less likely to manifest symptoms of myalgia than non-pregnant women (24).

In agreement with the literature, the findings of this systematic review show that myalgia is a common COVID-19 symptom frequently used as an indicator for screening, but that it is not one of the most common symptoms (31–33). Along with other symptoms, myalgia is associated with adverse pregnancy outcomes (e.g., high preterm birth rates and adverse pregnancy events), and therefore it is a significant clinical symptom that can be used as a risk assessment tool in pregnant women (33).

4. Headache

As with many other infections, headache is a common symptom identified in both pregnant and non-pregnant patients with confirmed SARS-CoV-2 infection (34, 35). In COVID-19 patients, headaches have been localized to specific lobes within

the brain or found to be diffused among many regions of the brain (36).

Another systematic review reported that headache was present with the disease but did not strongly associate with more severe disease (37). Compared to non-pregnant women, a higher proportion of pregnant women were found to experience headaches during the disease. Moreover, headache during pregnancy or postpartum was found to be worse in mothers with a chronic headache or an increase in severity (e.g., pain or pattern) compared to usual (38).

5. Dyspnea

Dyspnea (or shortness of breath) is a common symptom, although less common than fever and cough (4, 30, 39). It has been reported that the severity of dyspnea upon presentation at hospitals is correlated with more severe pathology and subsequent maternal death (40). In the clinic, dyspnea may be challenging to discern from gestational dyspnea owning to higher maternal demands for oxygen for metabolism, gestational anemia, and fetal respiration (30). Although shortness of breath does not appear in all mothers, the frequency at which it appears suggests that an initial screening should include shortness of breath (16, 30).

Additionally, an infographic that educates pregnant women to monitor for the top five symptoms of COVID-19 is presented below (**Figure 2**). This figure was adapted from the WHO's COVID-19: symptoms and severity infographics, specifically tailoring recommendations to pregnant women (41).

Limitations

One limitation of this systematic review is its ability to discern the etiology of certain symptoms as COVID-19 symptoms rather than derived from pregnancy. For example, both fatigue and muscle pain are typically observed in pregnant women and non-pregnant patients with COVID-19. Because these symptoms have been included in the systematic review, the sample numbers for these symptoms may be inflated. Therefore, clinicians must be wary of multiple possible etiologies for symptoms and must screen for multiple symptoms of COVID-19.

Additionally, the symptoms ranking included all SARS-CoV-2 variants across multiple time points from countries all around the world. Since the symptomology of COVID-19 varies according to the variant and within different populations, the result of this systematic review cannot be generalized. This data is crucial for understanding the clinical presentation of COVID-19 symptoms in pregnant women. Finally, the ongoing nature of the pandemic poses challenges to the generalizability of the results as research is rapidly evolving.

Future Work

As this systematic review consolidates data from all variants, future studies should aggregate symptom data according to variants, which would enable the comparison of clinical appearances of variants to help inform more effective treatments. Further resolution may be provided if symptomology was compared between various countries at one-time point to develop a profile of the symptoms in pregnant women.

In addition, future studies may build on this work by comparing COVID-19 symptoms in women at different stages of pregnancy and post-partum women, to provide more resolution to the pathophysiological course.

CONCLUSION

In summary, 42 unique COVID-19 symptoms were identified in 41,513 RT-PCR-diagnosed pregnant women. The top five COVID-19 symptoms in pregnant women were found to be cough, fever, muscle pain, headache, and shortness of breath. A list of ranked COVID-19 symptoms in pregnant women can be used as part of the clinical assessment when determining whether biochemical screening is required.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author.

AUTHOR CONTRIBUTIONS

MC, CM, and ME conceived the study. All authors approved the final manuscript.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fmed.2022.865134/full#supplementary-material

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Impact of the Early Stages of the COVID-19 Pandemic on Coverage of Reproductive, Maternal, and Newborn Health Interventions in Ethiopia: A Natural Experiment

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Background: The COVID-19 pandemic and response have the potential to disrupt access and use of reproductive, maternal, and newborn health (RMNH) services. Numerous initiatives aim to gauge the indirect impact of COVID-19 on RMNH.

Methods: We assessed the impact of COVID-19 on RMNH coverage in the early stages of the pandemic using panel survey data from PMA-Ethiopia. Enrolled pregnant women were surveyed 6-weeks post-birth. We compared the odds of service receipt, coverage of RMNCH service indicators, and health outcomes within the cohort of women who gave birth prior to the pandemic and the COVID-19 affected cohort. We calculated impacts nationally and by urbanicity.

Results: This dataset shows little disruption of RMNH services in Ethiopia in the initial months of the pandemic. There were no significant reductions in women seeking health services or the content of services they received for either preventative or curative interventions. In rural areas, a greater proportion of women in the COVID-19 affected cohort sought care for peripartum complications, ANC, PNC, and care for sick newborns. Significant reductions in coverage of BCG vaccination and chlorohexidine use in urban areas were observed in the COVID-19 affected cohort. An increased proportion of women in Addis Ababa reported postpartum family planning in the COVID-19 affected cohort. Despite the lack of evidence of reduced health services, the data suggest increased stillbirths in the COVID-19 affected cohort.

Discussion: The government of Ethiopia's response to control the COVID-19 pandemic and ensure continuity of essential health services appears to have successfully averted most negative impacts on maternal and neonatal care. This analysis cannot address the later effects of the pandemic and may not capture more acute or geographically isolated reductions in coverage. Continued efforts are needed to ensure that essential health services are maintained and even strengthened to prevent indirect loss of life.

Keywords: COVID-19, intervention coverage, maternal health, newborn health, Ethiopia

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BACKGROUND

The first case of COVID-19 in Ethiopia was reported on March 13, 2020 (1). Followed by early preventative measures such as mandatory quarantine for travelers, mask mandates, and communication efforts, the government of Ethiopia declared a national state of emergency on April 8, 2020 (2). The Ethiopian Federal Ministry of Health swiftly implemented a series of national COVID-19 response policies, including national guidelines to sustain essential health services during the pandemic (3). However, it is uncertain to what extent these guidelines were adopted by state and local authorities and succeeded in maintaining coverage of reproductive, maternal, and newborn health (RMNH) care. In addition, further pandemic-related supply and demand-side challenges may have impacted health services in Ethiopia.

On the supply side, many health facilities needed to re-allocate medical resources and personnel to emergency response, potentially reducing the availability and quality of non-COVID services (4–6). Staff shortages and nosocomial COVID-19 infection likely created burnout in the health workforce (7). Additionally, following the declaration of a national emergency, Ethiopia postponed nationwide routine vaccination campaigns and scheduled supplementary immunization activities (8). Other RMNH services delivered through campaigns were likely similarly disrupted.

Governmental restrictions on movement and limited access to transportation created barriers in accessing RMNH services on the demand side. There is evidence that these challenges disproportionately affected the most vulnerable groups who lived on daily wages (9). Although health facilities remained open during the pandemic, there is evidence of a decline in utilization of services in public hospitals due to fear of COVID-19 infection (4, 9, 10).

Supply and demand-side challenges potentially contribute to disruption in RMNH services, which put mothers' and children's health and well-being at risk. For example, a modeling exercise early in the pandemic estimated that even the most conservative prediction of RMNH service coverage reduction would lead to 253,500 additional child deaths and 12,200 additional maternal deaths over 6 months in low- and middle-income countries (11).

Recognizing the urgency of maintaining essential health services amid the pandemic, several global efforts have focused on monitoring service coverage to reduce disruptions. For example, the WHO "pulse" survey was implemented to gauge disruptions in health services across the globe. This survey found substantial disruptions in low- and middle-income countries, with routine immunization, family planning, and antenatal care services among the most frequently disrupted services (12). While providing a valuable overview of trends in service availability since COVID-19, this tool derives inputs from a limited number of key informants and is subject to self-report biases and may not capture the impact of the pandemic across the wider population. An alternative approach to monitoring changes in health service coverage during COVID-19 is to use routine data from health management information systems (HMIS) (13). In theory, HMIS provides "real-time" tracking of the coverage and quality of a range of health services. However, persistent challenges related to lags in reporting, poor/inconsistent data quality, and incomplete data due to the pandemic limit HMIS data's ability to provide reliable estimates (13–15). Lastly, the World Bank has supported several efforts to use phone-based surveys to assess the impacts of COVID-19 on households and individuals. Results from this high-frequency monitoring confirmed a reduction in care-seeking due to fear of COVID-19 exposure or stay-at-home orders. However, this tool also faces challenges related to non-response, under-coverage of vulnerable populations, and limited capacity to collect detailed responses (16).

This analysis aims to assess changes in RMNH intervention coverage before and during the COVID-19 pandemic using Performance Monitoring for Action Ethiopia longitudinal data. By comparing RMNH service utilization and birth outcomes between a COVID-19 unaffected cohort with those potentially impacted by COVID-19, this study provides insights into the effect of the COVID-19 on essential RMNH intervention coverage in Ethiopia using standard indicators and a population-representative sample.

METHODS

Data Source

Data for this study come from the Performance Monitoring for Action (PMA) Ethiopia survey, a survey project comprised of an annual nationally representative cross-sectional survey, a panel survey following women from pregnancy through 1 year postpartum, and an annual Service Delivery Point (SDP) survey. The data for this analysis come from the panel survey. PMA Ethiopia is conducted in collaboration between Addis Ababa University and Johns Hopkins Bloomberg School of Public Health.

PMA Ethiopia panel survey used multistage cluster sampling using probability proportional to size to select 217 enumeration areas (EAs) across six regions in Ethiopia, with region (Afar, Addis Ababa, Amhara, Oromia, Southern Nations Nationalities and Peoples, and Tigray) and residence (urban/rural) as strata. In Afar and Addis Ababa, only region was used for stratification. To identify women for the panel survey, a census was conducted among 36,614 households between October and November 2019. All women aged 15–49 were screened [32,792] and, if they reported being currently pregnant or having delivered within the past 6 weeks, were eligible for the panel study. In total, 2,889 women were identified as eligible and 2,855 enrolled to complete interviews at enrollment, 6 weeks, 6 months, and 1 year postpartum (**Figure 1**). Data used in this paper were reported at the 6-week interview, which had a follow-up rate of 93.3%.

PMA Ethiopia paused data collection in early April due to the COVID-19 pandemic. At that time, questionnaires were modified to include a range of questions about COVID-19 knowledge and risk and the role of COVID-19 in care-seeking behaviors for MNH. When data collection resumed in June with enhanced safety protocols, including social distancing, COVID-19 symptom screening, and mandatory mask requirements, all women with outstanding surveys were

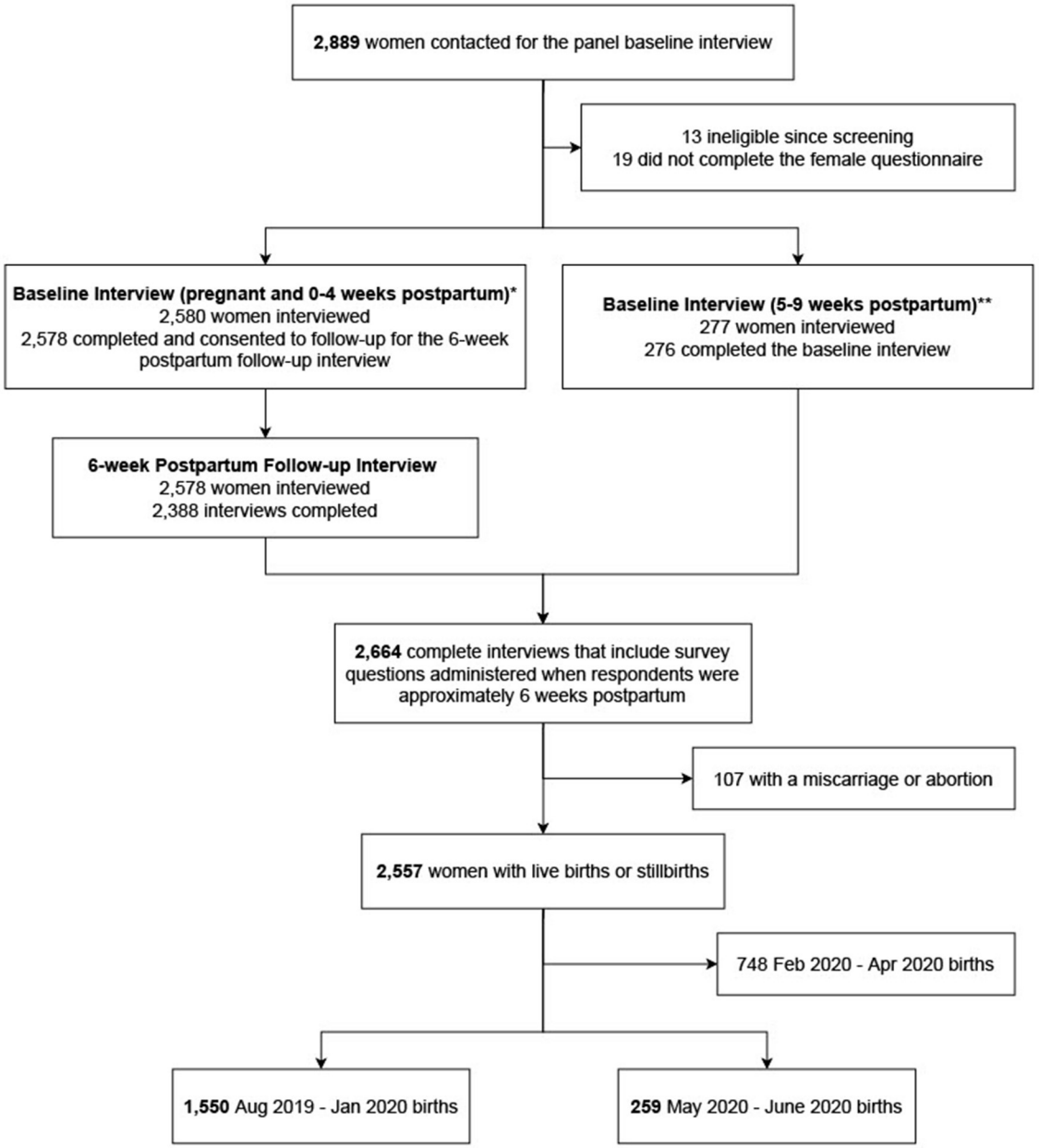

FIGURE 1 | Study cohort diagram. *Women who were pregnant or 0–4 weeks postpartum at the time of the first panel interview received survey questions related to maternal care services they received up to the time of interview. Estimated or actual delivery dates of women were used to schedule a second interview, which was conducted when respondents were about 6 weeks postpartum. Some 6-weeks postpartum interviews were conducted before the COVID-19 pandemic; others were conducted during the COVID pandemic. PMA survey interview questions slightly for interviews conducted during the COVID pandemic. **Women who were 5–9 weeks postpartum at the time of the first panel interview received a combined set of survey questions that other women received during two separate interviews. All of these interviews were conducted before the COVID-19 pandemic.

interviewed using the updated questionnaires. As a sub-cohort of women had delivered prior to the onset of the COVID-19 pandemic and a sub-cohort delivered during the COVID-19 pandemic, a "natural experiment" within the PMA Ethiopia cohort was introduced, providing a unique opportunity to apply a pre-post cross-sectional study design to examine the early impact of COVID-19 on the coverage of peripartum care indicators.

Ethical Approval

Women provided oral consent to participate at the initial household screening and prior to enrollment in the panel survey for all eligible women. All procedures were approved by both the Addis Ababa University [075/13/SPH] and Johns Hopkins Bloomberg School of Public Health [00009391] Institutional Review Boards. Additional information on the PMA Ethiopia survey can be found at Zimmerman (17).

Definition of COVID-19 Unaffected and Affected Cohorts

Restrictions to curb the spread of COVID-19 were introduced in Ethiopia between last March and early April, with some variation in date of introduction by regional states. In addition to structural disruptions, we assume this time also aligns with an increased public awareness of the potential threat of COVID-19. Translating this period of restriction into potential impact on health service access and use in the PMA cohort, we assume those women who gave birth in April or later could experience disruptions to late-ANC visits, care offered during childbirth, and services delivered in the first month after birth. If restrictions did impact service availability, we expect it would immediately affect labor and delivery care. Impact on ANC would be tempered due to repeat service visits throughout the pregnancy. For births that occurred in May 2020, disruption to antenatal service would translate to potential loss of the final pre-birth visit under a four-visit ANC schedule. Care delivered in the neonatal period could also have been impacted in births occurring as early as March 2020.

In defining the appropriate COVID-19 affected and unaffected groups, we also considered the comparability of recall periods. Due to a pause in six-week post-birth follow-up interviews in April and May, births between February and April received follow-up interviews up to 25 weeks after birth (**Supplementary Figure 1**). This delay in follow-up could result in lower recall accuracy across indicators and significant bias in indicators with reference periods tied to the timing of interview administration (e.g., current breastfeeding or family planning use) or time between birth and interview (e.g., care-seeking for illness in newborn since birth). For our primary analysis, we defined our COVID-19 affected cohort as those born in May 2020 (average recall period: 9.4 weeks) or later and our COVID-19 unaffected cohort as births between August 2019 (start of post-birth data collection) and January 2020 (average recall period: 6.8 weeks). Births that occurred between February and April 2020 were excluded.

We conducted a sensitivity analysis of indicators with a time-invariant reference period more loosely defining the unaffected cohort as August 2019 to February 2020 births (average recall period: 8.6 weeks) and the COVID-19 affected cohort as births in April 2020 or later (average recall period: 12.0 weeks). For indicators with unrestricted reference periods, therefore most susceptible to bias due to differences in recall period (i.e., vaccination, exclusive breastfeeding, care-seeking for infant illness, and postpartum family planning), we restricted the comparison of cohorts to only follow-up interviews that occurred more than five weeks and <10 weeks after birth (mean recall period COVID-19 unaffected cohort: 6.7 weeks; COVID-19 affected cohort: 7.9 weeks).

Indicators of Care Across the MNH Continuum of Care

We examined the effect of the COVID-19 pandemic and response on health interventions in the peripartum period. The PMA Ethiopia six-week postpartum questionnaire collected data on standard indicators of health practices and interventions during antenatal care, childbirth, and the neonatal period. Where an intervention could only be received through contact with the formal health system (e.g., blood transfusion) we report the indicator as the proportion of the population delivering at a facility that received the intervention. These indicators serve to assess changes in the content (and potentially quality) of service administered during the time period. Indicators of service contact (e.g., facility delivery) are calculated as a proportion of the total target population and demonstrate potential changes in both care-seeking behaviors and service access. Interventions or practices that can be accessed through multiple healthcare channels or do not require engagement with the healthcare system are similarly presented as coverage indicators among the total target population.

Data Analysis

To assess the effect of the COVID-19 pandemic and response on health practices, services, and outcomes, we compared these indicators in our COVID-19 affected cohort vs. our unaffected reference cohort. The primary analysis estimated the odds ratio of intervention receipt or practice (yes/no) for those in the COVID-19 affected cohort compared to the reference cohort using logistic regression adjusting for survey weights. We calculated the association at the national level, with and without adjusting for characteristics of the mother and birth. The adjusted regression assessed the cohort effect after accounting for variations in parity (first birth, 1-2 previous births, 3+ births), maternal education (none, attended primary, attended secondary or higher), maternal age, household wealth (relative quintile), urban vs. rural residence, and regional state.

We also looked at associations between cohorts residing in Addis Ababa, other urban areas, and rural areas separately, with and without adjusting for covariates. We posited restrictions and COVID burden might have a greater impact in population centers that are more dependent on public transport, more vulnerable to economic shocks, and more susceptible to COVID-19 transmission. We also calculated the unadjusted coverage of each intervention or practice in both the COVID-19 affected and unaffected cohorts.

We also compared the incidence of stillbirth and neonatal death in the two cohorts using Poisson regression. To account for potential left truncation of our data due to the absence of early stillbirths among women enrolled late in pregnancy, we restricted our stillbirth analysis to only those enrolled in either their first or second trimester of pregnancy.

RESULTS

We analyzed data on health interventions collected 6 weeks after birth for 1,809 women, including 1,550 women who gave birth between August 2019 and January 2020 (reference cohort) and 259 women who gave birth in May 2020 or later (COVID-19 affected cohort) (**Supplementary Figure 2**). In the reference cohort, the 1550 pregnancies resulted in 1,506 singleton live births, 17 singleton stillbirths, 26 sets of liveborn twins, and twins with one stillborn. Among the women in the COVID cohort, the 259 pregnancies resulted in 13 stillbirths, 243 singleton live births, and three sets of liveborn twins. The cohorts were similar

in maternal education and age, household wealth, and regional distribution (**Table 1**). However, the COVID cohort included a greater proportion of primiparous and rural women.

The adjusted and unadjusted odds ratios of intervention receipt or practice in the COVID-19 affected cohort vs. the unaffected cohort at the national level are presented in **Table 2**. **Table 3** presents the adjusted and unadjusted odds ratios stratified by urbanicity, including Addis Ababa, other urban areas, and rural areas. Unadjusted estimates of intervention coverage in the COVID-19 affected cohort vs. unaffected reference cohort are presented at the national level (**Supplementary Table 1**) and stratified by residence (**Supplementary Table 2**).

Antenatal Care

At a national level, the adjusted odds ratio (AOR 1.53; 95% CI: 1.05–2.23) suggests a higher proportion of women in the COVID affected cohort received four or more ANC visits. Nationally, 39.4% (95% CI: 34.6–44.3) of women in the reference cohort had at least four ANC visits compared to 46.7% (95% CI: 38.1–55.5) in the COVID-19 affected cohort. The odds of four or more visits were also significantly higher among COVID-affected women within the rural population (AOR 1.59; 95% CI 1.03–2.48) and in Addis Ababa (AOR 3.91; 95% CI 1.48–10.30).

Despite a greater proportion receiving the recommended four or more visits, there was little difference in the content of ANC services they reported receiving. Nationally, there was no difference in the content of care. In rural areas, a greater proportion of women in the COVID-19 affected cohort reported receiving a deworming medicine during the pregnancy (AOR 1.76; 95% CI 1.07–2.89), and in Addis Ababa, a greater proportion of women in the COVID-19 affected cohort who accessed ANC reported receiving a stool test (AOR 3.52; 95% CI 1.06–11.64).

Care-Seeking for Complications

A consistently greater proportion of women in the COVID-19 affected cohort reported seeking care for complications during pregnancy, delivery, and post-delivery. Both the adjusted and unadjusted models showed greater odds of care-seeking for pregnancy complications (AOR 2.20; 95% CI 1.41–3.43), complications during delivery (AOR 2.27; 95% CI 1.22–4.23), and post-delivery complications (AOR 3.89; 95% CI 1.95–7.77). The association was driven by increased care-seeking for complications in rural areas, where the adjusted and unadjusted odds of care-seeking for pregnancy complications (AOR 2.39; 95% CI 1.41–4.05), complications during delivery (AOR 2.26; 95% CI 1.18–4.33), and post-delivery complications (AOR 4.02; 95% CI 1.90–8.52) were also higher in the COVID-19 affected cohort. There was no significant difference in care-seeking for complications in the urban population.

Labor and Delivery and Immediate Newborn Care

There was no difference in the overall facility delivery rate at the national level or within any of the stratified populations. Nationally, 55.5% (95% CI 44.9–65.6) of pregnant women delivered at a health facility in May 2020 or later compared to 54% (95% CI 41.2–52.2) of women who delivered prior to February 2020. Among women delivering at a health facility, there was limited variation in care content between the two cohorts. Nationally, among women who gave birth at a facility, the odds of uterotonic receipt after delivery was higher in the COVID-19 affected cohort (AOR 2.67, 95% CI 1.13–6.31). This association was observed in Addis Ababa (AOR 3.16, 95% CI 1.01–9.85) and other urban areas (AOR 3.88, 95% CI 1.08–14.00), but not in rural areas. The odds of early breastfeeding initiation in Addis Ababa were also higher in the COVID-19 affected cohort (AOR 6.64; 95% CI 1.43–30.87) than in the unaffected cohort.

In urban areas, not including Addis Ababa, the odds of chlorhexidine application to a newborn's cord stump were significantly lower in the COVID-19 affected cohort among both facility births (AOR 0.01; 95% CI 0.02–0.62) and the total population (AOR 0.09; 0.02–0.51). Chlorohexidine use was low (<10%) in urban areas in the COVID-19 unaffected cohort, and the drop translates to 0.9% (95% CI 0.2–4.3%) coverage among births in the urban population in May 2020 or later.

Postnatal Care (Routine PNC, Immunization, Sick Newborn Care, and Breastfeeding)

At a national level, there was no difference by cohort in the proportion of women or newborns that received a postnatal check within 48 h of delivery, either before release from a facility birth or through a visit with a health center or a health extension worker (HEW) following a community birth. In rural areas, the odds of receiving a home PNC visit (or check at a health facility) within the first week after birth was higher in the COVID-19 affected cohort (AOR 2.04; 95% CI 1.13–3.68) vs. the reference cohort, doubling from 8% (95% CI 5.9–10.9%) to 15.8% (95% CI 9.1–25.9%) receiving a visit.

Nationally, a greater proportion of children in the COVID-19 affected cohort were reported to have received a BCG or polio vaccine by the time of the follow-up interview. This was driven by an increase in the odds of immunization in the COVID-19 cohort in rural areas. The odds of both BCG (AOR 2.8; 95% CI 1.65–4.77) and polio (AOR 2.25; 95% CI 1.46–3.46) vaccination were higher in the rural COVID-19 affected cohort. However, in Addis Ababa, the odds of BCG vaccination were lower in the COVID-19 affected cohort compared to the reference cohort (AOR 0.09; 95% CI 0.02–0.44). In Addis Ababa, BCG vaccination coverage by 6 weeks of age dropped from 94.6% (95% CI 90.2–82.8%) to 71.1% (95% CI 40.9–89.8%) in the COVID-19 affected cohort.

In rural areas, the odds of care-seeking for sick newborns or young infants doubled in the COVID-19 affected cohort compared to the reference cohort (AOR 2.03; 95% CI 1.08–3.81). This represents an increase from 23.8% (17.4–31.7%) seeking care in the COVID-unaffected cohort to 38.9% (26.8–52.7%) seeking care in the COVID-19 affected cohort. There was no significant difference in care-seeking in the urban population, including Addis Ababa.

TABLE 1 | Characteristics of cohorts.

	Births Aug 2019–Jan 2020			Births May 2020 +		
	n	Proportion (%)	95% CI	*n*	Proportion (%)	95% CI
Parity	1,550			259		
0		14.5	[12.6–16.7%]		28.7	[22.8–35.5%]
1–2		40.1	[37.0–43.2%]		29.9	[22.5–38.5%]
3+		45.4	[42.0–48.9%]		41.4	[33.7–49.6%]
Maternal education	1,550			259		
None		41.0	[36.9–45.3%]		37.0	[30.3–44.1%]
Primary		40.4	[37.0–44.0%]		45.6	[38.0–53.3%]
Secondary		18.5	[15.8–21.5%]		17.5	[11.3–26.0%]
Maternal Age	1,550			259		
Average		27.2	[26.7–27.7]		26.544	[25.7–27.3]
Wealth Quintile	1,546			259		
1		19.8	[15.5–25.0%]		20.2	[14.4–27.6%]
2		19.7	[17.0–22.8%]		22.6	[15.8–31.1%]
3		19.7	[16.8–22.9%]		18.6	[13.7–24.7%]
4		21.2	[17.0–26.1%]		21.9	[15.1–30.6%]
5		19.6	[16.8–22.7%]		16.7	[12.0–22.9%]
Urbanicity	1,546			259		
Urban		23.1	[20.5–26.0%]		17.2	[14.0–20.8%]
Region	1,546			259		
Tigray		7.1	[5.7–8.8%]		5.9	[4.6–7.6%]
Afar		1.6	[1.3–2.0%]		2.6	[1.7–4.0%]
Amhara		20.8	[18.4–23.5%]		14.7	[11.3–19.0%]
Oromia		44.0	[40.0–48.2%]		44.0	[37.1–51.2%]
SNNP		22.7	[19.5–26.3%]		29.0	[23.6–35.1%]
Addis Ababa		3.7	[3.0–4.6%]		3.7	[2.8–4.9%]

Postpartum Family Planning

At a national level, the odds of a woman reporting she was using some form of family planning after her most recent birth were significantly greater in the COVID-19 affected cohort compared to the reference cohort. This was driven by a nearly seven-fold increase in reported postpartum family planning use in Addis Ababa among women who gave birth in May 2020 or later compared to women who gave birth before February 2020 (AOR 6.94; 95% CI 1.80–26.79). At six weeks after birth, 25.2% (18.9–32.7%) of women who gave birth prior to February 2020 reported using some form of postpartum family planning. This increased to 65.2% (36.1–86.1%) of women who delivered in May 2020 or later.

Intervention Coverage Sensitivity Analysis

Supplementary Tables 3, **4** show the odds ratio of intervention receipt in the COVID-19 affected and unaffected cohorts, using a more liberal definition of cohorts. Rather than excluding those respondents whose 6-week follow-up interview was delayed, we included those interviews in this analysis treating births between August 2019 and February 2020 as our COVID-19 unaffected reference cohort and births in April 2020 or later as our COVID-19 affected cohort.

Expanding the cohort time periods did not notably alter the results for the reference period invariant indicators. The increased odds of uterotonic use in the COVID-19 affected cohort at a national level is non-significant in the sensitivity analysis, although it remains significantly associated in urban areas. The odds of chlorohexidine use are also not significantly lower in the COVID-19 affected cohort in urban areas in the sensitivity analysis.

Constraining the analysis of indicators with unrestricted reference periods to follow-up interviews that occurred between 5 and 10 weeks after birth, there is no longer a difference in vaccination coverage nationally. However, the adjusted odds of BCG vaccination in the COVID-19 affected cohort remained statistically greater in the rural population (AOR 2.06; 95% CI 1.07–3.95) and statistically lower in Addis Ababa (AOR: 0.05; 0.01–0.37) for the COVID-19 affected cohort. Contrary to our primary analysis, the sensitivity analysis found no difference in care-seeking for neonatal or young infant illness in any area and no national-level difference in postpartum family planning coverage. The sensitivity analysis also showed a reduced magnitude of the greater odds of postpartum family planning in the COVID-19 affected cohort in Addis Ababa (AOR 4.02; 95% CI 1.02–15.85).

Mortality Outcomes

Beyond intervention receipt, we examined differences in maternally reported stillbirths and neonatal deaths in the two

TABLE 2 | Odds of intervention receipt in COVID-19 impacted cohort vs. unaffected reference cohort at national level.

	Unadjusted			Adjusted		
	n	OR	95% CI	*n*	AOR	95% CI
Women with 4+ ANC visits	1,809	1.35	[0.96–1.90]	1,809	1.53	[1.05–2.23]
Among women with any ANC:						
BP check	1,361	1.06	[0.61–1.86]	1,361	1.09	[0.61–1.93]
Weighed	1,361	1.15	[0.71–1.89]	1,361	1.23	[0.72–2.10]
Urine test	1,361	1.16	[0.75–1.80]	1,361	1.28	[0.80–2.06]
Blood test	1,361	1.2	[0.81–1.78]	1,361	1.48	[0.93–2.36]
Stool test	1,361	1.17	[0.80–1.73]	1,361	1.27	[0.83–1.95]
Syphilis test	1,361	0.7	[0.43–1.14]	1,361	0.71	[0.43–1.17]
HIV test	1,361	0.99	[0.63–1.55]	1,361	1.2	[0.69–2.07]
TT shot	1,361	1.24	[0.80–1.91]	1,361	1.21	[0.77–1.90]
IFA	1,361	1.16	[0.69–1.96]	1,361	1.26	[0.73–2.18]
Deworming	1,361	1.4	[0.89–2.22]	1,356	1.53	[0.96–2.45]
Women that received IFA during pregnancy	1,809	1.3	[0.86–1.96]	1,809	1.49	[0.96–2.31]
Women that received deworming during pregnancy	1,809	1.4	[0.89–2.19]	1,800	1.56	[0.99–2.45]
Pregnant women that sought care for:						
Pregnancy complications	918	2.15	[1.39–3.32]	918	2.2	[1.41–3.43]
Delivery complications	692	1.99	[1.15–3.44]	692	2.27	[1.22–4.23]
Post-delivery complications	556	3.49	[1.89–6.45]	556	3.89	[1.95–7.77]
Women who delivered in a health facility	1,809	1.06	[0.73–1.54]	1,809	1.07	[0.66–1.75]
Among women delivering in a health facility:						
C-section	1,103	0.79	[0.40–1.56]	1,101	0.83	[0.43–1.59]
Blood transfusion	1,103	1.63	[0.33–8.07]	702	1.38	[0.33–5.74]
Uterotonic use	1,103	2.41	[1.09–5.34]	1,101	2.67	[1.13–6.31]
Mother checked after birth	1,103	1.19	[0.75–1.89]	1,103	1.2	[0.75–1.93]
Baby resuscitated with ambu bag[#]	43	16.69	[1.17–237.27]	33	–	–
Chlorohexidine applied to cord stump	1,083	0.73	[0.28–1.93]	1,083	0.82	[0.31–2.13
Baby weighed at birth	1,103	1.33	[0.76–2.34]	1,101	1.42	[0.79–2.55]
Baby checked after birth	1,106	1	[0.60–1.68]	1,106	1.01	[0.60–1.69]
Skin to skin	1,106	0.83	[0.46–1.51]	1,104	0.86	[0.47–1.56]
Delayed bathing	1,106	1.66	[0.89–3.09]	1,104	1.75	[0.91–3.38]
Early initiation of breastfeeding	1,106	0.89	[0.52–1.50]	1,104	0.97	[0.55–1.70]
Women who received a c-section	1,809	0.83	[0.43–1.57]	1,800	0.84	[0.43–1.66]
Women who received a uterotonic	1,809	1.43	[0.97–2.10]	1,809	1.63	[1.07–2.48]
Newborns who had chlorohexidine applied to stump	1,779	0.98	[0.42–2.28]	1,779	1.2	[0.50–2.88]
Newborns receiving skin to skin	1,808	0.99	[0.66–1.48]	1,808	1.04	[0.65–1.65]
Newborns with delayed bathing	1,808	1.07	[0.72–1.61]	1,808	1.14	[0.74–1.75]
Newborns with early initiation of breastfeeding	1,808	0.88	[0.63–1.24]	1,808	0.92	[0.65–1.30]
Women who received a postnatal check within 48 hrs	1,809	1.28	[0.91–1.81]	1,809	1.38	[0.94–2.02]
Newborns who received a postnatal within first 48 hrs	1,779	1.24	[0.83–1.85]	1,779	1.28	[0.83–1.98]
Home visit (or sought care) within first week	1,779	1.37	[0.84–2.24]	1,779	1.54	[0.94–2.53]
BF counseling during PNC	607	1.14	[0.63–2.07]	605	1.11	[0.61–2.02]
Newborns who received BCG vaccine*	1,808	1.67	[1.12–2.48]	1,808	2.22	[1.35–3.67]
Newborns who received polio vaccine*	1,808	1.8	[1.28–2.54]	1,808	2.19	[1.47–3.25]
Newborns exclusively breastfed*	1,761	0.94	[0.62–1.41]	1,761	1.05	[0.69–1.59]
Sought skilled care for NN illness	641	1.65	[1.00–2.72]	638	1.83	[1.07–3.11]
Women practicing family planning post-delivery*	1,809	1.74	[1.17–2.58]	1809	1.76	[1.12–2.76]
Women who intend to practice family planning in next year*	1,492	1	[0.72–1.38]	1,492	1.06	[0.73–1.53]

[#]*Among children in need of neonatal resuscitation based on maternal report of asphyxia at birth.*

**At time of follow-up interview.*

Green shading indicates interventions with significantly greater odds of receipt in the COVID-19 cohort compared to the unaffected reference cohort.

Orange shading indicates interventions with significantly lower odds of receipt in the COVID-19 cohort compared to the unaffected reference cohort.

TABLE 3 | Odds of intervention receipt in COVID-19 impacted cohort vs. unaffected reference cohort by urban (Addis and other urban areas) and rural areas.

	Rural						Urban						Addis					
	Unadjusted			Adjusted			Unadjusted			Adjusted			Unadjusted			Adjusted		
	n	OR	95% CI	*n*	OR	95% CI	*n*	OR	95% CI	*n*	OR	95% CI	*n*	OR	95% CI	*n*	OR	95% CI
Women with 4+ ANC visits	1,127	1.57	[1.03–2.37]	1,127	1.59	[1.03–2.48]	513	1.06	[0.50–2.22]	513	0.99	[0.46–2.11]	169	2.17	[0.83–5.69]	169	3.91	[1.48–10.30]
Among women with any ANC:																		
BP check	802	1.11	[0.62–2.02]	802	1.03	[0.57–1.89]	430	2	[0.22–18.36]	428	1.82	[0.46–7.22]	107	–		68	–	
Weighed	802	1.3	[0.76–2.21]	802	1.23	[0.70–2.17]	430	0.86	[0.16–4.75]	416	0.8	[0.15–4.39]	107	–		68	–	
Urine test	802	1.25	[0.75–2.08]	802	1.29	[0.75–2.22]	430	1.25	[0.42–3.70]	419	1.06	[0.40–2.81]	129	1.24	[0.22–6.99]	125	1.87	[0.26–13.30]
Blood test	802	1.36	[0.87–2.12]	802	1.49	[0.91–2.44]	430	1.08	[0.22–5.28]	428	0.84	[0.15–4.56]	107	–		9	–	
Stool test	802	1.34	[0.84–2.15]	802	1.34	[0.80–2.24]	430	0.8	[0.39–1.64]	428	0.83	[0.41–1.68]	129	2.37	[0.70–8.10]	125	3.52	[1.06–11.64]
Syphilis test	802	0.67	[0.36–1.26]	802	0.64	[0.34–1.21]	430	0.97	[0.35–2.70]	423	0.85	[0.29–2.48]	129	0.87	[0.25–3.04]	125	0.93	[0.26–3.36]
HIV test	802	1.04	[0.62–1.77]	802	1.09	[0.60–1.99]	430	4.44	[0.60–32.87]	428	4.31	[0.74–24.92]	107	–		28	–	
TT shot	802	1.29	[0.78–2.14]	802	1.25	[0.75–2.08]	430	1.18	[0.47–2.93]	427	0.91	[0.31–2.69]	129	0.96	[0.23–4.06]	127	0.66	[0.16–2.69]
IFA	802	1.14	[0.63–2.06]	802	1.16	[0.63–2.13]	430	2.06	[0.58–7.34]	406	1.89	[0.52–6.84]	129	1.45	[0.36–5.88]	108	1.36	[0.33–5.63]
Deworming	802	1.52	[0.91–2.54]	797	1.68	[1.00–2.80]	430	0.85	[0.25–2.89]	347	0.71	[0.22–2.28]	129	0.63	[0.06–6.73]	79	0.24	[0.02–3.66]
Women that received IFA during pregnancy	1,127	1.37	[0.86–2.20]	1,127	1.47	[0.90–2.39]	513	1.44	[0.65–3.20]	510	1.42	[0.61–3.34]	169	1.52	[0.35–6.58]	163	2.35	[0.66–8.32]
Women that received dewormer during pregnancy	1,127	1.57	[0.95–2.59]	1,118	1.76	[1.07–2.89]	513	0.74	[0.22–2.44]	494	0.68	[0.20–2.31]	169	0.73	[0.07–7.54]	102	0.38	[0.04–4.13]
Pregnant women that sought care for:																		
Pregnancy complications	598	2.25	[1.34–3.76]	598	2.39	[1.41–4.05]	250	1.37	[0.56–3.34]	247	1.07	[0.39–2.95]	57	–		50	–	
Delivery complications	440	2.26	[1.25–4.11]	440	2.26	[1.18–4.33]	184	1.89	[0.15–23.28]	183	–		68	0.53	[0.03–9.32]	51	0.63	[0.01–33.07]
Post-delivery complications	394	4.04	[2.03–8.07]	394	4.02	[1.90–8.52]	122	1.79	[0.26–12.15]	108	7.11	[0.81–62.26]	40	1.26	[0.13–12.33]	21	1.42	[0.09–22.70]
Women who delivered in a health facility	1,127	1.27	[0.82–1.96]	1,127	1.13	[0.69–1.87]	513	0.75	[0.20–2.86]	513	0.65	[0.22–1.87]	169	0.13	[0.01–3.02]	19	0.18	[0.01–4.99]
Among women delivering in a health facility:																		
C-section	467	0.5	[0.11–2.26]	465	0.49	[0.12–2.03]	469	1.58	[0.62–4.02]	460	1.5	[0.50–4.47]	167	1	[0.45–2.21]	158	1.15	[0.49–2.67]
Blood transfusion	467	2.88	[0.45–18.34]	126	2.29	[0.21–24.97]	426	–		309	–							
Uterotonic use	467	2.19	[0.78–6.14]	465	2.37	[0.72–7.76]	469	3.47	[1.02–11.76]	468	3.88	[1.08–14.00]	167	2.96	[0.90–9.69]	164	3.16	[1.01–9.85]
Mother checked after birth	467	1.29	[0.73–2.27]	467	1.24	[0.69–2.25]	469	1.2	[0.47–3.09]	463	1.08	[0.37–3.17]	167	0.78	[0.26–2.38]	164	0.7	[0.20–2.41]
Baby resuscitated with ambu bag[#]																		
Chlorohexidine applied to cord stump	453	0.89	[0.31–2.54]	453	1.08	[0.39–2.98]	463	0.1	[0.02–0.61]	369	0.1	[0.02–0.62]	167	6.25	[4.05–9.64]	167	–	
Baby weighed at birth	467	1.64	[0.82–3.30]	465	1.6	[0.78–3.28]	469	0.79	[0.32–1.94]	468	0.61	[0.23–1.65]	143	–		141	–	
Baby checked after birth	466	0.96	[0.49–1.89]	466	0.92	[0.45–1.88]	470	1.1	[0.43–2.76]	462	0.98	[0.33–2.87]	170	1.94	[0.76–4.97]	170	2.3	[0.75–7.01]
Skin to skin	466	0.97	[0.43–2.18]	464	0.94	[0.40–2.23]	470	0.57	[0.23–1.41]	469	0.58	[0.22–1.50]	170	0.82	[0.37–1.84]	167	0.87	[0.43–1.76]

(Continued)

TABLE 3 | Continued

	Rural						Urban						Addis					
	Unadjusted			Adjusted			Unadjusted			Adjusted			Unadjusted			Adjusted		
	n	OR	95% CI	*n*	OR	95% CI	*n*	OR	95% CI	*n*	OR	95% CI	*n*	OR	95% CI	*n*	OR	95% CI
Delayed bathing	466	1.57	[0.71–3.44]	464	1.59	[0.68–3.76]	470	2	[0.76–5.23]	466	2.1	[0.80–5.54]	170	–		170	–	
Early initiation of breastfeeding	466	0.8	[0.43–1.51]	464	0.82	[0.42–1.61]	470	0.87	[0.26–2.91]	452	1.01	[0.27–3.71]	170	4.54	[1.16–17.83]	170	6.53	[1.39–30.57]
Women who received a c-section	1,127	0.59	[0.14–2.52]	1,118	0.5	[0.12–2.18]	513	1.5	[0.61–3.70]	494	1.53	[0.53–4.44]	169	0.95	[0.43–2.11]	160	1.08	[0.47–2.45]
Women who received a uterotonic	1,127	1.54	[0.97–2.46]	1,127	1.53	[0.95–2.48]	513	2.09	[0.86–5.07]	513	2.49	[1.02–6.07]	169	2.4	[0.79–7.32]	166	2.44	[0.77–7.67]
Newborns who had chlorohexidine applied to cord stump	1104	1.38	[0.55–3.45]	1104	1.61	[0.61–4.26]	506	0.08	[0.01–0.52]	397	0.09	[0.02–0.51]	169	6.01	[4.03–8.97]	169	–	
Newborns receiving skin to skin	1,123	1.17	[0.72–1.91]	1,123	1.11	[0.65–1.89]	513	0.71	[0.31–1.62]	513	0.62	[0.25–1.56]	172	0.89	[0.40–1.97]	169	0.96	[0.48–1.91]
Newborns with delayed bathing	1,123	1.05	[0.66–1.67]	1,123	1.04	[0.64–1.69]	513	1.76	[0.78–3.94]	513	1.87	[0.87–4.03]	147	–		99	–	
Newborns with early initiation of breastfeeding	1,123	0.84	[0.58–1.21]	1,123	0.84	[0.57–1.23]	513	1.05	[0.32–3.41]	502	1.1	[0.30–3.99]	172	4.72	[1.19–18.64]	172	6.64	[1.43–30.87]
Women who received a postnatal check within 48 hrs	1,127	1.6	[1.06–2.41]	1,127	1.52	[0.99–2.33]	513	0.88	[0.37–2.10]	513	0.84	[0.33–2.15]	169	0.9	[0.25–3.23]	166	0.88	[0.20–3.84]
Newborns who received a postnatal check within 48 hrs	1,104	1.51	[0.92–2.48]	1,104	1.38	[0.82–2.31]	506	0.85	[0.35–2.06]	506	0.78	[0.28–2.13]	169	1.61	[0.64–4.02]	169	1.84	[0.63–5.41]
Home visit (or sought care) within first week	1,104	2.14	[1.17–3.92]	1,104	2.04	[1.13–3.68]	506	0.65	[0.25–1.69]	506	0.66	[0.25–1.71]	169	0.77	[0.26–2.28]	163	0.89	[0.30–2.61]
BF counseling during PNC	269	1.29	[0.64–2.62]	267	1.16	[0.56–2.41]	236	1.34	[0.30–5.98]	232	1.56	[0.28–8.77]	102	0.51	[0.10–2.48]	100	0.67	[0.13–3.43]
Newborns who received BCG vaccine*	1,123	2.62	[1.55–4.43]	1,123	2.8	[1.65–4.77]	513	1.05	[0.45–2.44]	513	1.02	[0.40–2.59]	172	0.14	[0.03–0.59]	153	0.09	[0.02–0.44]
Newborns who received polio vaccine*	1,123	2.18	[1.43–3.32]	1,123	2.25	[1.46–3.46]	513	1.88	[0.73–4.87]	510	1.94	[0.84–4.51]	172	1.71	[0.17–17.53]	136	3.24	[0.59–17.93]
Newborns exclusively breastfed*	1,091	0.86	[0.54–1.38]	1,091	0.95	[0.59–1.51]	500	1.54	[0.49–4.86]	497	1.89	[0.56–6.38]	170	1.37	[0.45–4.18]	167	1.53	[0.45–5.18]
Sought skilled care for NN illness	420	2.04	[1.12–3.71]	417	2.03	[1.08–3.81]	160	0.75	[0.22–2.53]	157	0.73	[0.19–2.75]	61	1.53	[0.41–5.63]	55	3.12	[0.43–22.53]
Women practicing family planning post-delivery*	1,127	1.69	[0.98–2.94]	1000	1.47	[0.80–2.68]	513	1.92	[0.85–4.33]	510	1.81	[0.73–4.51]	169	5.56	[1.38–22.49]	169	6.94	[1.80–26.79]
Women who intend to practice family planning in next year at time of follow-up interview	979	1.17	[0.83–1.66]	979	1.14	[0.77–1.69]	399	0.47	[0.15–1.47]	396	0.45	[0.13–1.52]	114	0.66	[0.11–3.94]	44	0.6	[0.15–2.31]

*Green shading indicates interventions with significantly greater odds of receipt in the COVID-19 cohort compared to the unaffected reference cohort. Orange shading indicates interventions with significantly lower odds of receipt in the COVID-19 cohort compared to the unaffected reference cohort. #Among children in need of neonatal resuscitation based on maternal report of asphyxia at birth. *At time of follow-up interview.*

TABLE 4 | Differences in stillbirth and neonatal death rates in COVID-19 impacted cohort vs. unaffected reference cohort by strata.

	Unadjusted			Adjusted			Births Aug 2019–Jan 2020			Births May 2020 +		
	n	RR	95% CI	*n*	ARR	95% CI	*n*	Rate	95% CI	*n*	Rate	95% CI
Stillbirths												
National	785	2.24	[0.93–5.39]	785	2.71	[0.92–7.94]	523	0.021	[0.011, 0.042]	262	0.048	[0.026,0.086]
Rural	536	2.03	[0.79–5.18]	536	2.19	[0.72–6.70]	348	0.024	[0.012, 0.050]	188	0.049	[0.025,0.094]
Urban	186	5.19	[0.30–88.65]	186	–		137	0.009	[0.001, 0.086]	49	0.049	[0.011,0.197]
Addis Ababa	63	–		63	–		147	0	–	25	0	–
Neonatal deaths												
National	1,808	0.99	[0.38–2.56]	1,808	0.83	[0.34–2.05]	1,559	0.023	[0.015, 0.035]	249	0.023	[0.009,0.056]
Rural	1,123	0.78	[0.24–2.55]	1,123	0.69	[0.23–2.05]	946	0.025	[0.015, 0.040]	177	0.019	[0.006,0.061]
Urban	513	2.84	[0.44–18.31]	513	–		466	0.018	[0.008, 0.042]	47	0.052	[0.011,0.214]
Addis Ababa	172	–		172	–		147	0.014	[0.003, 0.054]	25	0	–

cohorts (**Table 4**). There was no significant difference in neonatal mortality by cohort. However, nationally, stillbirths were more common in the COVID-19 affected cohort (4.8%; 95% CI 2.6–8.6%) compared to the reference cohort (2.1%, 95% CI 1.1–4.2%). The odds of stillbirth were borderline higher in the COVID-19 affected cohort in the primary analysis, but the sensitivity analysis found the odds of stillbirth were 2.58 times higher (95% CI 1.04–6.43) among births in April 2020 or later compared to births prior to March 2020 (**Supplementary Table 3**).

DISCUSSION

The availability of data on care from a representative sample of women who gave birth just before the COVID-19 pandemic and early in the pandemic offers unique insight into the impact of the early stages of the pandemic on peripartum care in Ethiopia. Unlike other data sources for monitoring the impact of the COVID-19 pandemic and response on maternal and newborn health, this study provides standard indicators of RMNH coverage from a representative sample of women who recently gave birth. If the pandemic, or pandemic response, disrupted access or use of health services, we expect it would be detectable in intervention coverage measures.

This dataset shows little evidence of COVID-19 disrupting RMNH services in Ethiopia in the initial few months of the pandemic. There were no significant reductions in the proportion of women seeking health services or the content of services they received for either preventative or curative interventions. In rural areas, the data suggest a greater proportion of women in the COVID-19 affected cohort sought care for pregnancy, delivery, and postpartum complications, as well as ANC, PNC, and care for sick newborns. Similar increases were not detectable in urban areas. The only significant reductions in coverage observed in the COVID-19 affected cohort were commodity-dependent interventions, specifically BCG vaccination in Addis Ababa and chlorohexidine use in other urban areas. The clearest evidence of a potential change in health behavior tied to the pandemic was the increased proportion of women in Addis Ababa who reported postpartum family planning in the COVID-19 affected cohort.

Despite the lack of evidence of a reduction in health services, the data suggest increased stillbirths in the COVID-19 affected cohort. In the primary analysis, the small sample size could not detect a significant difference in the odds of stillbirth in the two cohorts; however, the association was significant with the increased sample in the sensitivity analysis. Multiple studies have shown increased stillbirth rates, particularly in LMICs, during the pandemic (18, 19). In the absence of reductions in ANC and childbirth coverage, the origins of this increase in stillbirths are unclear. However, reductions in the quality and comprehensiveness of antenatal and delivery services may have occurred that are not captured through this analysis.

The national and regional governments of Ethiopia acted in a quick and coordinated manner to respond to COVID-19. Preparations for the COVID-19 response began in January 2020 (20). With the first case detected in Ethiopia in March 2020, compulsory quarantine, communications programs, school closures, public gathering bans, and city/region-specific restaurant and bar closures were initiated. In addition to restrictions to limit the spread of COVID-19, the government issued guidance to support the continued provision of essential health services (21) and began recruiting additional health workers and recalling retired health workers to absorb the anticipated strain on the health system (22). Supplemented by actions to limit impacts on transportation and the economy (20), these efforts addressed potential barriers to care and averted reductions in RMNH service coverage in the early stages of the pandemic.

Our analysis showed no difference in overall facility delivery rates; however, a previous analysis of this dataset demonstrated a reduction in hospital births in urban areas, with deliveries shifting to lower-level health facilities (23). This shift away from higher-level facilities, particularly those hospitals selected to handle COVID-19 patients, may have occurred with other interventions as well. Our analysis examining overall changes in coverage does not capture the shift in location of service receipt if it did not alter overall service coverage. This study

is a natural experiment that capitalizes on the chance start of the COVID-19 pandemic during ongoing PMA Ethiopia data collection. As such, the study was not powered to capture differences between the COVID-19 affected and unaffected cohorts. Although sampled women gave birth either before or during the COVID-19 pandemic at random, the two cohorts had slightly different characteristics. Our estimates of the effect of COVID-19 on coverage accounted for differences in known covariates; however, there is potential for residual confounding. Our analysis used standard indicators on care-seeking and content of care. These indicators are based on maternal report of care and may be subject to recall errors or social desirability biases (24). However, data in both cohorts were collected using the same questions, and we anticipate reporting errors to be consistent between the two cohorts. While the pandemic may have also impacted the quality of services, we do not have robust data on the quality of care received. Given the timing of the pandemic relative to the survey, our analysis only captures a snapshot of the impact of COVID-19 during late pregnancy, childbirth, and early infancy. As ANC services should be accessed throughout the pregnancy, the impact of COVID-19 on cumulative ANC interventions would likely be attenuated by the undisrupted services in earlier trimesters. Finally, our primary factor for defining our two cohorts is time. Seasonality, other health programs, or secular changes in services may also have impacted access to care for women who delivered prior to February 2020. However, all the births occurred within a ten-month window, minimizing the potential impact of non-COVID-19 related changes in the health system.

The government of Ethiopia's prompt and well-constructed response to control the COVID-19 pandemic and ensure continuity of essential health services appears to have successfully averted negative impacts on maternal and neonatal care to a large extent. While this analysis cannot address the later effects of the pandemic, the evidence suggesting little disruption to RMNH services in the initial stages of the pandemic is promising. As progress continues to be made in the control of the pandemic, continued efforts are needed to ensure that essential health services are maintained and even strengthened to prevent indirect loss of life. Lessons learned from Ethiopia's largely successful response will be important in preparing for future crises and planning for effective emergency response.

DATA AVAILABILITY STATEMENT

The datasets presented in this study can be found in online repositories. The names of the repository/repositories and accession number(s) can be found below: https://www.pmadata.org/data/request-access-datasets.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the Addis Ababa University, College of Health Sciences [075/13/SPH] and Johns Hopkins Bloomberg School of Public Health [00009391] Institutional Review Boards. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

ICMJE criteria for authorship read and met and agree with manuscript and conclusions: EC, JQ, TR, AS, SS, and LZ. Conducted analysis: EC and JQ. Drafted paper: EC, JQ, and LZ. All authors read, edited, and approved the manuscript.

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SUPPLEMENTARY MATERIAL

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Impact of the COVID-19 Pandemic on Patient- and Family-Centered Care and on the Mental Health of Health Care Workers, Patients, and Families

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During the COVID-19 pandemic, hospitals around the world were forced to reorganize their processes in an attempt to contain the spread of the virus while still providing adequate care to patients. In the Pediatric Intensive Care Unit (PICU) setting, changes in family visitation protocols and restrictions on parent chaperones during hospitalization, as well as other changes, interfered with care. Based on a narrative review of the literature, supported by the authors' observations in practice, we aimed to describe the impact of the pandemic on patient and family-centered care (PFCC) in the PICU environment, especially regarding the presence of family members, family support, and communication with patients and their families, as well as the effects of changes in these practices on the mental health of those involved. In this context, several strategies were used to sustain PFCC, and, despite many challenges, attempts were made to achieve the bare-minimum goals of humanized care for patients, families, and providers alike.

Keywords: intensive care units, pediatrics, children, health care, humanization of care, family-centered care

INTRODUCTION

The novel coronavirus (SARS-CoV-2) spread rapidly worldwide, resulting in a pandemic being declared in March 2020 (1). Children represent only 1 to 5% of all cases of coronavirus disease 2019 (COVID-19) overall (2, 3) and generally experience a milder clinical condition compared to adults, with few reported deaths (4). One study found that, among pediatric cases, 14.2% of diagnosed patients were asymptomatic, 36.3% had mild symptoms, 46% moderate, 2.1% severe, and 1.2% were critically ill, with only one death reported (5). Infants and young children experience more severe disease than older children do (6). Of the patients who required intensive care, some developed severe acute symptoms, especially those with comorbidities; however, most had good outcomes with the treatment provided (7, 8).

As the disease spread worldwide and aiming to ensure the continuity of adequate care, the need arose to restructure and reorganize patient management protocols. As health care workers, families, and patients were forced to practice physical distancing, the relationship between them and the

practices involved in patient- and family-centered care (PFCC) were affected directly and indirectly (9). Based on a narrative review of the literature, and supported by our observations in clinical practice, we aimed to describe the impact of the pandemic on PFCC in the PICU environment, especially regarding the presence of family members, family support, and communication with patients and their families, as well as their effects on the mental health of those involved.

PFCC: An Overview

PICU care has evolved substantially in recent years, both in terms of technology and humanization of care. Visits and the presence of parents at the bedside during a child's hospital stay were long forbidden. After World War II, with the mass separation of children from their parents, several studies emerged on the psychological effects of this separation during childhood, including hospital admissions (10). However, until the mid-20th century, children were still separated from their parents during hospitalization. At this time, a growing movement sought to raise awareness of the importance of meeting the psychosocial and developmental needs of children, as well as of the importance of the family in promoting child health and well-being. As research was published demonstrating the effects of separation of children from their families, many facilities began to adopted policies that encouraged parents to remain at their children's side during hospitalization and medical procedures (11).

The perspectives and information provided by the child's family play an important role in clinical decision-making, considering that the family is the main source of strength for the child (12). In addition, some pediatric patients are not able to verbalize their symptoms and desires, either due to their stage of development or their clinical condition, leaving parents in charge of communicating on behalf of the child and thus making collaboration between parents and health care workers particularly important (11).

In an attempt to change the way providers care for and interact with children and families, PFCC—a health care practice based on respect for individual needs and values (13), which encompasses comprehensive care and guides patient and family autonomy in care and decision-making (12)—was introduced in pediatrics. PFCC is an approach to planning, implementing, and evaluating health care based on collaboration between providers, patients, and the family, for the benefit of all; its core tenets are dignity and respect, information sharing, participation, and collaboration (14). These approaches lead to better health outcomes and wiser resource allocation, as well as greater stakeholder satisfaction (12). In **Table 1**, we cite some of the studies that address patient- and family-centered care.

PFCC guidelines include having the family present in the PICU, providing family support, and communicating with family members (13). The pandemic and the attendant increase in COVID-19 cases have led to economic, social, and political impacts in several countries, as well as implications for the availability of hospital beds, equipment, and other health resources (22). In order to contain the spread of the pandemic, several restrictive and restructuring measures were implemented, including in hospitals, with impacts on PFCC and on the mental health of those involved.

Family Presence in the PICU

The U.S. Centers for Disease Control and Prevention (CDC) advises that visits to health facilities be limited during the pandemic. Visits to patients who are in COVID-19 isolation should be restricted to those who provide essential care, such as parents, with only one person allowed at a time. The presence of family members during aerosol-generating procedures or respiratory specimen collections is contraindicated (23). In most PICU settings, all visits were banned, only one parent or legal guardian was allowed to remain with the child and, even so, for shorter periods of time (24). At some hospitals, older children and adolescents were not allowed a chaperone when they were sedated. In addition to these restrictions, other issues can prevent parents from being with their children, such as COVID-19 infection itself, which requires isolation of the infected parent and reorganization of the family unit so that another responsible adult can chaperone the child.

Maintaining social distancing from one's family during hospitalization can lead to greater parental vulnerability, threaten parental autonomy, and risk returning to a disease-centered approach, neglecting patient- and family-centered care (25). Studies carried out before the pandemic showed that more than half of all parents of children admitted to a PICU experienced symptoms of anxiety or depression during their child's hospitalization, which remained for approximately 3 months after discharge (26). Of these, 10.5 to 21% were diagnosed with post-traumatic stress disorder (PTSD) and 84% continued to experience symptoms of this disorder after their child's discharge from the PICU, with mothers being most affected. Among children, 5 to 28% had a diagnosis of PTSD after PICU admission, and 35 to 62% had symptoms of PTSD (27).

Another study showed that parents of children hospitalized during the pandemic had significantly higher rates of anxiety and depression symptoms than parents of children hospitalized before the pandemic period (28). Children who have lost a parent to COVID-19 are more susceptible to mental health problems due to fear of circumstances and grief over the loss of the parent (29).

For children in palliative care and their families, visits are particularly important. Restricting visits in these cases increases anxiety, suffering, and moral damages, and negatively impacts patient quality of life (30, 31). In addition, the suffering of family members of children who die in the PICU can be made worse by being away from their support network (31).

The presence of family members during PICU hospitalization is essential to minimize the emergence of psychological symptoms in children and parents alike, both during hospitalization and after discharge. Given the current situation, new ways of providing PFCC are needed. Virtual meetings have been the strategy used in some facilities to bring parents closer to

TABLE 1 | Articles on PFCC in PICU.

Title	Authors	Year	Local	Design	Main findings
Exploring the experiences of parent caregivers of children with chronic medical complexity during pediatric intensive care unit hospitalization: an interpretive descriptive study (15)	Janet E Rennick et al. (3)	2019	Canadá	Interpretive descriptive study	Need for a different approach to PICU care for chronic medical complexity, with an emphasis on establishing parent-staff partnerships to optimize patient care; Parents were vigilant about their child's comfort, noting the importance of reminding staff of the child's unique sensitivities and needs; While they felt they played an important role, parents did not always feel welcome; Parents struggled when physicians made decisions without consulting them, when information they provided about their child's preferences and needs was not acknowledged, or when the team did not apprise them of changes in the child's care plan; The needs expressed by parents of chronic medical complexity during PICU hospitalization included enhanced partnerships with health care professionals, improved communication with staff, and more attention to continuity of care in the PICU and across hospital services.
Nurses' reflections on benefits and challenges of implementing Family-centered care in pediatric intensive care units (16)	Heather Coats et al. (7)	2018	EUA	Qualitative description	Family-centered care brings benefits to parents, but it also creates many challenges for the team; The two main changes to this care are ICU policies related to visiting hours and family presence at the bedside and (2) transformation of the ICU's physical environment from a shared open space to individual private rooms; Nurses play a key role in the implementation of PFCC.
Elements of family-centered care in the pediatric intensive care unit: an integrative review (17)	Claire A. Richards et al. (3)	2017	EUA	Integrative review	Were identified 5 main themes related to Family Centered Care: 1) sharing information with parents. 2) hearing parental voices. 3) making decisions for or with parents. 4) individualizing communication; and 5) negotiating roles; There are gaps between parents' expectations of their involvement and how much they perceive that they are involved in the care of their child; Clinicians still own information and determine how much information parents will have access to, how much they will participate in decisions, and when they will be involved in procedures; Asking parents about their expectations regarding communication and their participation can improve doctor-family relationships, patient care, reduce conflicts and alleviate emotional distress.
A narrative synthesis of the components of and evidence for patient- and family-centered care (18)	Kaitlin P. Gallo et al. (3)	2017	EUA	Narrative synthesis	The PFCC has a positive impact on patient and/or family behavior, experience, knowledge and attitudes of patients/family, provider behavior and health status; The relationship of the individual components of the PFCC and the results showed that socio-emotional support to the patient or family was associated with positive changes in the patient/knowledge, attitudes and/or family experience.
Parent satisfaction with communication is associated with physician's patient-centered communication patterns during family conferences (19)	Tessie W. October et al. (5)	2016	EUA	Cross-Sectional study	Patient-centered communication scores higher when topics are related to psychosocial, lifestyle, and socio-emotional focus vs. medically focused conversation; Parental satisfaction is significantly higher the more the communication is patient-centered; The severity of the patient's illness were the factors influencing and maintaining parental management.

(Continued)

TABLE 1 | Continued

Title	Authors	Year	Local	Design	Main findings
Models of care delivery for families of critically Ill children: an integrative review of international literature (20)	Kate Curtis et al. (3)	2015	Australia	Integrative review	None of the care models analyzed offers intervention throughout each phase of care until (or after) hospital discharge, but at a specific stage of it; The models of care evaluated all had a positive impact on enhancing families' and parents' experience in a paediatric setting; Models of care applying only one or two aspects of approaches such as FCC, shared care, partnered care and increased caregiver involvement in care provision of critically ill children were associated with reduced parental anxiety, increased parental satisfaction in care provided and improved communication between parents and health care providers.
Family-Centered care in the pediatric intensive care unit (21)	Kathleen L. Meert et al. (3)	2013	EUA	Narrative review	Preliminary research on the implementation of programs related to PFCC in the PICU setting generally suggests benefits to patients, families, and staff; The development of PFCC policies and their implementation in clinical practice should reflect the needs of specific patient populations and settings, and thus requires continued input from patients, families, and staff; Patient-centered communication is the ideal process through which PFCC is implemented in daily practice.

their children, sharing decision-making for care and minimizing the negative impacts of separation (9).

Family Support

Family support refers to the support provided by health care workers to family members on issues including family education, involvement in care, use of tools for assertive communication and support of family decisions, as well as respect, recognition, and acceptance of the family's values and emotions when faced with a poor prognosis or the death of the patient, aiming to improve the mental health of parents during and after PICU discharge and increase family satisfaction with care (13).

Studies have shown that parents are satisfied with the care provided in PICU settings, especially with regard to providers' attitudes (32–34). During the COVID-19 pandemic, we have found that many health care workers have also been affected psychologically due to increased workload, fear of contamination, and shortage of human and material resources, among other factors (35). The risk of contagion, absence from work when infected, and even witnessing the deaths of colleagues and patients have created additional stress for many health care providers (36). The idiosyncrasies of health care work compound the aforementioned issues and include being undervalued, poor working conditions, unsafe physical infrastructure, inadequate staffing, poor flow along care pathways, lack of cooperation for teamwork, and support from leaders, among others (35).

The prevalence of mental disorders in front-line providers is expected to rise, as psychological disorders such as anxiety, depression, and PTSD have already been identified in health care workers after previous pandemics (37). Among nurses who worked directly in the care of patients with severe acute respiratory syndrome (SARS) during the 2003 outbreak, the development of psychiatric symptoms was linked to direct exposure to SARS patients, history of previous mood disorder, younger age, and perceived negative feelings (38).

In addition to the difficulty of providing support due to the absence of other family members at the PICU, we believe that the mental health of providers themselves also interferes with this practice, considering that they are also emotionally distressed and experiencing the consequences of the pandemic on their personal lives.

Availability of counseling within the hospital is of paramount importance to support the fight against COVID-19, as well as to support children and parents during treatment and hospitalization. The pandemic has hindered the provision of psychological and spiritual support to families (31). However, virtual care has been a method of providing support and helping to cope with the situation, with many services offered free of charge to the population (29, 39).

Several health facilities have also invested in hiring mental health teams to support their personnel, working to prevent and treat symptoms arising from the burden of working in a pandemic context.

Communication With Patients and Families

Communication between health care workers, family members, and patients is a core feature of PFCC. Interdisciplinary meetings with the family help ensure assertive communication, increase trust in the team, and improve family satisfaction. Active listening and expressions of empathy and support must all be present in communications (13). The use of personal protective equipment (PPE) such as masks and gowns has been recommended both inside and outside the hospital. However, these interfere with nonverbal communication, which is of the utmost importance in interactions between providers, patients, and families, and can make it difficult for health care workers to gauge the emotional reactions of family members, of which they must also be aware (9, 40).

Shared decision-making between physician, patient, and family is at the heart of communication in PFCC. However, during the pandemic, difficult situations—such as the need to decide which patients will receive treatment and which will be denied due to limited resources—cause ethical stalemates, with psychological repercussions for health care workers; this interferes with provider-patient-family communication (22, 41).

The high workload of health personnel and the absence of family members at some moments during hospitalization have also interfered with communication. In this context, telemedicine has been used as a strategy to maintain communication with families, such as by holding video calls with parents during rounds and scheduling meetings to share decisions and care plans (9). Although not equivalent to face-to-face encounters (42), these strategies can minimize difficulties in communication.

DISCUSSION

The COVID-19 pandemic has imposed several organizational changes in hospital settings, as well as the implementation of new contingency protocols to ensure continuity of patient care while containing the spread of the virus. The need to restrict visitation of PICU patients during the COVID-19 pandemic is understandable, considering the high transmissibility of the virus, the scarcity of PPE, and the lack of knowledge about the course of the disease (42). However, there were difficulties in finding a balance between containing the spread of the disease and maintaining the humanization of care, through such strategies as allowing the presence of family members (31).

PFCC is the gold standard of care in pediatrics. Considering the importance of family presence at the bedside in PICU settings while respecting guidelines to control the spread of the virus, most institutions generally found ways to allow at least one family member to remain with the child during hospitalization, which helps both child and parent face the situation and, in the event of the patient's death, allows for a better working through of bereavement (42).

The repercussions of the pandemic directly and indirectly affect patients, families, and health personnel; all have suffered physical and emotional consequences. It is essential that support be available to all, at all levels, in order to prevent and address harmful impacts (41). Comprehensive care in the PICU environment requires a holistic bio-psycho-social understanding of the subject; the pandemic has created stress at all of these levels. Thus, patients hospitalized during this period and their family members were exposed not only to the habitual stress of being in hospital or having a child in hospital but also to various other concerns inherent to the pandemic period, such as unemployment, financial difficulties, bereavement, and social isolation, among others, which reflect on experiences during hospitalization.

One of the main ways to maintain contact between family and health care workers, as well as between patients and their relatives, has been the use of technology. Video calls for virtual visits and meetings with multidisciplinary teams were implemented all over the world. However, some families had limited access to a reliable internet connection and electronic devices that support video calls, among other difficulties (43).

Medical news was often communicated by phone or video calls, with a negative impact on family support, as this hindered perceptions of and responses to the families' emotions.

Having the family present is a core element of PFCC. We found evidence that several strategies were used to bring families closer and ensure their participation in care, and believe that also had positive impacts on medical teams, with families as allies in patient care (42).

Drastic changes in care processes were required during this period, and substantial efforts were needed to maintain PFCC. The long-term consequences of the pandemic on the lives of patients, families, and health care workers remain unclear.

AUTHOR CONTRIBUTIONS

AL and PG contributed to the conception or design of the study and acquisition, analysis or interpretation of data, wrote the manuscript, critically reviewed the manuscript, gave final approval, and agrees to be responsible for all aspects of the work ensuring integrity and accuracy. VB, GA, FC, and CC wrote the manuscript, critically reviewed the manuscript, gave final approval, and agrees to be responsible for all aspects of the work ensuring integrity and accuracy. All authors contributed to the article and approved the submitted version.

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Stunting among kindergarten children in China in the context of COVID-19: A cross-sectional study

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Background: The impact of COVID-19 has most likely increased the prevalence of stunting. The study aimed to determine the prevalence of stunting among kindergarten children in the context of coronavirus disease 2019 (COVID-19) in Longgang District, Shenzhen, China, and its risk factors.

Methods: A cross-sectional study was conducted to identify children from 11 sub districts of 481 kindergartens in the Longgang District of Shenzhen City from May to July 2021. In the context of COVID-19, an online survey was conducted to gather demographic information, height, birth information, and lifestyle. The prevalence of stunting was calculated, and the risk factors were analyzed using binary logistic regression with three stepwise models.

Results: A total of 118,404 subjects were included from May to July 2021, with a response and questionnaire effective rates of 85.75% and 95.03%, respectively. The prevalence of stunting and severe stunting were 3.3% and 0.8%, respectively. Model 3 showed that risk factors for stunting were male sex [odds ratio (OR) = 1.07], low birth weight (OR = 2.02), insufficient sleep time (OR = 1.08), less food intake than their peers (OR = 1.66), slower eating than their peers (OR = 1.16), accompanied by grandparents alone or non-lineal relatives (reference: parents accompanying) (OR = 1.23, 1.51), and children induced to eat (OR = 1.17). Protective factors included only-child status (OR = 0.66), reported high activity (OR = 0.37, 0.26, 0.23), parents with high education levels (father: OR = 0.87, 0.69; mother: OR = 0.69, 0.58), high monthly income per capita of the family (OR = 0.88, 0.74, 0.68), and allowing children to make food choices (OR = 0.82).

Conclusion: The stunting rate of children in kindergartens in Longgang District is 3.3%, close to the level of developed countries but higher than the average level of developed cities in China. The relatively high stunting rate

in children under 3 years old in 2021 may be associated with the influence of COVID-19. Appropriate policies should be formulated for individuals and families with children to help children establish good living habits and reduce stunting.

KEYWORDS

stunting, kindergarten children, malnutrition, coronavirus disease 2019, eating behavior, feeding behavior

Introduction

Stunting refers to the height/length-for-age two standard deviations below the median, according to standard growth charts (1). Studies showed that stunting significantly impacts the life and health of children throughout their lives (including adolescence and adulthood) (2–6). Stunting is a major global health priority and was estimated to affect 22.0% or 149.2 million children under 5 years globally in 2020 (7). The World Health Organization (WHO) proposed a 40% reduction in stunted children as the first of six global nutrition targets by 2025 compared with the baseline data in 2010 (8). Although stunting has declined steadily since 2000, there remain challenges to achieving this goal. Coronavirus disease 2019 (COVID-19) increased the difficulty of achieving the goal. The epidemic has impacted social and economic development. Control of public places, the suspension of kindergartens, and the increase of online courses have affected children's lives and health (9). The WHO reported that the impact of COVID-19 likely increased the prevalence of stunting (7).

Currently, there is a lack of investigations on the stunting rate among preschool children in areas with rapid economic development against the background of the epidemic affecting social and economic operations. Longgang District is in the northeast of Shenzhen. In recent years, its economy has developed rapidly, ranking first among the top 100 industrial regions in China from 2018 to 2021, according to the China Information and Communication Research Institute (10–13). However, due to the impact of COVID-19 and Sino-American trade friction, the gross domestic product in the Longgang District decreased by 7.6% year on year in 2021 (14). In the present study, we aim to perform a cross-sectional study of the prevalence of stunting in the Longgang District in 2021 and identify the risk factors associated with stunting.

Abbreviations: COVID-19, coronavirus disease 2019; WHO, World Health Organization; HAZ, height-for-age; LAZ, length-for-age; CI, confidence intervals; OR, odds ratio; PA, physical activity.

Materials and methods

Study design

We conducted a cross-sectional study of enrolled preschoolers from kindergartens of Longgang District, Shenzhen City, Guangdong Province, in 2021. There are 11 sub districts and 481 kindergartens in Longgang District. Sporadic COVID-19 cases were reported in Shenzhen during the survey. The control measures in kindergartens are strict. Because of the epidemic, we conducted an online questionnaire survey in kindergartens. The information included height, demographic data, birth information, and lifestyle. The prevalence of stunting and risk factors among preschoolers in the Longgang District was analyzed.

Based on the previous literature (15), this paper constructed a conceptual framework for analyzing factors associated with stunting (**Figure 1**). The framework provided a way to understand that different factors affect each other and jointly lead to stunting. Distal factors such as birthplace, ethics, parents' qualifications, and other socioeconomic factors can affect height/length through intermediate and proximal factors. Family factors such as primary caregiver at home, number of children, and feeding behavior of caregivers belong to intermediate factors, which can affect height/length through proximal factors. Proximal factors include children's lifestyle and birth factors.

Participants and diagnostic criteria

We investigated children in kindergartens in the Longgang District using a general investigation from May to July 2021. The researcher first contacted the person in charge of all kindergartens in Longgang District, with kindergartens as the unit, and explained the contents and purpose of the survey. If the person in charge of the kindergarten agreed to participate in this survey, all children who met the inclusion and exclusion criteria were included.

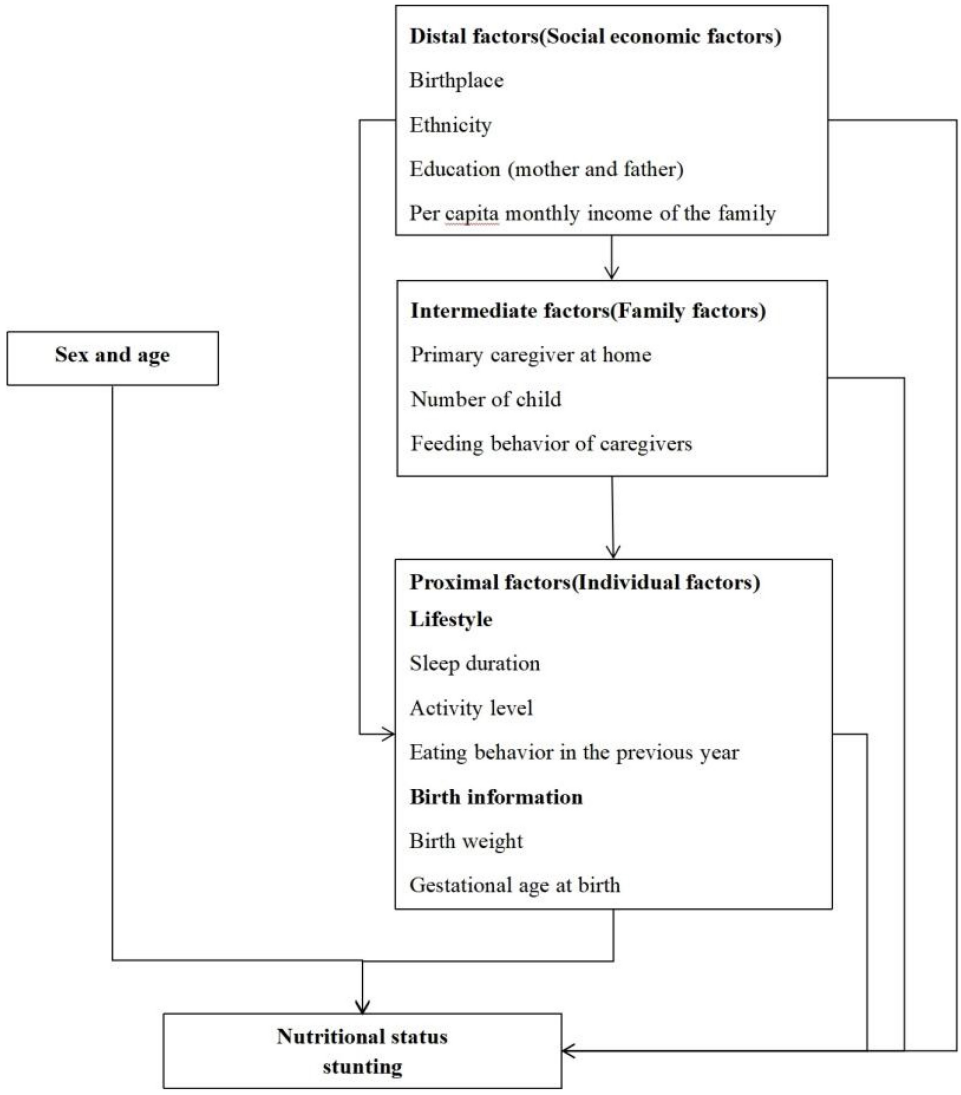

FIGURE 1
Conceptual framework.

The inclusion criteria were as follows: children studying in kindergartens in Longgang District, Shenzhen, in the second semester from 2020 to 2021; guardians possessed reading and writing skills and were willing and able to complete the survey. Exclusion criteria were children who did not complete or submit the questionnaire to the online system.

Criteria for the diagnosis of stunting: children less than 60 months old are judged according to WHO Child Growth Standards (2006 Edition) (16). 5-year-old children (60–71.9 months old) are judged according to WHO Child Growth Standards (2007 Edition). Z-score is the deviation of an individual's value of the median value of a reference population, divided by the standard deviation of the reference population. If the Z-score of height/length-for-age (HAZ/LAZ) was less than –2, it was considered stunting. If the HAZ was less than –2, it was judged as stunting. For children under 6 years old (less than 72 months old), severe stunting was defined as HAZ less than –3. Children aged 6 and above were judged according to the People's Republic of China's "screening for malnutrition in school-age children and adolescents" (WS/T 456-2014). If the child's height was no more than the cutoff value, the child was judged to be stunted. Stunting was not diagnosed if the child had a clear cause (e.g., genetic metabolic diseases).

Data collection

All investigators were trained uniformly. Unified standard operating procedures were developed for the investigation process to ensure the quality of the investigation. The

investigator introduced the survey to the guardians of the subjects, explained in detail the requirements for filling out the questionnaire, and issued a unique identification code for the subject. The guardians of the subjects can enter the online system to participate in the investigation with the unique identification code. The home page of the electronic survey provided the basic introduction and informed consent form. The subjects who chose to agree to participate filled out the questionnaire.

Data included the following: (1) demographic characteristics (gender, date of birth); (2) height/length to one decimal place in centimeters; (3) distal factors (birthplace, nationality, parents' qualifications, per capita monthly income of the family); (4) intermediate factors (Primary caregiver at home, Number of children, feeding behavior of caregivers). Feeding behavior of caregivers includes forcing or punishing children to coerce them to eat more, inducing them to eat (e.g., using toys or television), and attitudes toward children's bad eating habits. These behaviors were recorded if the caregiver engages in such behavior more than 3 days per week. (5) Proximal factors (see below).

(i) Sleep duration
Adequate sleep for children under 3 years is at least 11 h daily. For children over 3 years of age, more than 10 h a day is sufficient (17, 18).

(ii) Activity level
There were four activity levels: essential inactivity, less activity, general, and more significant activity.

(iii) Eating behavior in the previous year
This category includes eating less than their peers, eating slowly, not being interested in food, not eating in fixed places, and inattention while eating. Children demonstrating this behavior more than 3 days a week were considered to have this dietary behavior. The caregivers were asked to report whether there was picky eating.

(iv) Birth information
Birth information includes birth weight and gestational age at birth. If the birth weight was less than 2.5 kg, it was considered to be low birth weight. It was considered premature if the gestational age at birth was less than 37 weeks.

Statistical analysis

Categorical data were expressed as percentages and 95% confidence intervals (CI). According to the data type, the chi-square test or Fisher's exact test was used to compare the differences between groups. Binary logistic regression was used to calculate the correlations between stunting and demographic characteristics, birth status, the lifestyle of children, and the feeding behavior of caregivers in the previous year with three stepwise models based on the conceptual framework. Binary logistic regression was used because the dependent variable, stunting, is dichotomous. Model 1 was constructed with distal factors to estimate their effect on stunting. Model 2 was constructed with distal and intermediate factors. Model 3 was constructed with distal, intermediate, and proximal factors. The statistical analysis was conducted using SPSS 20.0 (IBM, NY, United States). Two-sided *p*-values less than 0.05 were considered to be statistically significant.

Results

A total of 39 (8.11%) of kindergartens in the Longgang District refused to participate in the survey, and 442 (91.89%) agreed to participate. A total of 145,303 children from 442 kindergartens were investigated. A total of 124,593 children participated in the survey, with a response rate of 85.75%. Of these, 4,211 participants failed to complete the survey, and 1,978 subjects lacked critical information such as birth date or height. Finally, 118,404 subjects were included in the study for an effective rate of 95.03% (**Figure 2**). We set a test question in the questionnaire to reflect the accuracy of the questionnaire. The subjects were required to choose the kindergartens where the children were. A total of 117,870 subjects answered the test item correctly (99.55%).

The prevalence of stunting was 3.3% (95% confidence interval 3.2–3.4%). The rate of stunting in children under 5 years old was 3.6%, and that of children under 6 years old was 3.6%. There were significant differences in stunting rate among ages, education levels of the father and mother, and per capita monthly income of families and primary caregivers of children. There were no significant differences between genders and nationalities (**Table 1**).

Among 88,519 children under 6 years of age, the prevalence of severe stunting was 0.8% (0.7%–0.9%). There were significant differences in the rate of severe stunting among children under 6 years old in gender, education level of the father and mother, and per capita monthly income of family and primary caregivers of children; however, there was no significant difference among nationalities (**Table 2**).

In model 3, binary multivariate logistic regression showed that showed that risk factors for stunting were male sex [odds ratio (OR) = 1.07], low birth weight (OR = 2.02), insufficient sleep time (OR = 1.08), less food intake than their peers (OR = 1.66), slower eating than their peers (OR = 1.16), accompanied by grandparents alone or non-lineal relatives (reference: parents accompanying) (OR = 1.23, 1.51), and children induced to eat (OR = 1.17). Protective factors included only-child status (OR = 0.66), reported high activity (OR = 0.37, 0.26, 0.23), parents with high education levels (father: OR = 0.87, 0.69; mother: OR = 0.69, 0.58), high monthly income per capita of the family (OR = 0.88, 0.74,

TABLE 1 Prevalence of stunting among preschoolers in Longgang District, Shenzhen City, China in 2021 ($n = 118,404$).

Characteristics	No of participants	No with stunting	Prevalence,% (95% CI)	*P*-value
Overall	118,404	3,912	3.3 (3.2–3.4)	
Age (years)				<0.001
Age < 3	158	6	3.8 (0.8–6.8)	
3 ≤ age < 6	88,361	3,228	3.7 (3.5–3.8)	
6 ≤ age	29,885	678	2.3 (2.1–2.4)	
Sex				0.91
Male	63,184	2,084	3.3 (3.2–3.4)	
Female	55,220	1,828	3.3 (3.2–3.5)	
Ethnicity				0.28
Han nationality	112,836	3,714	3.3 (3.2–3.4)	
Other nationalities	5,568	198	3.6 (3.1–4.0)	
Education (father)				<0.001
Junior high school and below	20,744	1,087	5.2 (4.9–5.5)	
High school and junior college	55,864	1,903	3.4 (3.3–3.6)	
Bachelor's degree or above	41,796	922	2.2 (2.1–2.3)	
Education (mother)				<0.001
Junior high school and below	22,506	1,240	5.5 (5.2–5.8)	
High school and junior college	60,415	1,898	3.1 (3.0–3.3)	
Bachelor's degree or above	35,483	774	2.2 (2.0–2.3)	
Per capita monthly income (¥)				<0.001
Less than 5,000	25,887	1,204	4.7 (4.4–4.9)	
5,000 ~10,000 (5,000 included)	38,549	1,358	3.5 (3.3–3.7)	
10,000 ~ 20,000 (10,000 included)	30,648	768	2.5 (2.3–2.7)	
No less than 20,000	14,121	297	2.1 (1.9–2.3)	
Not filled in	9,199	285	3.1 (2.7–3.5)	
The primary caregiver at home				<0.001
Father/mother	101,705	3,305	3.2 (3.1–3.4)	
Ancestors (Grandpa/Grandma)	12,951	473	3.7 (3.3–4.0)	
Parents and grandparents	2,505	71	2.8 (2.2–3.5)	
Others (non-immediate family, Nanny)	1,243	63	5.1 (3.8–6.3)	

0.68), and allowing children to make food choices (OR = 0.82) (Table 3).

Discussion

Prevalence of stunting

Our main finding was that the incidence of stunting among kindergarten children in the Longgang District was 3.3% (3.2–3.4%). The stunting rate of children under 5 years old was 3.6%, significantly lower than that in the world in 2020 (22%) and lower than in East Asia in 2020 (4.9%). The incidence was close to the level of North America (3.2%) and slightly higher than those in northern Europe, Australia, and New Zealand (2.3%–2.9%) (7). Overall, the stunting rate of kindergarten children in Longgang District was significantly lower than that in most developing countries and close to or slightly higher than that in developed countries. The relatively low stunting rate in the Longgang District of China may be associated with improved living standards by improving China's economic level and children's health care services. In recent years, China's economic level has developed rapidly, and Shenzhen is in a golden development period of the superposition of Shenzhen Special Economic Zone and Shenzhen Pioneer Demonstration Zone. Economic development improves living standards, food supply, and quality. The Chinese government launched a series of nutrition improvement projects for Chinese children in several regions, providing good conditions for children's growth and development.

The stunting rate of children under 6 years old in Longgang District was 3.6%, and that of children over 6 years old was 2.3%. The stunting rate of children under 6 years old was lower than that of children under 6 years old in China reported in 2020 (4.8% Note: The data come from the monitoring of nutrition and health status of Chinese residents from 2015 to 2017), and

TABLE 2 Severe stunting rate for children under 6 years of age in Longgang District, Shenzhen City, China in 2021 ($n = 118,404$).

Characteristics	No. of participants	No. with severe stunting	Prevalence,% (95% CI)	*P*-value
Overall	88,519	713	0.8 (0.7–0.9)	
Sex				0.008
Male	46,907	413	0.9 (0.8–1.0)	
Female	41,612	300	0.7 (0.6–0.8)	
Ethnicity				0.14
Han nationality	84,330	671	0.8 (0.7–0.9)	
Other nationalities	4,189	42	1.0 (0.7–1.3)	
Education (father)				<0.001
Junior high school and below	14,382	204	1.4 (1.2–1.6)	
High school and junior college	41,578	349	0.8 (0.8–0.9)	
Bachelor's degree or above	32,559	160	0.5 (0.4–0.6)	
Education (mother)				<0.001
Junior high school and below	15,614	241	1.5 (1.4–1.7)	
High school and junior college	45,050	350	0.8 (0.7–0.9)	
Bachelor's degree or above	27,855	122	0.4 (0.4–0.5)	
Per capita monthly income (¥)				<0.001
Less than 5,000	18,734	238	1.3 (1.1–1.4)	
5,000–10,000 (5,000 included)	28,911	233	0.8 (0.7–0.9)	
10,000–20,000 (10,000 included)	23,143	135	0.6 (0.5–0.7)	
No less than 20,000	10,610	54	0.5 (0.4–0.6)	
Not filled in	7,121	53	0.7 (0.5–0.9)	
The primary caregiver at home				<0.001
Father/mother	75,266	586	0.8 (0.7–0.8)	
Ancestors (Grandpa/Grandma)	10,361	103	1.0 (0.8–1.2)	
Parents and grandparents	1,972	10	0.5 (0.2–0.8)	
Others (non-immediate family, Nanny)	920	14	1.5 (0.7–2.3)	

is comparable to that of urban prevalence (3.5%) (19). The stunting rate of children in Longgang District is higher than that in developed regions of China at 0.4% in 2016 and is comparable to the rate in Hunan Province of China of 3.1% in 2019 (20, 21).

The prevalence of stunting is strongly inversely correlated with the region's wealth (22). As a region with a developed economy in China, the stunting rate of preschool children in the Longgang District is higher than the average level of developed areas in China, which might be related to the demographic characteristics of the Longgang District. The population mobility of Longgang District is relatively large, and its permanent non-registered population is as high as 2,897,300, accounting for 72.45% of the permanent population, which ranks high nationwide (23). The floating population faces several obstacles to obtaining comprehensive, affordable public health services, and this is one of the weakest links in China's public health service system (23, 24). Studies showed that immigrant children's growth and health level might be affected by the relatively unstable living environment and the shortage of medical and health services (25–28).

The COVID-19 epidemic has little effect on the overall stunting rate in Longgang District. A nutritional survey on kindergarten children in Shenzhen was carried out in 2015 (29). A stratified random sampling method was used. The kindergartens were divided into 11 layers according to their affiliated maternal and child health hospital, and 1/4 of kindergartens were randomly assigned in each layer. Kindergartens in the Longgang District were one of the layers. Seventy-nine kindergartens were assigned randomly from 318 kindergartens in the Longgang District in the survey. The height was measured by the maternal and child healthcare system staff, and the measurement method was standardized. Criteria for the diagnosis of stunting were according to the WHO Child Growth Standards. The diagnostic criteria for children under 6 years were the same as in this study; The diagnostic criteria for children aged six and above were similar. So that the data in 2015 and 2021 are comparable. The prevalence of stunting among kindergarten children in the Longgang District of Shenzhen in 2021 was 3.3%, lower than that in 2015 (4.71%) (29). The relatively low stunting rate in 2021 may be associated with improved kindergarten construction in Shenzhen City. In recent years, the Education Bureau of Shenzhen Municipality has printed and distributed documents like *The Action Plan for*

TABLE 3 Logistic regression models for stunting among preschoolers in Longgang District, Shenzhen City, China, in 2021 (n = 118,404).

Characteristics	Model 1		Model 2		Model 3	
	Adjusted odds ratio (95% CI)	*P*-value	Adjusted odds ratio (95% CI)	*P*-value	Adjusted odds ratio (95% CI)	*P*-value
Age (reference: age < 3 years)						
3 years ≤ age < 6 years	1.07 (0.47 to 2.42)	0.88	1.04 (0.46 to 2.36)	0.93	1.00 (0.44 to 2.28)	0.10
6 years ≤ age	0.61 (0.27 to 1.38)	0.23	0.60 (0.26 to 1.36)	0.22	0.57 (0.25 to 1.30)	0.18
Sex (reference: female)						
Male	0.99 (0.93 to 1.06)	0.81	1.00 (0.93 to 1.06)	0.89	1.07 (1.00 to 1.142)	0.04
Ethnicity (reference: Han nationality)						
Other nationalities	1.05 (0.91 to 1.21)	0.52	1.06 (0.92 to 1.23)	0.41	1.07 (0.92 to 1.24)	0.38
Father's education (reference: junior high school and below)						
High school and junior college	0.85 (0.78 to 0.93)	<0.001	0.86 (0.78 to 0.94)	0.001	0.87 (0.79 to 0.95)	0.002
Bachelor's degree or above	0.66 (0.59)	<0.001	0.67 (0.60 to 0.76)	<0.001	0.69 (0.61 to 0.77)	<0.001
Mother's education (reference: junior high school and below)						
High school and junior college	0.68 (0.62 to 0.74)	<0.001	0.69 (0.63 to 0.75)	<0.001	0.69 (0.63 to 0.76)	<0.001
Bachelor's degree or above	0.56 (0.49 to 0.63)	<0.001	0.57 (0.50 to 0.64)	<0.001	0.58 (0.51 to 0.65)	<0.001
Per capita monthly income of the family (¥) (reference:<5,000)						
5,000–10,000 (5,000 included)	0.84 (0.78 to 0.91)	<0.001	0.86 (0.79 to 0.93)	<0.001	0.88 (0.81 to 0.96)	0.002
10,000–20,000 (10,000 included)	0.68 (0.62 to 0.75)	<0.001	0.70 (0.64 to 0.77)	<0.001	0.74 (0.67 to 0.81)	<0.001
No less than 20,000	0.62 (0.54 to 0.71)	<0.001	0.64 (0.56 to 0.73)	<0.001	0.68 (0.59 to 0.78)	<0.001
Not filled in	0.81 (0.71 to 0.93)	0.002	0.85 (0.74 to 0.97)	0.01	0.87 (0.75 to 0.10)	0.05
The primary caregiver at home (reference: parents)						
Ancestors (Grandpa/Grandma)	NA	NA	1.25 (1.13 to 1.39)	<0.001	1.23 (1.12 to 1.37)	<0.001
Parents and grandparents	NA	NA	0.89 (0.70 to 1.13)	0.33	0.90 (0.71 to 1.14)	0.37
Others	NA	NA	1.52 (1.18 to 1.97)	0.001	1.51 (1.17 to 1.96)	0.002
Only child	NA	NA	0.67 (0.61 to 0.73)	<0.001	0.66 (0.61 to 0.72)	<0.001
Birthplace (reference: Shenzhen)						
Other cities in China	1.01 (0.94 to 1.08)	0.88	1.04 (0.97 to 1.11)	0.28	1.04(0.97 to 1.12)	0.22
Other countries	0.87 (0.32 to 2.36)	0.79	0.85 (0.32 to 2.31)	0.75	0.84 (0.31 to 2.27)	0.73
Fetal age (reference: full-term)						
Premature birth (<37 weeks)	NA	NA	NA	NA	0.87 (0.76 to 1.00)	0.05
Birth weight (reference: ≥ 2.5 kg)						
Low birth weight (<2.5 kg)	NA	NA	NA	NA	2.02 (1.82 to 2.24)	<0.001
Physical activities (reference: Basically inactive)						
Less activity	NA	NA	NA	NA	0.37 (0.18 to 0.73)	0.005
General activity	NA	NA	NA	NA	0.26 (0.13 to 0.51)	<0.001
More intense activity	NA	NA	NA	NA	0.23 (0.11 to 0.45)	<0.001
Not filled in	NA	NA	NA	NA	0.26 (0.13 to 0.54)	<0.001
Sleep time (reference: sufficient)						
Not enough	NA	NA	NA	NA	1.08 (1.01 to 1.15)	0.03
Not filled in	NA	NA	NA	NA	2.87 (0.99 to 8.34)	0.05
Children eating behavior						
Supplementation of nutrients alone	NA	NA	NA	NA	1.00 (0.93 to 1.08)	0.99
Eating less than their peers	NA	NA	NA	NA	1.66 (1.50 to 1.84)	<0.001
Eating slower than their peers	NA	NA	NA	NA	1.16 (1.06 to 1.27)	0.001
Not interested in food	NA	NA	NA	NA	1.07 (0.96 to 1.20)	0.22
Distraction when eating (watch TV, play games)	NA	NA	NA	NA	1.02 (0.93 to 1.11)	0.71

(Continued)

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TABLE 3 (Continued)

Characteristics	Model 1		Model 2		Model 3	
	Adjusted odds ratio (95% CI)	*P*-value	Adjusted odds ratio (95% CI)	*P*-value	Adjusted odds ratio (95% CI)	*P*-value
An irregular dining place	NA	NA	NA	NA	1.10 (0.97 to 1.25)	0.13
Caregiver's judgment on whether the child is picky about food (reference: no)						
Picky food	NA	NA	NA	NA	1.01 (0.93 to 1.09)	0.78
Not sure	NA	NA	NA	NA	1.12 (0.95 to 1.31)	0.19
Feeding behavior of caregivers						
Little emotional exchange during the meal	NA	NA	1.08 (0.97 to 1.20)	0.18	1.02 (0.91 to 1.14)	0.78
Forcing or punishing children to eat	NA	NA	1.35 (1.17 to 1.56)	<0.001	1.02 (0.88 to 1.18)	0.79
Inducing children to eat (toys, television, story reward)	NA	NA	1.39 (1.24 to 1.57)	<0.001	1.17 (1.04 to 1.33)	0.01
Allowing children to choose their food at will	NA	NA	0.88 (0.80 to 0.97)	0.01	0.82 (0.75 to 0.90)	<0.001
Allowing children to snack freely	NA	NA	1.01 (0.86 to 1.18)	0.92	0.99 (0.85 to 1.16)	0.92
Allowing children to hang out while eating	NA	NA	1.06 (0.87 to 1.29)	0.55	0.95 (0.78 to 1.16)	0.62

the Development of Preschool Education in Shenzhen (2019–2020) to vigorously develop the kindergartens' construction. In 2015, private kindergartens accounted for more than 90% in Shenzhen, while this survey shows that public kindergartens have reached nearly 50%. The government has strengthened the health care work and dietary management in kindergartens, providing strong support for improving children's nutritional status.

Compared with the data of Shenzhen in 2015, the stunting rate of children under 3 years old in Longgang District increased nearly fourfold (3.8% vs. 1.0%). The relatively high stunting rate in 2021 may be associated with the influence of COVID-19. Social quarantine measures during the epidemic have significantly impacted children's living conditions and lifestyles. Studies showed that during COVID-19, children's physical activity (PA) decreased significantly, while the time spent watching electronic screens increased and unhealthy diets increased (30). We found that the COVID-19 epidemic significantly impacted the stunting rate of children under 3 years old in kindergartens, which suggests that more attention should be paid to the growth and development of children under 3 years old during the epidemic period.

Distal factors

The high education level of parents and per capita monthly income are related to stunting. The high education level of the father and mother was a protective factor, consistent with the results of observational studies (31, 32). This finding may be due to the higher education level of parents, who may acquire more nutrition knowledge conducive to scientific feeding. Higher per capita monthly income was a protective factor for stunting, similar to previous studies (33, 34). The higher the family's monthly income, the more parents can spend on nutrition and better feeding environments.

Intermediate factors

Primary caregivers at home and the number of children are associated with stunting. Compared with care by parents alone, care by grandparents alone or non-immediate relatives was a risk factor for stunting. Grandparental care, which has become a worldwide social phenomenon, gives rise to poor dietary behaviors and lower levels of physical activity (35, 36). Only-child status was a protective factor for stunting, similar to previous studies (37).

The feeding behavior of caregivers in the previous year is associated with stunting. Encouraging children to eat using incentives such as toys and television is a risk factor, while allowing children to choose food at will is a protective factor. The feeding pattern of parents' long-term reward inducing children to eat will reduce children's enjoyment of food, which is not conducive to establishing long-term good eating behavior. The allowable feeding style provides children with a more relaxed eating environment and improves their food enjoyment (38). However, it may lead to a reduction in the diversity of food intake. More studies are needed to explore the association between stunting and allowable feeding style.

Proximal factors

The present study shows that the risk of boys suffering from childhood stunting is 1.07 times that of girls, the same as many results from China (20, 21, 39, 40) and other regions (41, 42),

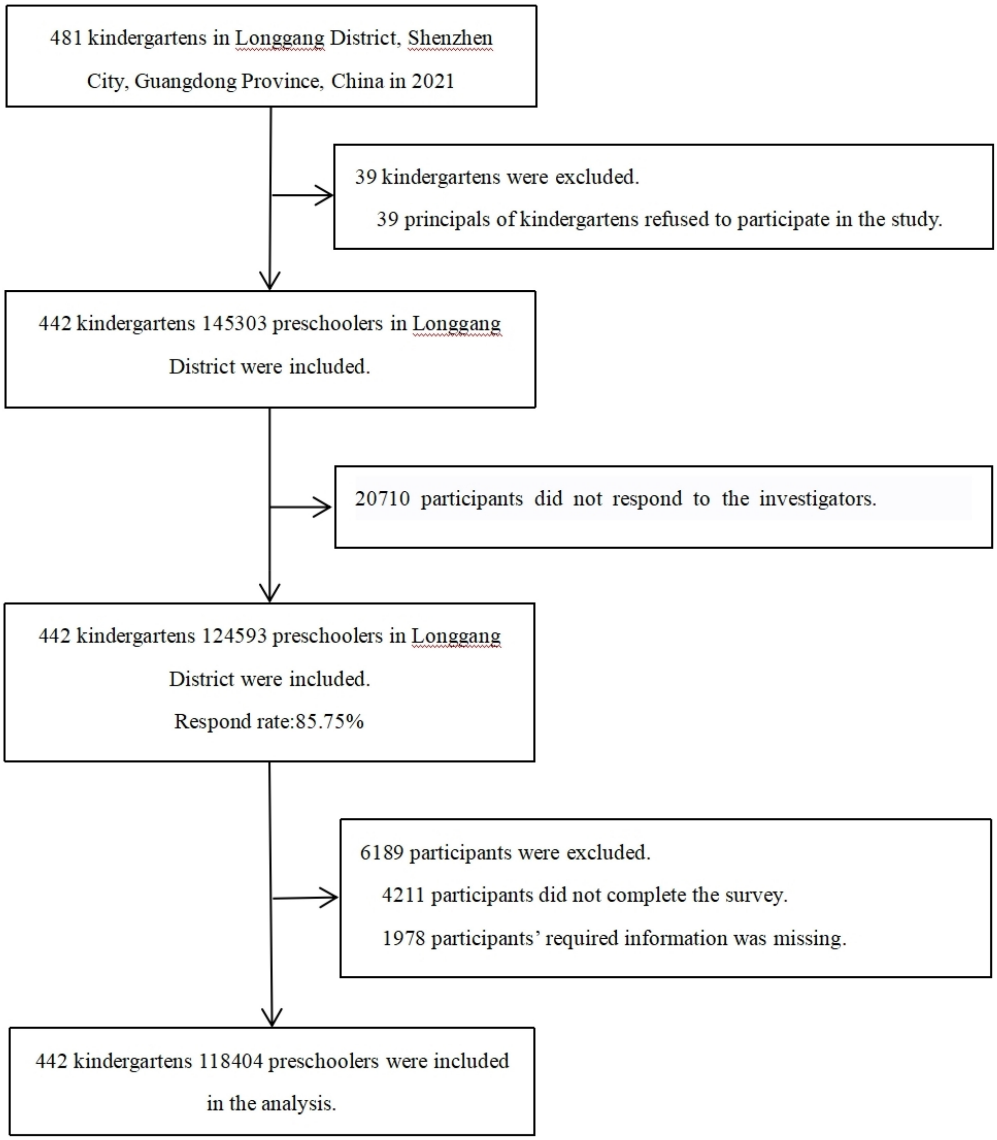

FIGURE 2
Study population.

probably due to the interaction of biological and socio-cultural factors. We also found differences between boys and girls in growth trajectories and immune function beginning prenatally (43, 44). Caregivers treat children of different genders differently (45–47).

Low birth weight is a risk factor for stunting in children, consistent with many other studies (39, 40, 48). Birth weight is an essential indicator of fetal intrauterine nutrition (49). Low birth weight children always have poor digestion ability and low immunity, which may affect their growth and development (50, 51).

We found that lifestyle factors such as insufficient sleep, less PA, less food intake, and slower eating than peers were risk factors for stunting. There are few studies on the correlation between height and sleep deprivation (52). A cohort study of children found no correlation between sleep deprivation and height (53), different from the results of the present study; more studies are needed to explore the relationship between them. PA is associated with children's growth and development. Studies showed that less active children are shorter, and PA-related epiphyseal loading positively affects the growth of healthy children (54). Poor dietary habits such as eating less and slowly can reduce the diversity of food intake and affect children's growth and development. Studies showed that measures such as closing kindergartens in the early stage of the epidemic of COVID-19 impacted children's activities, sleep, and other

aspects; short-term changes in PA and sedentary behavior may become permanently involved (55, 56).

This study has some limitations. First, the study was a web-based questionnaire. Compared to the paper version of the questionnaire, this method is more likely to attract responses from younger and more educated people (57, 58); this approach may underestimate the incidence of stunting. Second, a web-based survey cannot rule out the possibility of parents misreporting the children's heights. However, some major clinical characteristics reported by the participants were in line with the current survey in China. In addition, the correct rate of the questionnaire test was 99.55%, reflecting the accuracy of the survey results. Third, the study focused on the correlation between children's lifestyle and family environment and stunting; other relevant factors should be included in the future. Finally, although the results gave some insights into the effect of COVID-19 on stunting in kindergarten children, we did not measure the influence of the COVID-19 pandemic in this study.

The stunting rate of children in kindergartens in Longgang in 2021 was low, close to or slightly higher than that of developed countries in the world, but higher than that of other developed cities in China. This finding may be due to the high proportion of the floating population. The stunting rate of children under 3 years old in kindergarten increased significantly, possibly due to the epidemic of COVID-19. Stunting is associated with distal, proximal, and intermediate factors. From a policy perspective, our findings suggest that public health services for migrant children and children under 3 years old should be promoted during the epidemic. Health education for parents with low education levels should be strengthened, and pro-poor policies should be formulated to reduce the effect of distal factors like parents' education and family income. We should strengthen the guidance of caregivers' feeding behavior. In addition to parents, grandparents, and other caregivers should be targets of feeding behavior guidance to reduce the effect of intermediate factors. To reduce the effect of proximal factors, we should help children cultivate a healthy lifestyle, including sleep, activity, and eating behavior, through kindergarten and family education. Health management services for boys and maternal health care services should be strengthened to prevent stunting.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The Ethics Review Committee of Shenzhen Hospital of Beijing University of Traditional Chinese Medicine (Longgang) approved the study (SZLDH2021LSYM-030). Written informed consent from the participants or their legal guardian/next of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

Authors contributions

TL and XG conceptualized and designed the study andreviewed the manuscript. XM and XY drafted the initial manuscript, coordinated and supervised data collection, and analyzed the data. HY, YW, YT, CL, CB, FD, and ZW participated in data collection and analysis. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Association of family wellbeing with forwarding and verifying COVID-19-related information, and mediation of family communication quality

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Objective: We assessed the associations of family wellbeing with verifying and subsequently forwarding COVID-19-related information to family members and the mediating effect of the quality of family communication on these associations among Chinese adults in Hong Kong.

Methods: Under the Jockey Club SMART Family-Link Project, we conducted an online population-based survey, using Family wellbeing Scale and questions related to the family communication quality and forwarding and verifying COVID-19 information. Data were collected from 4,891 adults in May 2020. Prevalence estimates of forwarding and verifying COVID-19 information were weighted by sex, age, and education of the general population, and their associations with family wellbeing (ranged 0–10) were analyzed using generalized linear models with mutual adjustment. Their interactive effects on family wellbeing and the mediating effects of family communication quality were examined.

Results: In total, 53.9% of respondents usually/always forwarded COVID-19 information related to their family, 68.7% usually/always verified it before forwarding, and 40.9% did both. Greater family wellbeing was associated with usually/always forwarding [adjusted β (95% CI): 0.82 (0.72–0.92)] and usually/always verifying [0.43 (0.32–0.55)] (both $P < 0.001$) the information. Forwarding and verifying such information showed an additive effect on family wellbeing [1.25 (1.11–1.40)]. Family communication quality mediated the associations of family wellbeing with forwarding (83.7%) and verifying (86.6%) COVID-19-related information.

Conclusion: Forwarding COVID-19 information to family, verifying such information, and especially doing both, were associated with greater

family wellbeing, being strongly mediated by the quality of family communication. Individuals should be encouraged to verify COVID-19-related information before forwarding it to family members amidst the COVID-19 pandemic.

KEYWORDS

COVID-19, information sharing, fact-check, information overload, misinformation, family wellbeing

Introduction

Family communication, namely, sharing of information, knowledge, values, and beliefs, is essential for maintaining family relationships and fostering the wellbeing of the entire family and of each family member (1–4). Sharing information with family members and forming family groups on instant messaging applications were found to improve the quality of family communication and enhance wellbeing, both before and during the COVID-19 pandemic (1, 2, 5, 6). The pandemic has caused severe stress, uncertainties, and social isolation, amplifying the need to feel safe and socially connected. Sharing information with family may reduce loneliness and serve as an important source of health-related information (7, 8). We previously reported that individuals who shared COVID-19-related information with family reported greater family wellbeing (9). With technology advancing, the forwarding of information using electronic communication technologies, namely, instant messaging and social media, has become an increasingly prevalent and common behavior (10). People can massively redirect forwarded messages to others, with or without the recipient's consent; however, the recipient may find such messages overwhelming and irrelevant. The effect of forwarding such messages has not been studied so far.

The overabundance of information during the pandemic—also known as an infodemic—has made it difficult for people to find trustworthy sources and reliable guidance when needed (11). The forwarding of COVID-19-related information has led to widespread misinformation on social media that is not backed by the scientific consensus (12–18). Exposure to less trusted information sources (e.g., social media) and misinformation may increase confusion and perceived risks toward COVID-19 (19) and cause psychological distress (20–23), which may eventually lead to conflicts in the family (24, 25).

Verifying (fact checking) information and not sharing COVID-19-related misinformation can help curb the infodemic (19, 26). Forwarding trustworthy COVID-19-related information may promote family wellbeing; in contrast, forwarding unverified information may amplify the infodemic, hampering mental health. The reasons behind sharing unverified information, namely, perceived COVID-19 severity and vulnerability (27), fear and health anxiety (28, 29), importance of messages (30), entertainment, ignorance (e.g., lack of awareness), altruism (31), and coping with information overload (29), were increasingly studied. However, the effects of forwarding unverified COVID-19-related information on family wellbeing remain unclear. We performed a PubMed searched using the keywords "COVID-19," "family wellbeing," "information sharing," "forwarding information," "verifying information," "fact check," "information overload" and "misinformation" up to April 2022. We found that only one survey conducted prior to the current study and reported the association between the implementation of COVID-19 preventive measures and family wellbeing and the minor mediating effect of sharing COVID-19-related information with family in the association of individual health literacy and preventive measures (32).

To date, no report has examined how the handling of COVID-19 information affects family wellbeing. However, it is crucial to explore how the handling of COVID-19-related information [e.g., verifying the information and then forwarding it to family, which is highly recommended to confront the infodemic (19, 26)] is associated with family wellbeing to provide insights for future research and to determine best practices on strategies to protect family wellbeing from the infodemic.

Given the high Internet (91.7%) and social media (98.0%) penetration rates (33) and the high prevalence of using the Internet to search for information (95.9%) and to communicate (98.9%) (34) in Hong Kong, this study aimed to examine (1) the independent associations of forwarding and verifying COVID-19-related information with family wellbeing, (2) the interaction between forwarding and verifying such information on family wellbeing, and (3) the mediating effect of the quality of family communication in such associations among Chinese adults in Hong Kong.

Materials and methods

Study design and participants

The present population-based survey study, known as the first Family Amidst COVID-19 (FamCov1) survey and conducted under the Jockey Club SMART Family-Link Project,

was performed in Hong Kong between 26 and 31 May 2020. The study aimed to recruit as many respondents as possible within these 6 days as wave 2 of the COVID-19 outbreak was under control during this period. The eligibility criteria were as follows: (1) adults in Hong Kong aged 18 years or older and (2) able to read and understand Traditional Chinese. Details of the conducted survey have been published in previous reports (6, 35, 36). In short, a probability- and non-probability-based online panels were invited to complete a self-administered online survey *via* email through the Hong Kong Public Opinion Research Institute, a well-known local survey agency (37). A total of 20,103 invitation emails were opened; 6,956 individuals accessed the survey link, of which 4,921 shared useable data after providing informed consent (response rate, 24.5%). After excluding 30 respondents who had no family members, a total of 4,891 respondents were included in the current study. The study was approved by the Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster (UW 20-238).

Measurements

Independent variables

Forwarding COVID-19 information to family members refers to a specific information sharing behavior on digital platforms such as social media (e.g., Facebook) and instant messaging applications (e.g., WhatsApp). We asked: "When the pandemic was severe, how often did you forward COVID-19-related information to your family members?" In terms of verification, the following question was asked: "When the pandemic was severe, how often did you verify before forwarding COVID-19-related information to family members?" (38). The responses to both questions were recorded as 0 (never) to 5 (50–50) to 10 (always) or "I don't know/refuse to answer," which were recoded into binary variables [seldom/sometimes (0–6) and usually/always (7–10)] with "do not know/refuse to answer" considered as missing data.

Dependent variables

Family wellbeing was measured with the Family wellbeing Scale, which was developed based on the Chinese adults' perspectives on family wellbeing in Hong Kong, and included three questions related to perceived family health, happiness, and harmony (4). The three questions, which also were used in our previous studies (1, 5, 32, 36), were "Do you think your family is (1) healthy, (2) happy, and (3) harmonious?" The responses were scored from 0 to 10 (0 = very unhealthy/unhappy/inharmonious; 5 = 50–50; 10 = very healthy/happy/harmonious). The sum of the three item scores divided by 3 was the composite score of family wellbeing (2, 32). The quality of family communication was assessed using the question "How good do you find the quality of communication between you and your family members?," with responses scored from 0 to 10 (0 = very bad; 5 = 50–50; 10 = very good) (6).

Covariates

Data related to the sex, age group, education, household monthly income, number of cohabitants, and housing status of the respondents were collected (35, 36, 39). Sociodemographic variables were recoded: age (18–24, 25–44, 45–54, and 65 years or older), household income [less than or equal to the median monthly household income per person in Hong Kong (low) (40) vs. high], education (secondary or below vs. postsecondary), and housing (rented vs. owned). A socioeconomic score (SES; range 0–3) was obtained by summing the scores of education (0 = secondary education or lower and 1 = post-secondary education), household income (0 = low and 1 = high), and housing status (0 = rented and 1 = owned). The SES was further recoded as low (0–1), medium (2), or high (3) according to similar characteristics relating SES scores of 0 and 1 (35, 36, 39).

Statistical analysis

The prevalence estimates of forwarding and verifying COVID-19-related information were weighted by the sex, age, and education of the Hong Kong general population (41, 42). The independent samples *t*-test and one-way ANOVA were used to compare the quality of family communication and family wellbeing based on the respondents' characteristics and behaviors of forwarding and verifying COVID-19-related information. The magnitude of the differences was demonstrated using the effect size (ES): eta-squared (η^2) for variables with two or more groups and Cohen's *d* for binary variables. Generalized linear models were used to calculate the adjusted odds ratio (OR) and 95% CI of the quality of family communication and family wellbeing for behaviors of verifying and forwarding COVID-19-related information to examine independent associations, adjusting for each other and socio-demographic characteristics. Cross-product terms of verifying and forwarding COVID-19-related information were added in the regression models to examine the interactions. However, no significant interaction was found, and the additive effects of forwarding and verifying COVID-19-related information on family wellbeing were further examined. A composite variable was created by combining the forwarding and verification of COVID-19-related information into four groups: (1) both seldom/sometimes, (2) usually/always forwarding and sometimes/seldom verifying, (3) usually/always verifying and seldom/sometimes forwarding, and (4) both usually/always. The association of the created variable with family wellbeing was then tested using the generalized linear model, adjusted for sociodemographic factors. *PROCESS Macro v3.5* by Hayes,

a well-known mediation analysis tool in *IBM SPSS*, was used to examine the mediating (indirect) effect of the quality of family communication on the associations of forwarding and verifying COVID-19-related information with family wellbeing (43, 44). Bias-corrected bootstrap CI method with 5,000 replications was used to obtain the 95% CIs of the direct and indirect effects of verifying and forwarding COVID-19-related information on family wellbeing mediated *via* the quality of family communication, with adjustment for verifying in the analysis of forwarding (and vice versa) and sociodemographic factors. $P < 0.05$ was considered statistically significant. To test the robustness of results, the analyses were repeated with re-categorization of forwarding and verification of COVID-19-related information [less than half the time (score < 5) vs. half the time or more (score ≥ 5)]. All the data were analyzed using IBM SPSS v26.

Results

Table 1 shows that 50.1 and 41.2% of the respondents were aged 25–44 and 45–64 years, respectively, and 43.7% were man. After weighting, 53.9% of the respondents were found to usually/always forward COVID-19-related information to family members, whereas 68.7% usually/always verified the information before forwarding. Those who usually/always forwarded such information reported better quality of family communication (mean ± SD, 7.04 ± 1.68 vs. 5.78 ± 2.19; $P < 0.001$; ES: 0.65) and greater family wellbeing (7.45 ± 1.43 vs. 6.49 ± 1.83; $P < 0.001$; ES, 0.59) than those who seldom/sometimes did so. Those who usually/always verified such information also reported better quality of family communication (6.62 ± 1.98 vs. 5.97 ± 2.14; $P < 0.001$; ES, 0.32) and greater family wellbeing (7.14 ± 1.65 vs. 6.61 ± 1.78; $P < 0.001$; ES, 0.31). With the variables of forwarding and verifying COVID-19-related information combined, 18.0% of respondents seldom/sometimes did both and 40.9% usually/always did both; family wellbeing was the greatest among those who usually/always did both and the least among those who seldom/sometimes did both (7.52 ± 1.44 vs. 6.25 ± 1.90; $P < 0.001$; ES, 0.09).

Table 2 shows that compared with seldom/sometimes forwarding COVID-19-related information to family members, usually/always forwarding the information was associated with better quality of family communication, independent of whether the information was verified [adjusted β (95% CI), 1.04 (0.93–1.16); $P < 0.001$]. Similarly, compared with the respondents who seldom/sometimes verified COVID-19-related information, those who usually/always did so reported better quality of family communication [0.51 (0.38–0.65); $P < 0.001$]. Greater family wellbeing was associated with usually/always forwarding [0.82 (0.72–0.92); $P < 0.001$) and verifying [0.43 (0.32–0.55); $P < 0.001$] COVID-19-related information after mutual adjustment. No interaction between forwarding and verifying COVID-19-related information was found ($P = 0.85$); however, compared with those who neither usually/always forwarded nor verified the information, those who usually/always forwarded only [0.82 (0.63–1.01); $P < 0.001$], usually/always verified only [0.43 (0.29–0.58); $P < 0.001$] and usually/always did both [1.25 (1.11–1.40); $P < 0.001$] reported greater family wellbeing.

Table 3 shows that the associations of forwarding and verifying COVID-19-related information with family wellbeing were attenuated after including the quality of family communication as a mediator; 86.6 and 83.7% of the independent total effect of forwarding and verifying COVID-19-related information on family wellbeing was mediated by the quality of family communication, respectively. Moreover, 85.6% of the total effect of forwarding as well as verifying COVID-19-related information on family wellbeing was mediated by the quality of family communication.

The results of the robustness analysis are shown in Supplementary table 1; similar results were obtained after re-categorizing the forwarding and verifying of COVID-19-related information. The forwarding of COVID-19 information >50% of the time was associated with greater family wellbeing [2.96 (2.59, 3.33), $P < 0.001$]. The corresponding figure for verifying such information was 1.62 (1.05, 2.19), $P < 0.001$. Similarly, Supplementary table 2 shows that the 91.2% and 82.8% of the total effect of forwarding and verifying COVID-19-related information on family wellbeing was mediated by the quality of family communication.

Discussion

We have first shown that usually/always forwarding COVID-19-related information to family members, usually/always verifying it before forwarding, and especially doing both were associated with greater family wellbeing and that these associations were significantly mediated by the quality of family communication.

Our results show that forwarding COVID-19-related information to family members was associated with greater family wellbeing, which was mediated by the quality of family communication. The perceived proper use of instant messaging was shown to help overcome the geographical constraints (45) and encourage family communication (46). During the COVID-19 pandemic, with social distancing measures in place, instant messaging has become instrumental in connecting family members (47, 48). Message forwarding is one of the most common core functions of instant messaging applications (10), and forwarding COVID-19-related information can initiate discussions (49) and increase family communication. Through such interactions, family members can support one another to alleviate the impacts of COVID-19 on their mental health (50) and enhance family wellbeing (3). Yet, any family member

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TABLE 1 Sociodemographic characteristics and behaviors of forwarding and verifying COVID-19 information ($N = 4,891$).

	Unweighted		Weighted			Family communication				Family wellbeing			
	n	(%)	*n*	(%)	Effect size^	Mean	(SD)	*P**	Effect size^^	Mean	(SD)	*P**	Effect size^^
Sex													
Male	2,138	(43.7)	2,295	(47.1)	0.03	6.45	(2.08)	0.89	0.004	7.05	(1.72)	0.098	0.05
Female	2,753	(56.3)	2,583	(52.9)		6.44	(2.02)			6.97	(1.69)		
Age group, years													
18–24	219	(4.5)	416	(8.5)	0.29	5.31	(2.44)	<0.001#	0.05	6.01	(2.23)	<0.001#	0.05
25–44	2,449	(50.1)	1,581	(32.4)		6.11	(2.13)			6.77	(1.75)		
45–64	2,013	(41.2)	1,839	(37.7)		6.88	(1.80)			7.32	(1.53)		
65 or above	210	(4.3)	1,041	(21.3)		7.31	(1.46)			7.69	(1.25)		
							***P* for trend**	<0.001			***P* for trend**	<0.001	
Education													
Secondary or below	659	(13.6)	3,183	(65.7)	0.53	6.75	(1.84)	<0.001	0.18	7.20	(1.48)	<0.001	0.14
Postsecondary	4,199	(86.4)	1,662	(24.3)		6.39	(2.07)			6.97	(1.73)		
Household monthly income													
Lower	1,270	(29.8)	2,201	(52.6)	0.23	6.13	(2.11)	<0.001	0.22	6.69	(1.82)	<0.001	0.27
Higher	2,986	(70.2)	1,986	(47.4)		6.58	(1.99)			7.15	(1.62)		
Housing													
Rent	1,603	(33.9)	1,744	(36.6)	0.03	6.18	(2.10)	<0.001	0.21	6.73	(1.76)	<0.001	0.25
Owned	3,120	(66.1)	3,025	(63.4)		6.61	(2.00)			7.16	(1.65)		
Socioeconomic score													
Low (0–1)	790	(18.9)	2,160	(52.3)	0.40	6.17	(2.07)	<0.001#	0.007	6.73	(1.76)	<0.001#	0.01
Middle (2)	1,497	(35.8)	1,376	(33.3)		6.41	(2.03)			6.93	(1.73)		
High (3)	1,891	(45.3)	595	(14.4)		6.64	(2.01)			7.23	(1.62)		
							***P* for trend**	<0.001			***P* for trend**	<0.001	
Forwarding COVID-19 information													
Seldom/sometimes	2,304	(47.3)	2,238	(46.1)	0.01	5.78	(2.19)	<0.001	0.65	6.49	(1.83)	<0.001	0.59
Usually/always	2,569	(52.7)	2,615	(53.9)		7.04	(1.68)			7.45	(1.43)		
Verifying COVID-19 information													
Seldom/sometimes	1,297	(26.1)	1,506	(31.3)	0.052	5.97	(2.14)	<0.001	0.32	6.61	(1.78)	<0.001	0.31
Usually/always	3,583	(73.9)	3,310	(68.7)		6.62	(1.98)			7.14	(1.65)		
Always forwarding and verifying													
Neither	774	(16.0)	869	(18.0)	0.06	5.48	(2.27)	<0.001#	0.10	6.25	(1.90)	<0.001#	0.09
Usually/always forwarding	493	(10.2)	638	(13.2)		6.73	(1.66)			7.18	(1.38)		
Usually/always verifying	1,509	(31.1)	1,339	(27.8)		5.93	(2.12)			6.61	(1.78)		
Both	2,074	(42.8)	1,972	(40.9)		7.12	(1.69)			7.52	(1.44)		
							***P* for trend**	<0.001			***P* for trend**	<0.001	

	Mean	(SD)	Mean	(SD)	ES
Family communication	7.00	(1.70)	7.12	(1.62)	0.07
Family wellbeing	6.44	(2.05)	6.62	(1.96)	0.09

Missing data were excluded.

Socioeconomic score (SES): a composite score of education, household monthly income per person, and housing analyzed as low (0–1), middle (2), and high (3).

Always forwarding and verifying: A composite variable by combining forwarding and verifying COVID-19-related information into four groups: (1) neither (both seldom/sometimes forwarding and verifying), (2) always forwarding (and sometimes/seldom verifying), (3) always verifying (and seldom/sometimes forwarding), and (4) both (always forwarding and verifying).

^Effect size (ES) for difference between weighted and unweighted sample: Categorical variables: Cramer's V: 0.10–0.30, small; 0.30–0.50, medium; ≥0.50, large; Continuous variables: Cohen's d: 0.2 (small), 0.5 (medium), 0.8 (large).

^^Effect size (ES) for variables with two or more groups: Eta-squared (η^2): 0.01 (small), 0.06 (medium), and 0.14 (large); ES for variables with two groups: Cohen's d: 0.2 (small), 0.5 (medium), and 0.8 (large).

*Independent sample t-tests and One-Way ANOVA were performed with unweighted sample.

#*Post-hoc* analyses showed significant difference between all the groups.

TABLE 2 Associations of family wellbeing with forwarding and verifying COVID-19 information ($N = 4891$).

	Family communication						Family wellbeing					
	Crude β	(95% CI)	*P*	Adj β*	(95% CI)	*P*	Crude β	(95% CI)	*P*	Adj β*	(95% CI)	*P*
Forwarding COVID-19 information												
Seldom/sometimes	0			0			0			0		
Usually/always	1.27	(1.16, 1.38)	<0.001	1.04	(0.93, 1.16)	<0.001	0.97	(0.88, 1.06)	<0.001	0.82	(0.72, 0.92)	<0.001
Verifying COVID-19 information												
Seldom/sometimes	0			0			0			0		
Usually/always	0.65	(0.52, 0.78)	<0.001	0.51	(0.38, 0.65)	<0.001	0.53	(0.42, 0.64)	<0.001	0.43	(0.32, 0.55)	<0.001
	Crude β	**(95% CI)**	***P***	**Adj β****	**(95% CI)**	***P***	**Crude β**	**(95% CI)**	***P***	**Adj β****	**(95% CI)**	***P***
Always forwarding and verifying												
Neither	0			0			0			0		
Usually/always forwarding	1.25	(1.04, 1.47)	<0.001	1.07	(0.84, 1.30)	<0.001	0.93	(0.75, 1.12)	<0.001	0.82	(0.63, 1.01)	<0.001
Usually/always verifying	0.45	(0.29, 0.62)	<0.001	0.56	(0.35, 0.70)	<0.001	0.36	(0.22, 0.50)	<0.001	0.43	(0.29, 0.58)	<0.001
Both	1.64	(1.48, 1.80)	<0.001	1.56	(1.39, 1.73)	<0.001	1.28	(1.14, 1.41)	<0.001	1.25	(1.11, 1.40)	<0.001

Missing data were excluded.
Data were unweighted.
Always forwarding and verifying: A composite variable by combining forwarding and verifying COVID-19 related information into four groups: (1) neither (both seldom/sometimes forwarding and verifying), (2) always forwarding (& sometimes/seldom verifying), (3) always verifying (& seldom/sometimes forwarding), and (4) both (always forwarding and verifying).
*Adjusted for sex, age, SES score, and verifying and forwarding COVID-19 related information mutually.
**Adjusted for sex, age, SES score.

who is obsessed with COVID-19 may easily forward large numbers of messages to others with or without their consent. Passive recipients of the forwarded messages might find those messages irrelevant or overwhelming (10). Future studies should investigate how family members would respond to forwarded COVID-19-related information.

We found that compared with seldom/sometimes verifying COVID-19-related information, usually/always verifying such information before forwarding it to family members was associated with greater family wellbeing, which was also mediated by the quality of family communication. Verifying before forwarding may reduce the spread of misinformation and circumvent misperceptions related to COVID-19 (51, 52), contradictory information and conflicts (24), and psychological distress (20–23). However, many motives not to verify COVID-19-related information before spreading included perceived herd behavior (willingness to spread the information as many do so) (29), perceived COVID-19 severity and vulnerability (27), fear and health anxiety (28, 29), importance of messages (30), entertainment, ignorance (e.g., lack of awareness), altruism (31), and coping with information overload (29). A mixed-method study reported that Chinese older adults tended to forward unverified health-related information because their main purpose of forwarding the information was to maintain relationships rather than provide real information support (48). However, Chinese people find it challenging to correct a senior relative's forwarded misinformation because their culture emphasizes that elders should be respected (53). To reduce the spread of misinformation and contradictory information and to avoid conflicts, which will help promote family wellbeing, it is important to encourage individuals of all ages to verify COVID-19-related information before forwarding it to family members by addressing their motives. Moreover, future studies need to evaluate the moderating effect of specific verification methods on the association between forwarding COVID-19-related information and family wellbeing as we did not ask how the respondents verified COVID-19 information to evaluate its appropriateness and effects on family wellbeing.

The overall effects of forwarding COVID-19-related information on family wellbeing were greater than those of verifying such information (adjusted β: 0.82 vs. 0.43). We assumed that more frequent verification would lead to more accurate information, but only if appropriate sources were used. In addition to the frequency of information verification, eHealth literacy and verification sources are important factors associated with the accuracy of COVID-19-related information (7, 30, 54, 55). Future studies should confirm and compare the strengths of these associations and examine how sources of

TABLE 3 Adjusted indirect, direct, effect of forwarding, and verifying the COVID-19 information on family wellbeing *via* family communication ($N = 4,891$).

		Family wellbeing β^ (95% CI)
Forwarding [Ref: seldom/sometimes ($n = 2,304$)]	Indirect effect (through mediator)	0.71 (0.63, 0.79)***
	Direct effect (without mediator)	0.11 (0.05, 0.17)**
	Total effect (direct and indirect)	0.82 (0.72, 0.92)***
	Proportion of total effect mediated	86.6%
Verifying [Ref: seldom/sometimes ($n = 1,297$)]	Indirect effect (through mediator)	0.36 (0.26, 0.45)***
	Direct effect (without mediator)	0.08 (0.01, 0.14)*
	Total effect (direct and indirect)	0.43 (0.32, 0.55)***
	Proportion of total effect mediated	83.7%
		Family wellbeing β^^ (95% CI)
Usually/always forwarding and verifying [Ref: Neither ($n = 774$)]	*Indirect effect (through mediator)*	
	Usually/always forwarding ($n = 493$)	0.73 (0.57, 0.89)***
	Usually/always verifying ($n = 1,509$)	0.37 (0.22, 0.51)***
	Both ($n = 2,074$)	1.07 (0.94, 1.20)***
	Direct effect (without mediator)	
	Usually/always forwarding ($n = 493$)	0.09 (-0.03, 0.20)
	Usually/always verifying ($n = 1,509$)	0.07 (-0.02, 0.15)
	Both ($n = 2,074$)	0.18 (0.10, 0.27)***
	Total effect (direct and indirect)	
	Usually/always forwarding ($n = 493$)	0.82 (0.63, 1.01)***
	Usually/always verifying ($n = 1,509$)	0.43 (0.29, 0.58)***
	Both ($n = 2,074$)	1.25 (1.11, 1.40)***
	Proportion of total effect mediated	85.6%

Missing data were excluded.
Data were unweighted.
Socioeconomic score: a composite score of education, household monthly income per person, and housing analyzed as low (0–1), middle (2), and high (3).
Always forwarding and verifying: A composite variable by combining forwarding and verifying COVID-19-related information into 4 groups: (1) neither (both seldom/sometimes forwarding and verifying), (2) always forwarding (and sometimes/seldom verifying), (3) always verifying (and seldom/sometimes forwarding), and (4) both (always forwarding and verifying).
^Adjusted for sex, age, and SES score.
^^Adjusted for sex, age, SES score and verifying and forwarding COVID-19-related information mutually.
*P < 0.05; **P < 0.01; ***P < 0.001.

information verification and eHealth literacy are related to the quality of family communication and family wellbeing.

We did not observe any interaction between forwarding and verifying COVID-19-related information on family wellbeing. However, the additive effects (usually/always forwarding and verifying) resulted in the highest scores of family wellbeing, which were also greatly mediated by the quality of family communication. Whether the associations were causal warrants further studies.

Although the positive association of family wellbeing with forwarding and verifying COVID-19 information mediated by the quality of family communication, nearly 25% of the respondents seldom/sometimes forwarded as well as verified the information and only 40% usually/always did both. Therefore, there is an urge to advocate the importance of verifying and forwarding COVID-19 information to family in enhancing family communication and wellbeing during the COVID-19 pandemic. A moderate level of fear of COVID-19 in Hong Kong adults exits and ≈40% of them perceive COVID-19-related harms to their family (35, 36). Education, social, and health professionals should thus encourage people to verify and forward reliable COVID-19-related information to family to promote family communication and wellbeing during and after COVID-19 pandemic. Moreover, verifying COVID-19-related information from the Internet is challenging but essential to combat the infodemic; public health professionals should educate people about basic digital literacy (e.g., cross-checking different information sources, visiting reliable sources, visiting

the actual source instead of a website summary) to increase the ability of information verification (56, 57).

Our study had several limitations. First, all data were self-reported and subject to recall errors. Second, although the temporality of the associations could not be ascertained, the forwarding and verifying of COVID-19-related information was considered at an earlier time-point (during wave 2 of the pandemic) as compared with family communication and wellbeing (after wave 2). Thus, prospective studies are required to ascertain the associations noted in this study. Third, social desirability cannot be avoided in self-administered questionnaires; however, the respondents were recruited *via* email to complete the self-administered, anonymous online questionnaire, which could reduce social desirability in reporting forwarding and verifying COVID-19-related information (58, 59). Fourth, our sample had more educated respondents than the general population. Thus, the prevalence estimates, even after weighting, might not be generalizable to the general population. The educated group may be more digitally health literate (60) and thus more aware of the importance of information verification (30). However, only slight differences were found in the behaviors of forwarding and verifying COVID-19-related information and the family wellbeing between the unweighted and weighted samples.

Conclusions

We have first shown the association of family wellbeing with verifying and then forwarding COVID-19-related information to family members as well as a strong mediating effect of the quality of family communication. However, prospective studies are warranted to confirm the observed associations. Considering that the COVID-19 pandemic is still underway and causing stress and uncertainties with detrimental effects on families, public healthcare professionals should encourage the verification and forwarding of COVID-19-related information to family members to ensure family communication and wellbeing.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by Institutional Review Board of the University of Hong Kong/Hospital Authority Hong Kong West Cluster & Ref. no: UW 20-238. The patients/participants provided their written informed consent to participate in this study.

Author contributions

BW: Conceptualisation, Data curation, project administration, formal analysis and writing—original draft. SS and WG: Writing—review and editing. AL: Conceptualization and writing—review and editing. SH, MW, and TL: Supervision, conceptualization, and writing—review and editing. All the authors participated in the critical review of this study and provided final approval for the publication submission.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Supplementary material

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Maternal well-being and family adaptation during COVID-19 in fragile X syndrome

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Mothers of children with fragile X syndrome are at increased risk of experiencing anxiety and depression due to potential genetic risk and to stress associated with parenting a child with significant behavioral, emotional, and educational support needs. During the initial shutdown and subsequent restrictions of the COVID-19 pandemic, mothers of children with fragile X reported experiencing elevated levels of anxiety and depression relative to their usual levels of well-being. Many indicated that the negative consequences of exposure to COVID-19 and related stressors, as well as the impacts of the pandemic on their family, directly affected their anxiety and depression. Mothers reported on specific sources of distress as well as potential sources of resilience and positive adaptation that occurred during the first year of the COVID-19 pandemic.

KEYWORDS

anxiety, COVID-19, *FMR1* premutation, fragile X syndrome, adaptation

Introduction

This study examined the impacts of the COVID-19 pandemic on the mental health of mothers of children with fragile X syndrome. Fragile X syndrome is caused by an elongated CGG trinucleotide repeat on the *FMR1* gene, located on the X chromosome. Individuals with between 55 and 200 CGG repeats carry the premutation and individuals with >200 repeats have the full mutation (1, 2). Here, we focus on mothers of children with the full mutation (FXS), who are themselves carriers of the premutation or the full mutation. Current prevalence estimates suggest that as many as 1 in 151–208 women in the United States carry the premutation (3, 4).

Women with the *FMR1* premutation are at elevated risk for neuropsychiatric disorders, including anxiety and depression (5–9), and the stress of raising a child with FXS can exacerbate these symptoms (10–13). Specifically, mothers of children with FXS experience elevated rates of anxiety, depression, and affective disorders relative to mothers of children without disability (14, 15). They may also report more pessimism and concerns with the future, as well as increased family conflict, relative to mothers of

children with Down syndrome (16). As such, mothers who carry the *FMR1* premutation represent a group which may benefit from mental health services, especially during stressful or difficult periods.

The COVID-19 pandemic reached the United States in March 2020, causing communities across the nation to enact restrictions on public interaction, including school closures and restrictions of therapeutic services. Families of children with developmental disabilities were greatly impacted by these restrictions. Specifically, 52.3% of families of individuals with intellectual and developmental disabilities reported losing access to speech therapy, 57.2% to occupational therapy, 62.9% to ABA therapy, 73.6% to social skills services, and 89% to other recreation services (17). This immense loss in therapeutic services may have negatively impacted the mental health of families of children with neurodevelopmental disorders such as FXS.

Pandemic-related changes in social support and supplementary services may have compounded challenges in caring for a child with a disability that were already present pre-pandemic. During COVID-19, caregivers of children with intellectual disability reported experiencing significantly greater levels of anxiety and depression than caregivers of typically developing children, with over 40% of the former group endorsing moderate to severe levels of anxiety and depression compared to ∼ 10% of the latter (18). Additionally, anxiety and depression were negatively associated with measures of social support, household income, and house size (proxy for family size), and were positively associated with stress (caregiver, financial, and lockdown stress) (18). As such, the additional stress added by pandemic restrictions and loss of social support and services likely negatively impacted mental health in parents/caregivers of children with developmental disabilities.

Specific to families with FXS, one study reported that children with FXS experienced worsening sleep quality and increased behavioral problems during the first 5 weeks of the Italian full lockdown (19). Families also reported reduced access to external support and services. However, mothers did not report changes in their self-efficacy as parents. Although this study provided important information on how the COVID-19 pandemic has affected families with FXS, the authors did not directly probe mental well-being in mothers of children with FXS, who are at known increased risk of mental health problems. Furthermore, despite the stability in parental self-efficacy, there is a need to understand the specific challenges that parents and families of children with FXS have experienced during the COVID-19 pandemic.

Because mothers of children with FXS are at increased genetic risk of experiencing anxiety and depression, and because occurrence of anxiety and depression can be exacerbated by parenting stress and demands, the purpose of this study was two-fold: to characterize mental well-being of *FMR1* premutation mothers during the COVID-19 pandemic and identify potential sources of risk and resilience toward pandemic-related changes in mental health. This set of analyses utilizes a unique cohort of mothers of children with FXS who have been part of an ongoing longitudinal study of parenting and child development in FXS. As such, we considered current (i.e., pandemic) levels of anxiety and depression as well as changes relative to past levels, which enabled us to identify changes in mental health symptomology that is related to the COVID-19 pandemic and describe potential sources of risk and resilience for each family.

Methods

Participants

Thirty-six mothers of children with FXS provided data for these analyses. Their ages ranged from 41 to 59 years of age, with a mean age of 50.22. Two mothers had FXS, two had mosaicism for the pre- and full mutations, and the remaining 32 had the premutation. Among mothers with the premutation, the CGG repeat length ranged from 74 to 130, as confirmed through blood sample analyses. Because there were relatively few mothers with full mutation alleles, we did not consider maternal responses by genetic groups. Mothers were predominantly white and non-Hispanic (89%) and 61% had household incomes greater than $79,999. One mother was white and Hispanic, two were Black and non-Hispanic, and one was Black, Hispanic, and Pacific Islander. Children (8 girls) ranged in age from 16.6 years to 20.75 years of age, with a mean age of 19. Fifteen of the children had FXS and autism co-morbidity, as measured by the CARS and ADOS-2 [see Fielding-Gebhardt et al. (20) for more details].

Study procedures were approved by the University of Kansas Human Research Protection Program, which ensures all legal and ethical standards necessary to protect the rights, well-being, and privacy of research participants, and in accordance with IRB standards, participants provided informed consent prior to participating in research activities.

Procedure

The participants were part of an ongoing longitudinal study at the University of Kansas. In the parent study, mothers and their children with FXS were visited in their homes up to 8 times over a 17-year period, with one additional remote data collection conducted through the mail. Initial recruitment for the parent study took place through a parent listserv, a national registry, advertising at national conventions, and through parent support networks. Participants were initially recruited because they had a child with FXS.

For this study, data were collected remotely through the mail between October 2020 and January 2021. Pre-pandemic

average levels of anxiety and depression were calculated from two data collection visits (roughly 2012 and 2018) and one remote assessment (2015). Six participating families did not complete the remote assessment. Otherwise, all participants provided data at all time points.

Measures

Anxiety and depression

The Center for Epidemiological Studies – Depression scale [CES-D; Radloff (21)] was used to measure maternal symptoms of depression. This 20-item assessment asks mothers to indicate how frequently they have experienced symptoms of depression (e.g., feeling lonely, feeling sad, crying spells, etc.) over the past week. Items are scored on a scale from 0 to 3, with higher scores indicating more severe symptoms of depression. A clinical cut-off of 16 indicates that an individual with a score $\geq$16 may be at risk for clinical depression.

The original Profile of Mood States tension and anxiety subscale [POMS-TA; McNair et al. (22)] was used to measure maternal symptoms of tension and anxiety. There are 9 items on the tension and anxiety subscale which ask the mother to indicate how she was feeling during the past week. Items were scored from 0 to 4, with higher scores indicating more severe symptoms of anxiety. Nyenhuis et al. (23) reported a clinical cut-off of 17.2 (equal to 1.5 standard deviations above the standardization mean in a normative sample of adult women). Mothers with POMS-TA scores >17.2 were considered to have clinically significant symptoms of anxiety.

COVID-19 survey

The COVID-19 Exposure and Family Impact Scales [CEFIS; Center for Pediatric Traumatic Stress (24); Kazak et al. (25)] were used to measure families' exposure to COVID-19 and their perceptions of its impact. Mothers completed the survey between October 2020 and January 2021, between 7 and 10 months following the national outbreak of the pandemic and the onset of nationwide COVID-19 restrictions. Mothers were instructed to consider their families' experiences during the pandemic from March 2020 to present. For this survey, "families" referred to the mother, her child with FXS, those living in their household (i.e., father, siblings), extended family, and close friends who were considered like family. Because this measure was rapidly developed following the onset of the COVID-19 pandemic, at the time this manuscript was written there were no clinical cut-offs. However, normative data and psychometrics are provided in an article by Kazak et al. (25).

There are 25 CEFIS-Exposure items asking participants about exposure and related events such as stay at home orders, changes in income and/or employment, and whether family members contracted or had symptoms of COVID-19. Higher scores on the Exposure scale indicate higher exposure to potentially traumatic aspects of the pandemic. The CEFIS-Impact scale measures the perceived impact of the pandemic on the family. Ten CEFIS-Impact items are rated along a 4-point scale with higher scores indicating more negative impact. We included one additional item in the Impact scale, "How has the COVID-19 pandemic affected your emotional well-being, specifically depression?" In addition to the Exposure and Impact items, two CEFIS-Distress items are rated along a 10-point scale and assess the severity of COVID-19-related distress the mother and child each experienced. Again, higher scores indicate more distress. In addition to the CEFIS items, we asked mothers to elaborate on their answers to the Exposure and Impact scales. The final item on the CEFIS asks mothers to expand on their experiences during the COVID-19 pandemic and discuss other effects of COVID-19 not covered in the rest of the items.

The open-ended and elaboration questions were qualitatively coded using a conventional content analysis approach [Hsieh and Shannon (26)]. Two researchers (HF-G and SB-O) read all the responses and identified common themes in the qualitative answers. We then created a coding scheme (available upon request) based on these themes. Each researcher independently scored all participants' answers, and then compared scores. When there were disagreements on codes, the two researchers agreed by consensus.

Results

COVID-19 pandemic effects and changes

Mothers reported substantial individual differences in exposure to and impact of COVID-19. The average level of exposure on the CEFIS-Exposure scale was 7.61, with a range from 2 to 17. Over three-quarters of mothers reported that they had stay at home orders, their child's school was closed, their child's education was disrupted, or that they missed an important family event such as a vacation or graduation, see **Table 1**. Over half of the families had a family member who worked outside the home in an essential personnel role. The next most commonly endorsed CEFIS-Exposure items were (1) a family member was exposed to a positive COVID-19 case, (2) family self-quarantined due to travel or exposure, (3) family was unable to care for or visit another family member, and (4) family income decreased. The total number of mothers who endorsed each CEFIS-Exposure item is presented in **Table 1**.

The CEFIS-Impact scale contained 11 items, 10 in the original version of the assessment along with one additional item (depression) that was added for this study. Each CEFIS-Impact item was rated along a 4-point scale (1 = a lot better, 2 = a little better, 3 = a little worse, and 4 = a lot worse). Mothers could also select "N/A" which we interpreted to mean "does not apply to me/my family" or "no change." The distribution of scores is

presented in Figure 1. While most mothers reported positive changes in "getting along," many also reported negative impacts for most of the other items, including nearly 77% who reported worsening anxiety, 55% who reported worsening depression, and 74% who reported worsening mood. Anxiety, depression, and mood were all significantly more likely to be reported as "a little worse" or "a lot worse," while sleeping, eating, and getting along were significantly more likely to have improved, with mothers more frequently reporting these activities got "a little better" or "a lot better."

Mothers reported variable levels of distress associated with the COVID-19 pandemic both for themselves and for their children with FXS. Twenty mothers (55.6%) endorsed distress scores >5 (along a 10-point scale, with 10 indicating highest distress) for their own distress and 18 (50%) endorsed distress scores >5 for their child's distress.

TABLE 1 CEFIS-Exposure scale items and frequencies.

Item	Description	# Reporting	% Reporting
1	Stay at home order	33	91.7
2	Schools/childcares closed	36	100
3	Education disrupted	32	88.9
4	Unable to visit/care for family member	16	44.4
5	Family lived separately	7	19.4
6	Someone moved into home	3	8.3
7	Had to move out of home	0	0
8	Family member worked outside home/essential worker	21	58.3
9	Family member in healthcare providing direct care	8	22.2
10	Difficulty getting food	2	5.6
11	Difficulty getting medicine	0	0
12	Difficulty getting healthcare	3	8.3
13	Difficulty getting other essentials	7	19.4
14	Self-quarantined due to travel or exposure	16	44.4
15	Family income decreased	11	30.6
16	Family member cut back work hours	9	25
17	Family member required to stop working	8	22.2
18	Family member permanently lost job	6	16.7
19	Family lost health insurance/benefits	1	2.8
20	Missed and important family event	27	75
21	Family member exposed to positive COVID-19 case	14	38.9
22	Family member had symptoms or COVID-19 diagnosis	7	19.4
23	Family member hospitalized for COVID-19	3	8.3
24	Family member in ICU for COVID-19	2	5.6
25	Family member died from COVID-19	2	5.6

Anxiety and depression

We compared mothers' levels of anxiety and depression over time, specifically examining the differences between three pre-pandemic occasions and the COVID-19 occasion. Using mixed effect models, which are better able to account for expected within person covariance than repeated measure ANOVAs, we found that there were significant differences between pre-pandemic and pandemic era anxiety and depression scores. Average anxiety score during COVID was 9.89 (range 1–27) which was significantly higher than average anxiety scores in October 2017 (average = 6.92, range = 0–20, $p = 0.01$) and July 2015 (average = 6.93, range = 0–20, $p = 0.01$), but not significantly different than anxiety in December 2010 (average = 7.92, range = 1–23, $p = 0.08$). Depression scores were highest during COVID (average = 11.75, range = 1–38) and were significantly higher than in October 2017 (average = 6.89, range = 0–28, $p = 0.000$), July 2015 (average = 8.43, range = 0–29, $p = 0.01$), and December 2010 (average = 8.89, range = 0–27, $p = 0.03$).

In addition to elevated anxiety and depression scores during COVID, the distribution of scores increased, with more variability in the severity of symptoms. Figure 2 shows the distribution of mental health symptom scores prior to and during the pandemic. Three mothers (8.33%) met or exceeded the clinical cut-off on the POMS-TA prior to COVID-19, while six mothers (16.7%) had clinically significant symptoms of anxiety during the pandemic. Similarly, pre-pandemic, five mothers (13.89%) had clinically significant symptoms of depression on the CESD, but during the pandemic, ten mothers (27.8%) had clinically significant symptoms of depression.

Sources of risk and resilience during the COVID-19 pandemic

Maternal anxiety was associated with COVID-19 Exposure ($r = 0.41$, $p < 0.05$), maternal Distress ($r = 0.51$, $p < 0.01$), and child Distress ($r = 0.37$, $p < 0.05$), such that mothers experienced more anxiety when Exposure and Distress were higher. This trend was the same for maternal depression, with mothers experiencing higher depressive symptoms when Exposure and Distress were higher ($r = 0.46$, $p < 0.01$, $r = 0.54$–0.62, $p < 0.01$). There was a small subset of mothers who indicated their anxiety ($n = 5$) and/or depression ($n = 3$) had improved. Mothers who had improvements in mental health did not differ from the rest of the sample in their likelihood of having had children with co-morbid autism, having sons, having lower income, having their child with FXS in an in-school versus online-only education setting, or in working either part- or full-time.

In addition to the mothers who reported reduced anxiety and/or depression, there was a subset of mothers who indicated that the overall impact of COVID-19 was positive. Seven mothers indicated that the overall impact of COVID-19 was

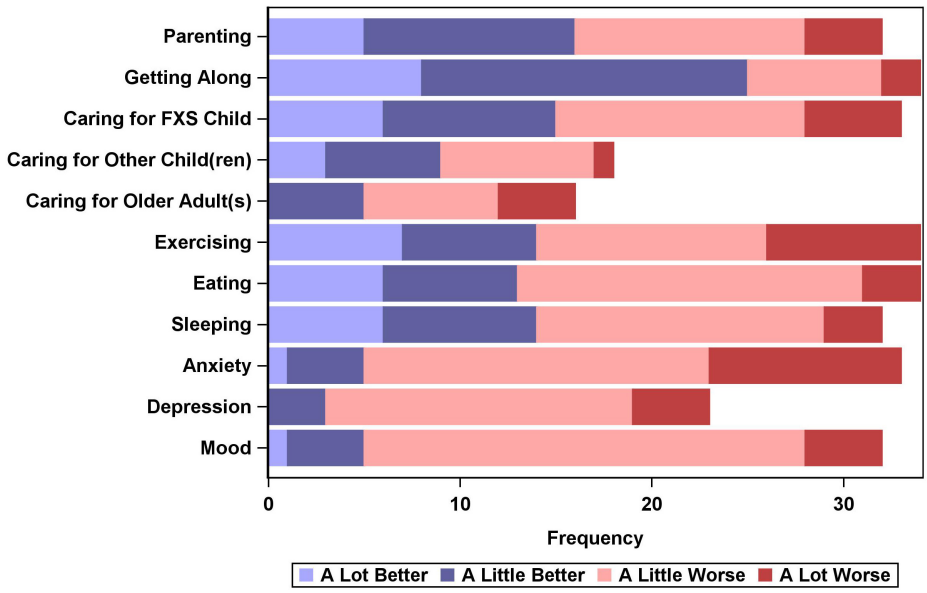

FIGURE 1
Distribution of CEFIS-impact scale item responses.

slightly positive, noting improvements in exercise (n = 5), eating (n = 6), and sleeping (n = 7). None of them reported clinically significant levels of depression or anxiety, nor did they face increased economic anxiety due to COVID-19. None of these mothers was the parent of a child with co-morbid autism, and none reported that their offspring experienced an increase in problem behavior or had difficulty with the change in routine or schedule.

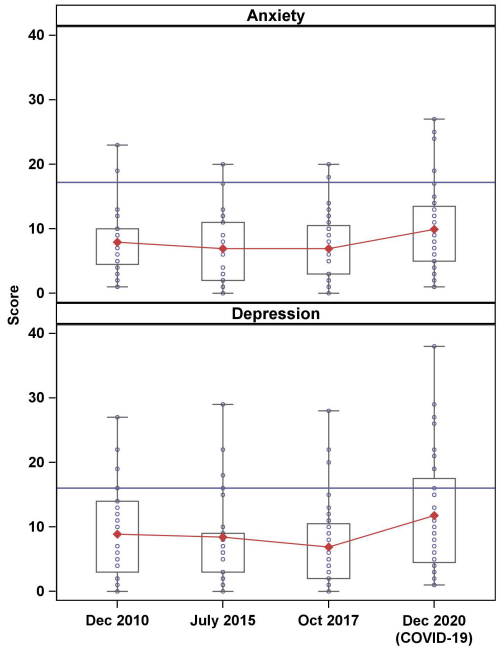

FIGURE 2
Distribution of anxiety and depression scores. Horizontal blue lines indicate clinical cut-offs and red lines connect mean scores over time.

The CEFIS open-ended questions were examined for shared themes on mothers' perceptions of the impact of the pandemic. Mothers' answers fell along several themes within two categories: sources of stress/negative effects and positive adaptation. Many mothers reported on difficulties and negative experiences during the COVID-19 pandemic. Mothers often offered explanations for the negative effects, including distress due to lack of social interaction for their child(ren) (n = 21, 58%); increased child stress and decreased child mental well-being (n = 8, 22%); concerning child behaviors (n = 4, 11%) and difficulties surrounding a lack of routine or schedule (n = 11, 31%). Furthermore, mothers also cited being stuck at home as a source of distress. See Table 2 for examples of mothers' reports from the open-ended questions. In contrast, many mothers reported that their child was able to positively adapt to the circumstances and that as a family they found positive experiences. Positive experiences during the pandemic period included increased family togetherness (n = 13, 36%), health improvements (n = 4, 11%), and child's ability to adapt (n = 6, 17%).

Discussion

The COVID-19 pandemic has had broad implications on mental health in general (27). Many mothers have taken

TABLE 2 Examples of COVID-19 associated difficulties and positive adaptations reported by mothers.

Sources of stress/negative effects
Reduction in access to services/activities (*n* = 8, 20%)
[He] missed his community outing with his habilitation aide. The aide changed several times during COVID. It was hard for the agency to keep and find staff. [He] craved school and the social interaction.
Lack of involvement in social activities like special Olympics is greatly missed.
Being home [he] could not do any sports, which he loves to go to basketball, bowling, soccer, baseball practices and games. All activities were canceled for kids. Losing all the sports activities. [He] was not happy at all.
Libraries closed and are still closed.
Social isolation (*n* = 21, 58%)
No social interaction has been hard.
They are very isolated as we have been strictly quarantined since March, rarely seeing family or friends.
Lack of social interaction with friends is distressing.
[He] misses other people and engagement besides immediate family.
Child well-being (*n* = 8, 22%)
[He] regressed, became agitated and always nervous, hard to calm. Worried a lot and watched news religiously. Very high anxiety.
It bothered [her] a lot. Lots of anxiety.
My son's anxiety and inability to enjoy activities has raised my anxiety.
In all my children, I saw and increase in anxiety and overall deterioration of mental health.
Child behaviors and regression (*n* = 4, 11%)
Behaviors resurfacing that haven't been seen in years.
Regressed in personal care areas.
Lots of increased stimming and big decrease in social skills.
Lack of routine (*n* = 11, 31%)
Feels like constant disruptions to their routines and no community interaction.
Disruption in routine has been moderately difficult.
Every cancelation would bother [her]. She likes routine. She kept saying she's going to "fight COVID and find a cure."
Family dynamics and conflict (*n* = 6, 17%)
My [non-FXS] son couldn't take virtual classes at home with a loud sibling- he had to go study in my mom's basement.
The only other thing not mentioned is probably just everyone being home all the time together, we don't get time to ourselves much as often. Mom and Dad are irritable, probably especially Mom. For instance, Dad is working from home and on a conference call right now and dog is barking at the squirrel outside. Mom is trying to get typical son out of bed for remote learning while trying to keep dog quiet.
Our house seemed smaller and smaller. Our 10- and 5-year-old with FX[S] seemed loud and stressful. It caused marriage stress. Had LOTS of trouble getting respite workers.
Being all together at home while trying to work or go to school has been difficult.
Positive adaptation
Family togetherness (*n* = 13, 36%)
It was great to get back to spending time together and eating all meals together.
With both of my children home we are all (parents included) communicating better. With little "hurry to this activity" between meals, etc., we are able to slow down and get clearer responses. Often thoughtful in a manner different than the past.
We did spend more quality time together – eating as a family, playing games.
On positive side- spent more time together as a family. We got to see online what my daughter is being taught. From speech, I learned how important PEC cards are – I created a schedule and menu of FX child's favorite foods.
We've played a lot of games, slowed down, sent a lot of cards, and had a lot of long talks – all good. Both houses got puppies – also good.
The time together at home as a family was great b/c we unplugged and had more quality time.
It was great to get back to spending time together and eating meals all together
Health improvements (*n* = 4, 11%)
We all lost weight and exercise more because we have more time.
We've incorporated puzzles, daily reading, and exercise which has been great.
We sleep more, prepare better meals, spend more time together.
Child adaptation (*n* = 6, 17%)
He adapted very well to remote learning. He missed seeing his teachers/peers when school closed. Disappointed that other things changed but did pretty well adjusting.
My youngest son with FXS did online until school went in-person. He adapted beautifully and loves it all.
She is happy to be a quarantine champion because she doesn't want to be in a COVID isolation sick.

on a higher burden of responsibility for childcare and have reported difficulty balancing work, childcare, and other family responsibilities, often to the detriment of their own mental health. Mothers in the general population have reported elevated anxiety and depression in the context of COVID-19 (28). Here, we demonstrate that mothers with the *FMR1* premutation had trouble adapting and coping during the pandemic, potentially resulting in decreases in mental well-being, but that many found sources of resilience and positive adaptation to the pandemic.

Although deterioration of mental health with age has been noted in *FMR1* premutation carriers (6, 9), our findings suggest that increases in anxiety and depression here were

likely due to COVID-19 pandemic and associated stress, as our sample has demonstrated relative stability in mental health symptomology over time (11). The comparison between previous levels of anxiety and depression with COVID-19 pandemic levels, along with the number of mothers experiencing worsening anxiety and depression, suggest that the increase in symptoms of anxiety and depression is directly associated with the COVID-19 pandemic in our sample. Furthermore, mothers of children with neurodevelopmental disabilities such as FXS, may be at increased risk for mental health problems in general (9, 16, 29, 30), which could have been further aggravated during a global pandemic. Indeed, caregivers of children with intellectual disabilities experienced higher anxiety and depression than caregivers of children without intellectual disabilities during the COVID-19 pandemic (18). In one report, 44% of parents of children with special educational needs and disabilities reported feeling anxious during the pandemic, and a subset also reported feeling overwhelmed and fearful (31). Mothers in our sample were no exception, with many reporting elevated symptoms of anxiety and depression.

In addition to their own mental health concerns, mothers also reported concerns about their children's well-being and behavior and about family dynamics, which is consistent with other studies on families of children with neurodevelopmental disabilities during COVID-19 (17, 18, 32). Specifically, families of children with autism have expressed concerns about their child being home all the time, about becoming sick, and about finances (32) – sentiments which were echoed in our families of children with FXS. Additionally, families of children with special educational needs and disabilities have reported stress due to caregiving demands, child behavior, changes in routine, and social isolation (31) – concerns which were again echoed in our sample.

One area of concern that has been highlighted during the COVID-19 pandemic is access to therapeutic, educational, and recreational services. Jeste et al. (17) reported a large drop in service availability during the early months of the pandemic, and Manning et al. (32) reported on the concerns of families of children with ASD, including school absence and worry about therapeutic services. All 36 families in our sample reported that schools or childcares closed in-person services, and nearly 90% reported that their child(ren) experienced disruption to their education. Many mothers also cited distress over reduced access to specific services and activities such as Special Olympics (**Table 2**).

Although we report on a unique cohort of mothers and children with FXS, there are several limitations to our study. Primarily, our sample is limited in racial, ethnic, and socioeconomic diversity. Given the racial health disparities seen in the United States and differences in access to care across communities, we cannot generalize our findings to all mothers of children with FXS. Our findings are further limited in scope as we did not compare maternal well-being and the impact of the COVID-19 pandemic in families of children with typical development. Additionally, data presented here were collected at the end of 2020, well before the Delta and Omicron waves began, so estimates of COVID-19 exposure and impact are likely to have changed since that time. However, our data do provide a compelling snapshot into the experiences of families with FXS at that time and highlight the support needs of all family members during difficult periods.

It is widely understood that the COVID-19 pandemic has had profound impact on the well-being of families, especially those of children with disabilities. Although many of our families experienced common negative consequences from the pandemic, many also reported positive adaptations. Mostly, mothers reported increased feelings of family togetherness, as they were able to take advantage of the shutdowns and spend more time with their children and partners, similar to other studies (31). Our families reported positive effects, such as the child's ability to adapt to at-home learning and the family's ability to slow down and improve their overall health. Thus, although the global pandemic has had incredible negative effects worldwide, there were still positives to be found in otherwise difficult situations. Our findings highlight the need to support families of children with developmental disabilities, specifically maternal mental health and access to services.

Data availability statement

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

Ethics statement

The studies involving human participants were reviewed and approved by the Human Research Protection Program at the University of Kansas. Written informed consent to participate in this study was provided by the participants' legal guardian/next of kin.

Author contributions

HF-G executed the study idea, collected, prepared, and analyzed the data, wrote the first draft of the manuscript, and incorporated comments and feedback from the co-authors. RSR prepared and analyzed the data and helped with the first and subsequent drafts of the manuscripts. SB-O collected and prepared the data and reviewed the manuscript. NB and SW collaborated in all stages and reviewed the manuscripts.

All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Adverse events following immunization of COVID-19 vaccine among children aged 6–11 years

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Introduction: Starting in December 2021, the Indonesian Government has recommended inactivated SARS-CoV-2 vaccine (CoronaVac) for children aged 6–11 years. This study aims to determine the prevalence and determinant factors of adverse events following immunization (AEFI) of the first dose and the second dose of the COVID-19 vaccine among children aged 6–11 years old.

Materials and methods: We conducted a cross-sectional study in Bantul District, Yogyakarta, Indonesia, in February–March 2022. Data were collected by trained interviews with 1,093 parents of children 6–11 years old who received the first dose and the second dose of the COVID-19 vaccine. Data were analyzed with chi-square and logistic regression.

Results: The prevalence of AEFI in the first dose of the COVID-19 vaccine was 16.7%, while the second dose was 22.6%. The most common symptoms of AEFI at the first dose were local site pain and fever, while at the second dose were cough and cold. Determinants of AEFI of COVID-19 vaccination among children were girls with OR 1.31 (95% CI 1.0–1.7; *P* 0.04), mass-setting of vaccination with OR 0.70 (95% CI 0.5–0.9; *P* 0.01), the history of AEFI in childhood vaccination with OR 1.63 (95% CI 1.2–2.2; $P < 0.01$) and administering other vaccines within 1 month before COVID-19 vaccination, with OR 5.10 (95% CI 2.1–12.3 $P < 0.01$).

Conclusion: The prevalence of AEFI in the first and the second dose of inactivated COVID-19 vaccine was comparable to that reported in the clinical trial study and the communities. Risk communication should be provided to the child and their parents regarding the risk of mild AEFI of the COVID-19 vaccine, especially for children with a history of AEFI in childhood vaccination and who received other vaccines containing the same adjuvant with CoronaVac within 1 month. A mass-setting of vaccination should be taken as an advantage to educate parents about the risk of AEFI and also about the reporting pathways.

KEYWORDS

AEFI, COVID-19 vaccine, children, prevalence, determinant factors

Introduction

Coronavirus 2019 (COVID-19) is a newly emerging disease and was announced as a global pandemic on March 2020 (1). Confirmed cases of COVID-19 have been reported by almost all countries globally, including Indonesia. Until early June 2022, this disease has infected more than 550 million people worldwide and caused more than five million deaths (2). While in Indonesia, more than 6 million people have been infected, with more than 150,000 deaths (3).

Vaccination against Coronavirus Disease (COVID-19) is one of the efforts taken to accelerate the occurrence of herd immunity and break the chain of transmission of COVID-19 (4). Nowadays, Indonesia has used 10 brands of COVID-19 vaccine designated for 208,265,720 civilians divided into four steps until March 2022 (5). At the end of 2021, vaccination coverage in Indonesia reached 77.3% for dose one and 54.6% for dose two (6).

Compared to adults, children and adolescents infected with SARS-CoV-2 are more likely to be asymptomatic or have milder symptoms with a lower risk of mortality (7), especially because children aged 6–11 years are in the process of alveologenesis and microvascular (8). However, those with underlying health comorbidities might be at risk for severe COVID-19, such as the multisystem inflammatory syndrome (9). In addition, children and adolescents can be important transmitters of SARS-CoV-2 in communities. Therefore, including children in the implementation of COVID-19 vaccination may give indirect benefits through community protection or herd immunity (7).

Starting in December 2021, the Indonesian Government has recommended the COVID-19 vaccine for children aged 6–11 years (10). Children aged 6–11 years are one of the targeted people to get vaccinated using one type of vaccine, namely CoronaVac, which is an inactivated virus vaccine developed by Sinovac Life Sciences (Beijing, China) by injecting intramuscularly in the upper arm at a dose of 0.5 ml (11) with two doses of 28 days intervals between doses (12). In the double-blind, randomized, controlled, phase 1/2 clinical trial, the CoronaVac was well tolerated and safe and induced humoral responses in children and adolescents aged 3–17 years (13).

In the Special Region of Yogyakarta by 30 June 2022, Bantul District was the second-largest contributor of COVID-19 cases with a total of 68,625 cases with 67,111 recovered (97.8%) and 1,506 deaths (2.2%) (14). A screening survey of COVID-19 in school settings in the Bantul District showed that the prevalence of COVID-19 infection was 4.2%, with unvaccinated status at risk of being infected in schools (15).

Along with increasing immunization coverage, there are also adverse events following immunization (AEFI), which is an untoward medical occurrence that follows vaccination and does not necessarily have a causal relationship with vaccine usage (16). There is not all kind of AEFI that is only vaccine-related but also anxiety-related due to immunization stress reaction, accidental, or procedural error (17). AEFI problems are closely related to public perception about the efficacy and safety of the vaccine. This is one of the factors related to the community's decision to accept or reject the vaccine. Vaccine refusal contributes to reduced vaccine coverage and herd immunity, leading to centralized outbreaks or pockets of infection in a specific group (18).

The National Agency of Drug and Food Control of Indonesia has issued an Emergency Use Authorization (EUA) based on studies of clinical trials phases 1, 2, and 3 on the safety and efficacy of the COVID-19 vaccine (19). From the clinical trial phase 1/2 CoronaVac showed a good safety profile and immunogenicity in children aged 3–17 years, the prevalence of adverse events was 27%, and most of them were mild and moderate in severity (13).

Du et al. conducted a systematic review and meta-analysis, which included six randomized controlled trials: three mRNA vaccines, two inactivated vaccines, and one adenoviral vector vaccine, assessing the safety, immunogenicity, and efficacy of the COVID-19 vaccine in children aged 3–17 years old. The study found that compared with mRNA vaccines and adenovirus vector vaccines, inactivated vaccines have a more satisfactory safety profile, both after initial and booster doses (20). As a new vaccine, it is necessary to know its security once implemented in a broader population. In addition, assessing the risk factors of AEFI in COVID-19 vaccination for children aged 6–11 years is essential. The study aims to assess the prevalence of inactivated COVID-19 vaccine AEFI and its determinants in children aged 6–11 years.

Materials and methods

We conducted a cross-sectional study in Bantul District, Yogyakarta, Indonesia, in February 2022. Before the study was conducted in early February 2022, vaccination coverage for children aged 6–11 years in Bantul District reached >90% for dose one. To achieve high coverage, vaccination is given in schools or the public service area. In total, 74.982 children aged 6–11 years were vaccinated during the vaccination drive. The first dose was given from December 2021 to January 2022. The second dose was administered after 28 days after the first dose. All recipients are routinely monitored at study sites for 15–30 min post-vaccine administration as part of the standard operating procedure for vaccination (12). Before administering a vaccine, there is a screening process to gather information about flu-like symptoms 7 days before and history of COVID-19 infection as well a history of close contact with a COVID-19 case. Vaccination officers can decide not to vaccinate children who have flu-like symptoms, are in close contact, or have a history of COVID-19 infection within a certain agreed time (11).

The target population was children aged 6–11 years who received the inactivated COVID-19 vaccine (CoronoVac) in Bantul District, which is 74,982 (21). Samples were those who met inclusion criteria (who received the second dose of the COVID-19 vaccine) and were obtained with stratified random sampling by clustering schools or other vaccination sites based on their regional characteristics (rural and urban). A cluster sample was taken from each list of vaccination sites using an MS Excel 365 random number generator.

We used an XLSForm from Microsoft Excel to develop the questionnaire and then upload it to the KoboToolbox, an electronic questionnaire developed by GitHub, Inc (22). All data collection can be taken online or offline, but a network connection is required to upload finalized forms. When all data collection has finished, then we export and download the final data into XLS format and enter it into Microsoft Excel for the cleaning and coding process before importing it to STATA 16. We use limiting parameters such as respondents' age must be at least 20 and set up a conditional question to minimize error in the data entry process. Enumerators could access the e-questionnaire through a web link, but KoboToolbox requires a username and password for accessing data and managing the data. While electronic forms have risks to ensure their reliability, validation is done by telephone when they find an input error so that respondents will be asked to provide their mobile number.

The questionnaire was developed based on the AEFIs standard set by the Ministry of Health of Indonesia (11) and consists of demographic characteristics (age, gender, parents' education level, parents' occupational, residency, school strata, and vaccination place), medical anamnesis (history of AEFI, comorbidities, history of post-confirmed COVID-19), vaccine-related anamnesis (history of administering another vaccine 1 month before) and any post-vaccine-related symptoms or AEFI by a recall for 14 days after receiving the second dose.

We define parents' educational level as elementary to junior high school (± 9 years of study) and senior high school to higher education (>9 years of study). Vaccination place was defined as limited settings, which are limited space in a homogeneous situation, such as school and public health center buildings, and mass-settings, which are open spaces in heterogeneous situations, such as village hall, park, or other multipurpose building. Comorbidities were defined as chronic diseases under treatment (11).

The questionnaire was piloted among 48 parents who have children aged 6–11 years and were not part of the sample. Trained enumerators collected data from the caregivers while waiting for their children to receive the second dose of the COVID-19 vaccine. The person-to-person interviews aim to recall AEFI in the first dose, then the caregiver will be asked for permission to conduct another phone-based interview 14 days later to follow up on AEFI of the second dose. The respondents are parents/guardians of children aged 6–11 years who received the COVID-19 vaccination in the Bantul District.

The minimal sample size required for the study was estimated to be 455 per cluster [urban and rural (23)], anticipating that 18.1% of study subjects will have AEFI with a 5% level of significance, 5% absolute error margin at a 95% confidence interval, and non-response estimates due to refusal or loss to follow up by 20%, so the minimum sample size was equal to 1,092 children and their parents/guardians. The inclusion criteria for this study were children aged 6–11 years who were accompanied by their parents/guardians who lived in Bantul District and had received vaccination in Bantul District. The exclusion criteria were incomplete information.

The data analysis was carried out on 1,093 subjects for the first dose and 972 subjects for the second dose (Figure 1). AEFI events as a dependent factor will be considered once for every child, so whenever children experience AEFI at both doses of CoronaVac, it will be counted as one event. The data was analyzed statistically by STATA 16 using the chi-square test and logistic regression. Variables with a $P < 0.25$ was continued into the multivariate analysis and considered significant if the $P < 0.05$.

Ethical approval was obtained from the Ethical Committee Faculty of Medicine, Public Health, and Nursing ethics committee, Universitas Gadjah Mada, with registration number KE/FK/0112/EC/2022. Written informed consent was obtained from the parents as respondents represent their children. Participation was voluntary, and confidentiality was ensured.

Results

Among 1,159 respondents who met the inclusion criteria, 66 (6%) respondents were excluded: 36 children (3%) due to an age of <6 years or more than 11 years. Nine children (1%) lived outside Bantul District and 21 children (2%) were not accompanied by their parents. A total of 1,093 children were recruited. A phone-based interview was conducted 14 days after the second dose, 121 respondents must be excluded due to being unresponsive while being contacted by enumerators nor do not have a cellphone (Figure 1). Based on Table 1, most respondents (79.4%) were mothers, and mostly had senior high school or higher education levels (71.1%). The most frequent occupation of the respondents was in the informal sector (82.9%).

Five hundred and sixty-one out of 1,093 (51.3%) children were male, with an average age of 8 years. Most children did not have comorbidities (97.4%) and did not receive any other vaccinations within 1 month before receiving the COVID-19 vaccination (97.4%). Most children did not have a history of AEFI in childhood vaccination (77.2%). Before children were scheduled to receive COVID-19 vaccination, 3.9% of children had a COVID-19 diagnosis (Table 1).

We found that 182 out of 1,093 (16.7%) children reported AEFI after the first dose, 220 out of 972 (22.6%) children reported AEFI after the second dose, and 46 children

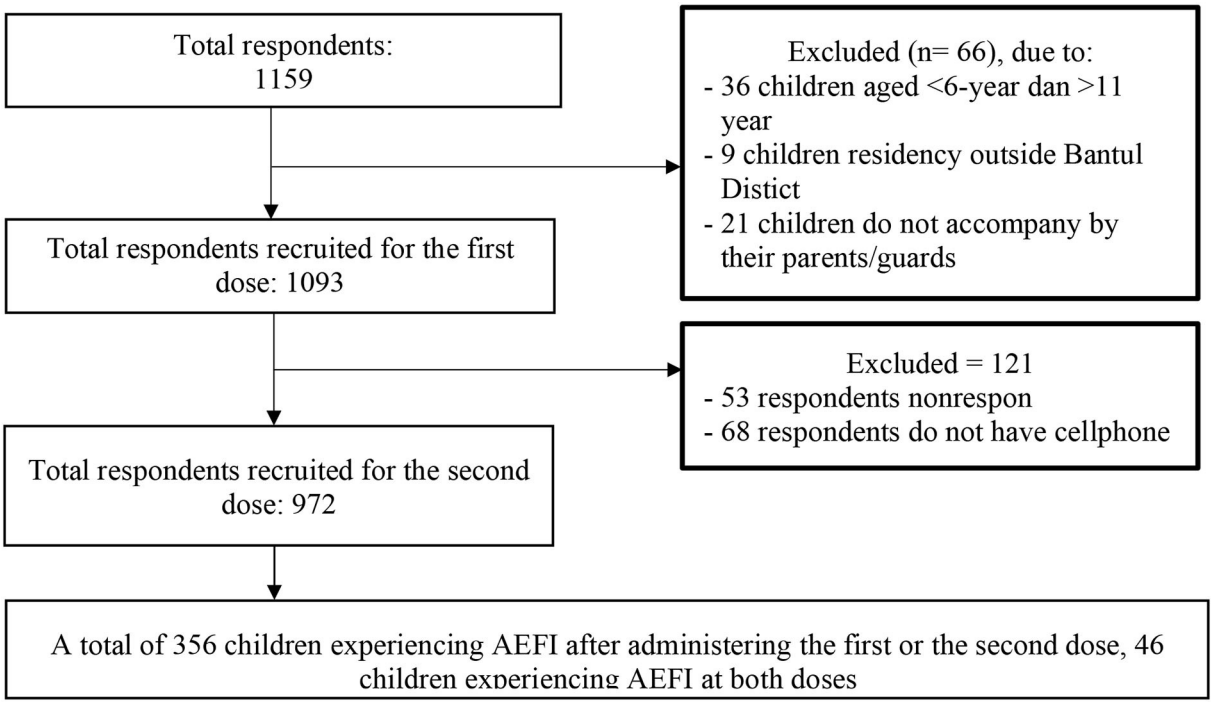

FIGURE 1
Respondents recruitment process.

experienced AEFI after the first and second doses. All symptoms were considered mild to moderate. In the first dose, most symptoms were local reactions such as pain at the injection site (7.2%), and systemic responses such as fever (5.2%), while in the second dose, most symptoms were systemic symptoms such as cough (11.8%) and common cold (9.2%) (Figure 2). A total of 18 (9.9%) and 35 (15.9%) children visited health providers to get treatment due to their AEFI. We found several rare symptoms such as hungry (3.0%) and sleepiness (1.1%) in the first dose. The symptoms of AEFIs in both doses are commonly observed on the same day of the vaccination and last mostly until the fourth day after that (Table 2).

Girls, mass-setting for the place of vaccination, having a history of AEFI in childhood vaccination, and administering another vaccine within 1 month have a significantly higher risk of AEFI of the COVID-19 vaccine in children aged 6–11 years (Table 3).

Discussion

We define adverse events following immunization (AEFI) as any untoward medical occurrence, which follows immunization that may be any unfavorable or unintended sign, abnormal laboratory finding, symptom, or disease (17). This study found that the prevalence of AEFI in the first dose vaccination is 16.7 and 22.6%, which is in line with the finding from the first and second phases of trials of CoronaVac (13). Meanwhile, another study in Pakistan found a higher rate of 33.5% after administering the first dose of inactivated COVID-19 vaccine Sinopharm (24). We found that the most common AEFI symptom was pain at the injection site, similar to the finding from the clinical phase study of the CoronaVac vaccine (13, 25) and other previous studies (24, 26). However, a high number of cough and common cold was found after the second dose of the COVID-19 vaccine. Although these two symptoms have been reported in phase clinical trials 1 and 2 of CoronaVac (27), it may also be a coincidence with COVID-19 infection. During the second dose vaccination period, the COVID-19 pandemic was entering the waves of omicron variants in Indonesia (28).

We also found some AEFI symptoms that are not stated on the manual vaccine of CoronaVac, such as sleepiness and hungry. Supangat et al. (29) reported that sleepiness was the second most common systemic effect among Indonesian medical clerkship students after receiving the CoronaVac vaccine. Another study by Franck et al. (30) found that sleep duration in the first 24 h after immunization was increased. Hendarto et al. (31) and Rachman et al. (32) found that feeling hungry is one of the AEFI symptoms reported by Indonesian CoronaVac recipients. Sleepiness may be explained by the immune response activated by

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TABLE 1 Characteristics respondents and children.

Variable	Categories	*n* (%)
Respondents		
Relation with children	Father	173 (15.8)
	Mother	870 (79.4)
	Other	50 (4.6)
Gender	Male	183 (16.7)
	Female	910 (83.3)
Age (year)	Early adulthood (20–40)	730 (66.8)
	Middle adulthood (41–60)	356 (32.6)
	Late adulthood (>60)	7 (0.6)
Education	Elementary-junior high school	316 (28.9)
	Senior high school-higher education	777 (71.1)
Occupation	Informal	906 (82.9)
	Formal	187 (17.1)
Residency	Urban	480 (43.9)
	Rural	613 (56.1)
Vaccination site	Limited setting	726 (66.4)
	Mass setting	267 (33.6)
Children		
Gender	Male	561 (51.3)
	Female	531 (48.7)
Age (years)	6	323 (21.2)
	7	207 (18.9)
	8	219 (20.0)
	9	162 (14.8)
	10	146 (13.4)
	11	127 (11.6)
School status	Public	770 (70.4)
	Private	323 (29.6)
History of AEFI in childhood	Yes	249 (22.8)
	No	844 (77.2)
Comorbidities	Yes	25 (2.6)
	No	1,065 (97.4)
History of COVID-19	Yes	43 (3.9)
	No	1,050 (96.7)
Administering other vaccines within 1 month before	Yes	28 (2.6)
	No	1,065 (97.4)

the vaccine, such as stress-related modulation of cytokine production by activated T cells that may enhance an inflammatory response to the hypothalamus response to vaccination (33). Sleep duration after vaccination may influence the immune response and boost the virus-specific adaptive cellular immunity (34). A similar mechanism through activated immune response may explain hungry after immunization.

TABLE 2 Time observed of onset and duration of adverse event following the first and the second dose of CoronaVac vaccine for children aged 6–11 years.

Day observed	First dose		Second dose	
	Onset *n* (%)	Duration *n* (%)	Onset *n* (%)	Duration *n* (%)
0	144 (79.1)	86 (47.3)	73 (33.2)	12 (5.5)
1	15 (8.2)	56 (30.8)	26 (11.8)	32 (14.5)
2	2 (1.1)	26 (14.3)	16 (7.3)	49 (22.3)
3	1 (0.5)	5 (2.7)	8 (3.6)	35 (15.9)
4	1 (0.5)	3 (1.6)	11 (5.0)	45 (20.5)
5	–	3 (1.6)	10 (4.6)	14 (6.4)
6	–	1 (0.5)	18 (8.2)	11 (5.0)
7	6 (3.3)	2 (1.1)	20 (9.1)	6 (2.7)
8	1 (0.5)	–	8 (3.6)	3 (1.4)
9	–	–	13 (5.9)	4 (1.8)
10	–	–	1 (0.5)	0 (0.0)
11	–	–	3 (1.4)	1 (0.5)
12	–	–	4 (1.8)	0 (0.0)
13	1 (0.5)	–	3 (1.4)	2 (0.9)
14	2 (1.1)	–	3 (1.4)	6 (2.7)
>14	9 (4.9)	–	3 (1.4)	

Some allergic reactions such as nausea and vomiting also appeared. These two symptoms are appropriate for non-anaphylactic allergic reactions that may be caused by non-human proteins, preservatives, or stabilizers in vaccine formulas (27). Symptoms of AEFI mostly appear on the same day after receiving the first dose and recover within 1–4 days. This finding is slightly different from findings of other COVID-19 inactivated virus vaccine that reports that many AEFIs occur in 1–7 days and recover in 2 days (13, 24, 35).

A study about Chad0x1 (AstraZeneca) as an activated-virus vaccine in children aged 6–17 years is slightly different with the loss of appetite symptoms, but the most frequent local symptoms are pain and tenderness. While in systemic symptoms, fatigue and headache were commonly reported. However, no severe symptoms found (36). Another study in the community also found the same results for the symptoms, although it was conducted in an older age (26, 35).

History of AEFI in childhood vaccination was significantly associated with the occurrence of AEFI after administering the first dose. This finding may be related to the manufacture of the vaccine itself, while some vaccines received by children when childhood have the same type as CoronaVac, which is inactivated virus (37). Especially, when children have a history of allergy to a vaccine component, it may increase the risk of AEFIs (38). Another study explained that a history of pain at site injection and fever after vaccination might increase the risk for recurrent AEFI with less or the same severity (37).

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TABLE 3 Determinants of adverse events following of CoronaVac vaccine for children aged 6–11 years.

Variable	AEFI	No AEFI	Univariate			Multivariate		
	n = 356 (%)	*n* (%)	OR	95% CI	*P*-value	OR	95% CI	*P*-value
Gender								
Male (561)	166 (29.6)	395 (70.4)	1	–	–	1	–	–
Female (532)	190 (35.7)	342 (64.3)	1.32	1.0–1.7	0.03*	1.31	1.0–1.7	0.04*
Age group								
6–8 years (658)	219 (33.3)	439 (66.7)	1.08	0.8–1.4	0.54			
9–11 years (435)	137 (31.5)	298 (68.5)	1	–	–			
School stratum								
Public (770)	253 (32.8)	517 (67.1)	1	–	–			
Private (323)	103 (31.9)	220 (68.1)	0.96	0.7–1.3	0.75			
Residency								
Urban (480)	158 (32.9)	322 (67.1)	1	–	–			
Rural (613)	198 (32.3)	415 (67.7)	0.97	0.7–1.3	0.83			
Parent's educational level								
Elementary (316)	92 (29.1)	224 (70.9)	0.79	0.6–1.1	0.12	0.82	0.6–1.1	0.17
Senior and higher (777)	264 (34.0)	513 (66.0)	1	–	–	1	–	–
Parent's occupational								
Informal (906)	290 (32.0)	616 (68.0)	0.86	0.6–1.2	0.38			
Formal (187)	66 (35.3)	121 (64.7)	1	–	–			
Vaccination took place								
Limited setting (739)	257 (34.8)	482 (65.2)	1	–	–	1	–	–
Mass setting (354)	99 (278.0)	255 (72.0)	0.73	0.5–0.9	0.03*	0.70	0.5–0.9	0.01*
History of AEFIs in childhood vaccination								
Yes (249)	105 (42.2)	144 (57.8)	1.72	1.3–2.3	<0.01*	1.63	1.2–2.2	<0.01*
No (844)	251 (29.7)	593 (70.3)	1	–	–	1	–	–
Comorbidities								
Yes (25)	11 (44.0)	14 (56.0)	1.65	0.7–3.9	0.22	1.25	0.5–2.9	0.59
No (1,068)	345 (32.3)	723 (67.7)	1	–	–			
Administering other vaccines								
Yes (28)	21 (75.0)	7 (25.0)	6.5	2.6–18.3	<0.01*	5.10	2.1–12.3	<0.01*
No (1,065)	335 (31.5)	730 (68.5)				1	–	–
History of COVID-19								
Yes (43)	13 (30.2)	30 (69.8)	0.89	0.4–1.8	0.74			
No (1,050)	343 (32.7)	707 (67.3)	1	–	–			

*P-value<0.05.
AEFI, adverse event following immunization.

We found that children with a history of administering other vaccines within 1 month before the COVID-19 vaccination had a higher risk of having AEFI. This might be explained by the accumulation of aluminum adjuvant, which can trigger a local inflammatory reaction and less often causes systemic effects such as exacerbation of autoimmune diseases and allergies (18). One month before the administration of the COVID-19 vaccine, there was a school child immunization month (BIAS) program using diphtheria–tetanus (Dt) vaccine for students in grade 1 and tetanus–diphtheria (Td) vaccine for the students in grade 2 and 5 of elementary schools. Both vaccines are inactivated vaccines containing an aluminum adjuvant, which is needed to enhance the immune response.

WHO has recommended co-administering the COVID-19 vaccine with another vaccine with a minimum interval of 14 days, but there was a study about influenza vaccine co-administering with the COVID-19 vaccine increased the risk for AEFI (39, 40).

Mass-setting for a place of vaccination may be related to anxiety-related AEFIs that were reported by Loharikar et al. (41) can occur in individuals receiving vaccinations by seeing their friend whose fear of needles and experiencing pain. This

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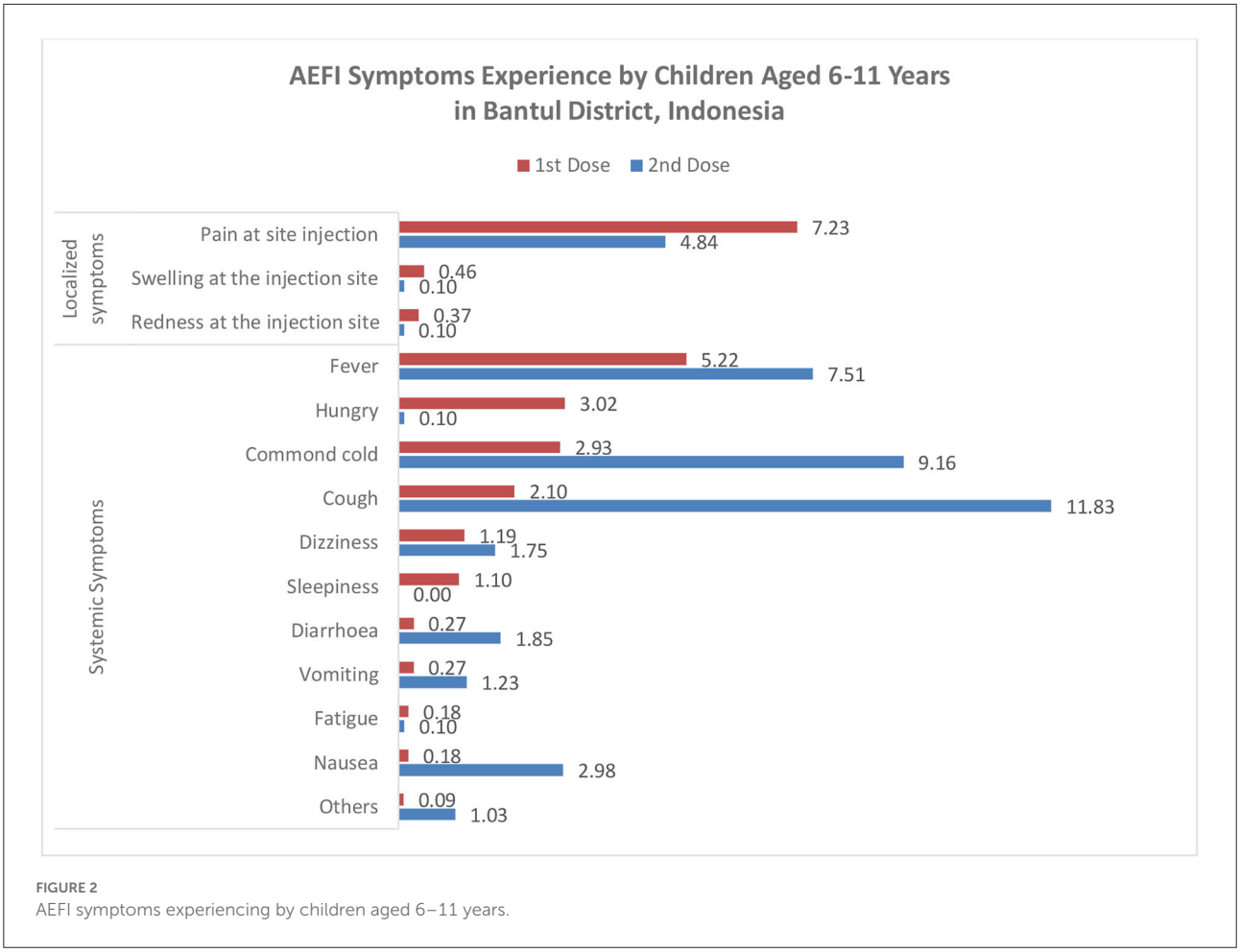

FIGURE 2
AEFI symptoms experiencing by children aged 6–11 years.

stimulation may decrease heart rate and vasodilation, cerebral hyperfusion, and the worst is a temporary loss of consciousness. The finding in this study was the opposite, mass-setting has a lower risk for AEFI. This may be due to the safety perception that mass-setting with a large number of health workers or staff support allows children to easily access get treatment while they are experiencing an AEFI (42).

Females are related to a tendency to report AEFI more than males also found in another study in communities (25, 43, 44). Besides, Bae et al. (44) *hypothesize* this finding as differences in immunological response between females and males, but this finding should be investigated more in the future study.

Strength and limitation

To the best of our knowledge, this study is the first of its kind to date where active surveillance of the COVID-19 vaccine was conducted, especially on children aged 6–11 years. We could not find any similar published study in the public domain until the data submission date. Our study will provide additional data regarding AEFI of COVID-19 in 6–11 aged children in a real setting. We selected the respondents using stratified random sampling that may represent the prevalence of AEFI in our setting. However, this study has some limitations. We did not conduct a causality assessment of AEFIs, so we could not assess if the AEFI was due to the vaccine reaction or other causes. We also did not assess the severity of AEFI. However, we assess if the children visit health providers for the event. A small number (9.9%) of children visited health providers but did not need hospitalization. This may reflect that most AEFIs were mild to moderate.

A possibility of recall bias may affect this study because we collected information on the fourth week after the dose. Children who developed serious AEFIs may not be covered in this study because they may not attend to get the second dose despite having a greater chance of experiencing recurrent AEFIs at dose two (45). Those who were experiencing non-serious AEFIs on the first dose could receive dose two with the same vaccine (46). Because the data collection was conducted at dose two vaccination, this study can only identify non-serious AEFIs.

Since this study has a limited participant population of children aged 6–11 years who may not reflect the general population demographic that used the CoronaVac vaccine, more extensive long-term studies with better representation of younger or older age groups are warranted. The higher occurrence of AEFIs in individuals with a history of AEFI in childhood vaccination needs to be investigated in future research.

Conclusion

The prevalence of AEFI in the first dose and the second dose of inactivated COVID-19 vaccine was comparable to that reported in the clinical trial study. Risk communication should be provided to the child and their parents regarding the risk of mild AEFI of the COVID-19 vaccine, especially for children with a history of AEFI in childhood vaccination and who received other vaccines containing the same adjuvant with CoronaVac within 1 month. A mass-setting of vaccination should be taken as an advantage to educate parents about the risk of AEFI and also about the reporting pathways.

Data availability statement

The original contributions presented in the study are included in the article/supplementary files, further inquiries can be directed to the corresponding author.

Ethics statement

The studies involving human participants were reviewed and approved by the Ethics Committee of the Faculty of Medicine, Public Health, and Nursing, Universitas Gadjah Mada, with registration number KE/FK/0112/EC/2022. The participants legal guardian/next of kin provided their written informed consent to participate in this study.

Author contributions

FP: concept, design, data collection, data analysis, first draft writing, and final draft writing. MS: concept, design, review, and edited the manuscript. RA: concept, design, and review of the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Negative effects of the SARS-CoV-2 pandemic: The interlinking of maternal attachment representation, coping strategies, parental behavior, and the child's mental health

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For more than two years, young families have been confronted with a large number of restrictions and following burdens as a result of the SARS-CoV-2 pandemic. In fact, it became evident, that the current circumstances are particularly stressful for child's mental health. With regard to the child's mental health in times of a pandemic, additional factors within the family, such as maternal attachment representations as well as coping strategies and parental behavior, may play an important role. This study aims to investigate the interplay of maternal attachment representation, coping strategies, parental behavior and child's mental health during the SARS-CoV-2 pandemic. In this longitudinal study, previously collected data regarding maternal attachment representation and newly attained data from the SARS-CoV-2-pandemic-assesment (lack of coping strategies, children's mental health and parental behavior) were combined and analyzed. The data were collected in an online survey since beginning of the pandemic, including $N = 73$ mothers. A path model was calculated in form of multiple linear regression. A path model could be confirmed, which indicates that insecure maternal attachment representation predicts lack of coping strategies during the pandemic [$b = 5.55$, 95%-CI = (4.51; 6.55), $p = 0.001$]. Furthermore, lack of coping strategies predicts harmful parental behavior during the pandemic [$b = -0.77$, 95%-CI = (−1.27; −0.21), $p = 0.007$], which in turn predicts children's mental health problems, namely behavioral problems [$b = -0.08$, 95%-CI = (−0.14; −0.01), $p = 0.027$]. Presence of short-time work and decrease in income since beginning of the pandemic were used as control variables. This means that since the pandemic mothers with insecure attachment representation have an increased risk of having only a few

Abbreviations
AAP, adult attachment projective picture system; CI, confidence interval; Ds, insecure-dismissing attachment; E, insecure-preoccupied attachment; F, secure-autonomous attachment; SARS-CoV-2, severe acute respiratory syndrome coronavirus type 2; SDQ, strengths and difficulties questionnaire; U, unresolved attachment

coping mechanisms available, leading to harmful parental behaviors and ultimately affecting the mental health of their children. In conclusion, the pandemic could potentially have a particularly negative influence on mothers with an insecure attachment type and therefore on their children. Therefore, tailored interventions for families should be offered that both focus on the different types of mental health problems in children and support parents in their coping skills.

KEYWORDS

SARS-CoV-2 pandemic, attachment representation, coping, child's mental health, childhood maltreatment, parental behavior

Introduction

For over two years the world's population has been facing the numerous restrictions and challenges caused by the current severe acute respiratory syndrome coronavirus type 2 (SARS-CoV-2) pandemic. These restraints include the endorsement of social distancing, sudden closure of schools and childcare, the loss of community programs and jobs, an increase in recessions or unemployment, home schooling, as well as lack of social support, for example from grandparents (1–4). Particularly families with young children are seriously affected by these measures and problems and in need to find solutions. Even important face-to-face meetings among children and young people in organized leisure activities like sports clubs, church or band practices are only very selectively possible due to social distancing and closures. This means crucial and development-relevant parameters of everyday life suddenly break away with potentially social, emotional and cognitive effects (5–7).

These consequences may be more urgently felt among children that are lacking a stable parental home. Numerous studies have previously shown that particularly in times of stress and uncertainty, that characterize a crisis such as the current SARS-CoV-2 pandemic, especially young children urgently need a secure and stable family environment (8–11). We may assume that a stable parental home seems to be a relevant protective factor in times of a pandemic. Since the parental role may hold a challenge for some mothers and fathers even in non-pandemic times it becomes evident that not all parents may be able to meet the special needs of their children in the demanding times of a pandemic (12). Parents confronted with psychological stress may have limited resources to recognize their children's needs (13).

The way individuals deal with stress or stressful live-events is closely linked to their attachment representation. Previous research shows that different attachment representations are related to various coping strategies, which can increase, prolong or improve stress responses (14–16).

The attachment system is the individual's homeostatic mechanism for regulating distress. It is developed in early childhood but is hypothesized to continue to influence emotional regulation and functioning throughout the entire lifespan. For example, if caregivers are insensitive, unresponsive or inconsistently available, the individual develops alternative methods to regulate affect. This can manifest from hypervigilance to signs of rejection or separation and a tendency to be overwhelmed by negative affect or to exaggerate distress in order to elicit a helping response in others. Therefore, adults with insecure attachment representations could cause ill-organized working models that are distorted and disrupted by defensive processes that frequently stand in the way of successful, engaging coping (17). Secure attachment style functions as a protective factor while coping with stress and depressive symptoms and people with secure attachment style are more likely to effectively regulate their negative emotions and have better strategies for solving problems when they experience fear and threats (18), i.e., sought social support in stressful situations more often than adults with insecure attachment (19).

Despite divergent definitions and conceptualizations, coping can generally be understood as a response to stressful situations with the aim of psychosocial adjustment (20). There are cognitive or behavioral ways to cope with stressors (21). Cognitive coping strategies aim to change one's perception or appraisal of a situation, whereas behavioral coping skills refer to actions which reduce the resulting effects of stressors, such as arising distress. According to Carver and Connor-Smith (22) these cognitive or behavioral strategies can further be divided into engagement and disengagement coping. Dijkstra and Homan (23) stated that engaging coping strategies such as confronting rather than diverting from stressors or their effects led to higher perceived control. In contrary, disengaging strategies induced a lack of control and were found to be related to deteriorated psychological well-being (23).

There is also evidence for an association between adult attachment, coping and parental behavior. Branjerdporn and colleagues (24) found that insecure attachment correlates with high levels of sensory sensitivity, which is associated with the use of passive coping strategies rather than active coping strategies when facing stressors. They also found a significant relation between adult anxious attachment and authoritarian as well as permissive parental behavior which was partially

mediated by sensory sensitivity. Besides, adult attachment avoidance was related to permissive parental behavior. This relation was fully mediated by sensory sensitivity.

The pandemic is a stressful time for all families. Findings show that families with risk factors, such as parents with insecure attachment representation, are particularly at risk of not coping as well during the pandemic as families with low risk factors (25–27). Specifically, adaptive coping strategies, secure attachment representation and supportive family environments may serve as protective factors for families experiencing stress and may differentially influence abuse potential (23).

Therefore, the aim of our study was to analyze the pathways between such risk factors, namely the maternal quality of attachment representation, the ability of coping, parental behavior and hence the mental health of the child during the SARS-CoV-2-pandemic.

Methods

Study design

TransGen is a joint interdisciplinary project with the goal to investigate protective and risk factors regarding the transgenerational transmission of maternal maltreatment experiences. In a prospective study design data comprising psychological, biological, and social factors from mothers and their new born child were collected. Five subprojects, including four clinical studies and one animal model, are part of the TransGen joint interdisciplinary project. From October 2013 until March 2017 data for this study has been collected. The project was funded by the Federal Ministry of Education and Research and it was approved by the University Ethics Committee Ulm.

Mother-child-dyads were recruited at the maternity unit of the Ulm University Hospital and accompanied during the first years of the child's life. Within three days after birth (measurement time t_0) the German version of the Childhood Trauma Questionnaire (CTQ) (28, 29) was used to access the maternal childhood maltreatment experiences. We also collected more data in three follow-up measurements: three months after birth (t_1), twelve months after birth (t_2), and roughly three years after birth (t_3).

To measure the current stress level of the mothers due to the pandemic, mothers participated in two online "SARS-CoV-2 pandemic surveys" in two periods of time. The first lasting from May 18th until July 31st, 2020, the second from March 1st until May 31st, 2021. The following results refer to the data from the second time slot only. For the online survey the platform "Unipark" was used. For all mothers in the study from 2013 to 2017 a profile was created with pseudonym in order to be able to assign the answers to the respective mothers in the course of the study. All participants received the same link to the survey by e-mail and only had to enter their individual pseudonym to connect their survey answers with their previous study data. The online "SARS-CoV-2 pandemic surveys was constructed in such a way that the survey could only be completed if all questions were answered and all necessary information was provided.

Participants

Between October 2013 and December 2015, a total of 533 mother-child-dyads were recruited in the maternity unit of the University Hospital of Ulm shortly after birth. Participants were excluded if any of the following exclusion criteria were fulfilled: Insufficient knowledge of the German language, mother's age <18, mother's current or former drug or alcohol abuse, mother's poor health (e.g., AIDS disease, hepatitis, etc.) or severe mental illness, child's extremely low birth weight (less than 1500 g), serious premature birth (less than 37 weeks of pregnancy) or birth complications. Written informed consent was provided by 240 mothers. The dyads were invited to a first laboratory and home visit data assessment 3 months postpartum (t1: laboratory and home visit), where maternal attachment representation was assessed. A total of $N = 240$ mother-child-dyads participated in the study at this assessment point. A second laboratory and home visit around the age of 12 months (t_2) were attended by 158 mother-child-dyads. These pairings also attended the third data collection around the child's third birthday (t_3). The 158 dyads were then contacted again per mail and asked to participate in the additional online questionnaire "SARS-CoV-2 pandemic survey" concerning the effect of the pandemic on families. 91 of the contacted mothers were willing to edit the survey until the end of July 2020. There were different reasons for not participating in measurement like a lack of time, no willingness to take part in a particular survey concerning the SARS-CoV-2 pandemic or merely not reaching the families. The second online "SARS-CoV-2 pandemic" survey was filled out by $n = 73$ participating mothers by the 31st of May 2021, where consequences of the SARS-CoV-2, coping strategies and parental behavior were assessed. We concluded a total of two waves of data collection (t_0*: May 18th–July 31st, 2020, t_1*: March 1st–May 31st, 2021), where the same measurements were collected. Analysis was just executed for complete data sets of mother-child-dyads at every wave of data collection, resulting in $N = 73$ sets after excluding missing values.

Measures

Consequences of SARS-CoV-2

In the "SARS-CoV-2-pandemic survey", which was collected in an online survey, numerous socio-demographic data of the mothers and their families were assessed. These

included age, educational level, occupations, and marital status, as well as the number of minors living in the household and the number of own children. Furthermore, more information regarding the mothers' and her potential partners' employment was examined. We also asked whether they were currently working in an essential field of work, whether they experienced short time work since the beginning of the pandemic, and whether the household's income had decreased by more than a quarter.

Maternal attachment

Maternal attachment representations were assessed at t1 using the Adult Attachment Projective Picture System (AAP) (30). The AAP is a standardized, objective, reliable and valid attachment interview using eight line-drawings. The participants are shown these drawings and asked a standardized set of questions to tell a story to each picture. The first is a neutral warm-up picture, which is followed by seven drawings depicting attachment-related scenes (e.g., separation, illness, loss, potential maltreatment). These seven stimuli are designed to activate the participant's attachment system. The participant's audio-recorded responses are evaluated considering content, discourse and defensive processes along the manual (30). In the AAP, the attachment representation is expressed by assigning it to one of the four attachment classifications: "Secure attachment", "Insecure-distant attachment", "Insecure-entangled attachment" and "Unprocessed trauma" (30). However, since in our study the N in the individual attachment classifications was too low to evaluate them individually, this study only distinguished between "secure attachment" and all other classifications which were summarized under the term "insecure attachment". Therefore, only the two superordinate classes are referred to in the analysis of the data of this study. All interviews were conducted by trained psychologists. AAP classifications were coded by two independent certified judges. Inter-rater reliability showed significant concordance for the four-group classification ($\kappa =$ 0.95, 95%-confidence interval [0.88, 1.04], $p < 0.001$), and for the two-group classification (organized vs. unresolved, $\kappa = 0.96$), 95%-confidence interval [0.91, 1.00], $p < 0.001$.These data are also consistent with results of validation studies on AAP. In the extensive psychometric validation study by George & West (30), the agreement between the AAP and AAI categories, the interrater reliability, the test-retest reliability (interval: three months) and the discriminant validity were checked. The reliability and validity of the AAP could be confirmed in the results of this study with an agreement of 90% between AAP and AAI regarding the four most relevant attachment groups. Interrater reliability was tested in this validation study between one primary rater and two independent raters. In this study, agreement between rater 1 and 2 was 90% ($\kappa = 0.79$, $p = 0.000$) for the 4-group classification, and 85% ($\kappa = 0.79$, $p = 0.000$) between rater 1 and 3. For the 2-group classification, the agreement was 99% ($\kappa = 0.66$, $p = 0.000$) and 85% ($\kappa = 0.79$, $p =$ 0.000). These results indicate a concurrent validity of the results of the study with the AAI.

The AAP classifies the four established attachment categories: secure, insecure-dismissing, insecure-preoccupied, and unresolved attachment. For our present study, attachment representations of the mothers were divided into two major classifications "secure" (F) and "insecure" (insecure-dismissing (Ds), insecure-preoccupied (E) and the unresolved attachment status (U).

Coping strategies

Psychological coping resources were measured in an online survey during the pandemic using the Pearlin Mastery Scale (31), considering individual resources and flexibility or perceived control. The scale consists of 7 items on a 4-point-Likert scale (1 = "strongly disagree" to 4 = "strongly agree") and therefore has a range from 7 to 28 points. The higher the score, the greater is the inability to exert coping strategies. A higher score means a greater tendency to have a lack of individual coping strategies. Hence our operationalization of coping strategies refers to the degree of perceived control over one's life, which reflects the individual's ability to effectively handle stressful situations or to execute appropriate strategies in dealing whit these situations. For example, a low score on the Pearlin Mastery Scale would mean that a person feels they have no control over important things in their life.

Parental behavior

We used 4 items in an online survey during the pandemic to measure whether there is an increase in harmful parental behavior since beginning of the pandemic. The items are in detail: "I've been yelling at the child more", "I am more impatient with the child", "Everyday life with the child is very chaotic", "I experience increased fear of raising my hand against the child". The items were rated on a 7-point Likert scale (1 = "does not apply at all" to 7 = "applies very much") with a higher score indicating a more pronounced harmful parental behavior. This means, the total item score states the extent of change in harmful parental behavior during the pandemic. Cronbachs Alpha was measured at $\alpha = 0.84$.

Children's mental health

The Children's mental health was assessed in an online survey using the German version of the Strengths and Difficulties Questionnaire (SDQ) (32), a behavioral screening questionnaire which is filled in by a parent. This instrument consists of five scales (emotional problems, externalizing behavioral problems, hyperactivity/attention problems, problems with peers and prosocial behavior) addressing positive and negative behavioral attributes of the children. Each scale contains 5 items and is rated on a 3-point Likert scale. In the "SARS-CoV-2-pandemic survey" a selection of these items was included. For the emotional problems scale all

five items were included: "Often complains of headaches, stomach-aches or sickness", "Many worries or often seems worried", "Often unhappy, depressed or tearful", "Nervous or clingy in new situations, easily loses confidence"; and "Many fears, easily scared". For the externalizing behavioral problems scale the following two items were chosen: "Often loses temper" and "Generally well behaved, usually does what adults request". The questions "Restless, overactive, cannot stay still for long" and "Constantly fidgeting or squirming" were selected as items for the hyperactivity/attention problems scale. In order to operationalize, for each of these three scales the individual item-values were summed up. The two scales "problems with peers" and "prosocial behavior" were not included, because of the children's limited social contacts outside of the family due to pandemic-related restrictions regarding school and kindergarten.

Statistical analyses

For all analyses significance level was defined with.05 as the critical alpha level. The data were evaluated using the SPSS Statistics 24.0 program (33). Mothers could not be supervised when answering the items of the online survey, therefore some questionnaires weren't completed. Only complete data sets were used for the data analysis. Descriptive statistics with means, standard deviations and relative frequencies are reported. Before considering the hypotheses descriptive statistics and two tailed Pearson correlations of model and control variables were calculated. Model variables were attachment representation using the AAP, average lack of coping strategies, average of harmful parental behavior, as well as the SDQ sum scores of the subscales hyperactivity, externalizing problems, and emotional problems. Presence of short-time work (coded as 1 = short-time-work, 2 = no short-time-work) and decrease in income (1 = decrease in income, 2 = no decrease in income) were included as control variables and were measured at both online-surveys.

Subsequently, the paths of the assumed path model were calculated using multiple linear regressions. The order of the variables was, as already mentioned, as following: maternal attachment representation, average lack of coping strategies, average of harmful parental behavior, and SDQ sum scores of the subscales hyperactivity, externalizing problems, and emotional problems. A total of three regression models were calculated, where the third model was calculated with three different dependent variables (1: dependent variable: lack of coping strategies, independent variable: maternal secure attachment representation; 2: dependent variable: average of harmful parental behavior, independent variables: maternal secure attachment representation, lack of coping strategies, 3.1: dependent variable: hyperactivity, independent variables: maternal secure attachment representation, lack of coping strategies, average of harmful parental behavior; 3.2: dependent variable: externalizing problems, independent variables: maternal secure attachment representation, lack of coping strategies, average of harmful parental behavior; 3.3: dependent variable: emotional problems, independent variables: maternal secure attachment representation, lack of coping strategies, average of harmful parental behavior). Additionally, presence of short-time work and decrease in income were included as control variables.

The requirements (34) were tested using scatter plots, standardized residuals, and leverages (to check for linearity as well as for outliers), the Durbin-Watson statistic (to check for autocorrelation), the tolerance and VIF values (to check for multicollinearity), and the *P-P* plot (to check for normal distribution of the residuals). As no clear outliers were determined based on more than one of the several criteria used, no individuals were excluded from the data analysis. Since heteroscedasticity was seen on visual inspection of the scatter plots, the regression analysis was performed with 1,000-fold bootstrapping to avoid bias in the coefficients. All other prerequisites were met.

Results

Descriptive analyses

Descriptive analyses are presented in **Table 1**. $N = 73$ mothers completed the second online survey of the SARS-CoV-2 online survey. The average age of the mothers was $M = 38.4$ years old ($SD = 4.0$), with a range of 31 to 46 years. 64.4% of the women had a high school diploma, 13.7% had a secondary school diploma, and 19.2% had a lower secondary school diploma.

TABLE 1 Descriptive analysis.

	M	SD	Range
Mother's age	38.4	4.0	31–46
Children's age	5.3	1.1	4–8
	N	**%**	
Education			
High school diploma	47	64.4	
Secondary school diploma	10	13.7	
Lower secondary school diploma	14	19.2	
No high school diploma	2	2.7	
Affected by short-time work first measurement	19	26.0	
Affected by short-time work second measurement	8	11.0	
Decrease in income since beginning of the pandemic first measurement	34	46.6	
Decrease in income since beginning of the pandemic second measurement	4	5.5	
Insecure attachment representation	28	38.4	

Only 2.7% asserted that they did not have a high school diploma. 26% of the mothers at the first measurement point and 11% at the second measurement point stated to be affected of short-time work. At the first survey 46.6% and at the second 5.5% reported a decrease in income since beginning of the pandemic. The children were between 4 and 8 years old on average $M = 5.3$ years ($SD = 1.1$). There was an equal gender distribution among the children.

Examination of the descriptive statistics revealed that 38.4% of the mothers in this sample had insecure attachment representations. The lack of coping strategies averaged at $M = 15.5$ ($SD = 3.4$) with a minimum of 8.5 and a maximum of 24.5. The harmful parental behavior ranged from 17 to 54 with an average of $M = 36.1$ ($SD = 8.9$). The sum score of the SDQ subscales were for the hyperactivity subscale at $M = 3.5$ ($SD = 1.2$; minimum = 2, maximum = 6), the externalizing problems subscale $M = 3.6$ ($SD = 1.0$; minimum = 2, maximum = 6), and the emotional problems subscale $M = 8.3$ ($SD = 2.2$; minimum = 5, maximum = 15, Cut-Off for abnormality = 5) (Table 2).

Correlation analyses

First, we demonstrate the significant correlations of the model variables: Attachment representation (coded as 0 = secure, 1 = insecure) correlated strongly and significantly with harmful parental behavior ($r = -0.87$, $p < 0.001$), lack of coping strategies ($r = 0.79$, $p < 0.001$), and emotional problems ($r = 0.56$, $p < 0.001$). Harmful parental behavior also correlated significantly with lack of coping strategies ($r = -0.83$, $p < 0.001$), hyperactivity ($r = -0.35$, $p = 0.002$), emotional problems ($r = -0.48$, $p < 0.001$) and externalizing problems ($r = -0.31$, $p = 0.008$). Furthermore, lack of coping strategies correlated with hyperactivity ($r = 0.26$, $p = 0.025$), externalizing problems ($r = 0.28$, $p = 0.018$) and emotional problems ($r = 0.52$, $p < 0.001$). Hyperactivity and externalizing problems also correlated significantly ($r = 0.37$, $p < 0.001$) (Table 3).

Second, correlations of the control variables are shown: Presence of short-time work at the first survey correlated with education ($r = 0.27$, $p = 0.023$) as well as short-time work at the second survey ($r = -0.29$, $p = 0.012$). Additionally, presence of short-time work at the second survey correlated significantly with lack of coping strategies ($r = -0.26$, $p = 0.027$) and decrease in income at the second measurement point ($r = 0.30$, $p = 0.010$).

Path model

The results of the multiple linear regressions used to analyze the path model are the following: (1) Lack of coping strategies were significantly predicted by secure vs. insecure attachment representations as well as presence of short-time work at the second measurement time point. (2) The harmful parental behavior was significantly determined by lack of coping strategies as well as insecure attachment representation. (3) In the final step, the child's symptoms were considered. Although it was not significant for the prediction of hyperactivity, the confidence interval (CI) of the coefficient of harmful parental behavior ends at zero, so it is still considered as a crucial variable in this model. In particular, because no other predictor showed an even remotely significant effect on hyperactivity. The child's externalizing problems were also significantly predicted only by harmful parental behavior. Emotional problems of the child, in turn, were not determined by harmful paternal behavior, as expected, but by the lack of coping strategies, which was intended to serve only as a control variable in this model. All results of the regression models to calculate the path model are shown in Table 4. The results of the path model analysis are summarized in Figure 1.

Discussion

The aim of our study was to investigate the relationship of maternal attachment representation, coping, parental behavior and child's mental health in the exceptional situation of the pandemic.

While many studies have already shown that regulatory measures to contain the pandemic such as contact restrictions, short-time work, school closures etc. have a negative impact

TABLE 2 Psychometric measures.

	M	SD	Range
Lack of coping strategies	15.5	3.4	8.5–24.5
Harmful parental behavior	36.1	8.9	17–54
Hyperactivity subscale	3.5[a]	1.2[a]	2–6[a]
Externalizing problems subscale	3.6[a]	1.0[a]	52–6[a]
Emotional problems subscale	8.3	2.2[a]	5–15

[a]Note:only selected items of those scales were assessed, therefore comparability to other studies is limited.

TABLE 3 Correlation analysis.

	1	2	3	4	5
1. Attachment representation					
2. Lack of coping strategies	0.79***				
3. Harmful parental behavior	−0.87***	−0.83***			
4. Hyperactivity subscale	0.22	0.26*	−0.35**		
5. Externalizing problems subscale	0.23	0.28*	−0.31**	0.37**	
6. Emotional problems subscale	0.56***	0.52***	−0.48***	0.18	0.21

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

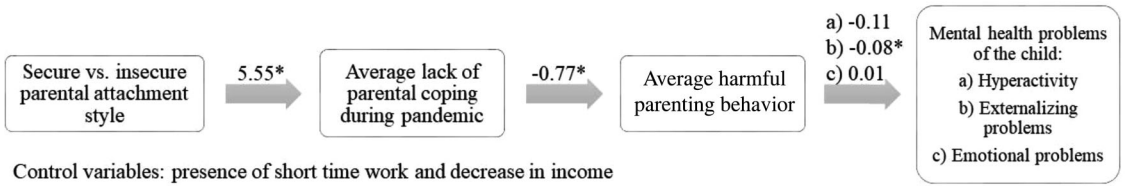

FIGURE 1
Path model of the interrelation of maternal quality of attachment representation, maternal ability of coping, harmful parental behavior and child's mental health.

TABLE 4 Results of regression models.

Model	*b* (SE)	95%-CI	*p*	$R^2_{adj.}$
Lack of coping				
Constant	17.61 (1.83)	[14.20; 21.51]	0.001	
Secure attachment	5.55 (0.51)	[4.51; 6.55]	0.001	
Short-time work first survey	0.49 (0.47)	[−0.40; 1.44]	0.297	
Decrease in income first survey	0.39 (0.47)	[−0.54; 1.30]	0.412	
Short-time work second survey	−2.85 (0.93)	[−4.84; −1.17]	0.002	
Decrease in income second survey	−0.78 (0.88)	[−2.34; 1.15]	0.268	0.669
Harmful parental behavior				
Constant	49.81 (7.24)	[33.32; 62.22]	0.001	
Secure attachment	−11.79 (1.84)	[−15.47; −7.94]	0.001	
Lack of coping	−0.77 (0.27)	[−1.27; −0.21]	0.007	
Short-time work first survey	−1.16 (0.91)	[−3.08; 0.60]	0.204	
Decrease in income first survey	−0.55 (0.91)	[−2.30; 1.25]	0.548	
Short-time work second survey	3.03 (2.13)	[−1.01; 7.68]	0.130	
Decrease in income second survey	1.34 (2.43)	[−4.92; 5.18]	0.527	0.811
Hyperactivity				
Constant	13.02 (4.70)	[2.94; 21.40]	0.009	
Secure attachment	−1.55 (0.96)	[−3.25; 0.57]	0.105	
Lack of coping	0.06 (0.12)	[−0.20; 0.29]	0.588	
Harmful parental behavior	−0.11 (0.06)	[−0.22; 0.01]	0.061	
Short-time work first survey	−0.54 (0.51)	[−1.51; 0.49]	0.283	
Decrease in income first survey	−0.36 (0.44)	[−1.12; 0.58]	0.440	
Short-time work second survey	0.63 (1.03)	[−1.56; 2.38]	0.473	
Decrease in income second survey	−1.03 (1.60)	[−4.25; 2.32]	0.489	0.032
Externalizing problems				
Constant	11.04 (2.69)	[5.82; 16.45]	0.001	
Secure attachment	−0.83 (0.64)	[−1.88; 0.57]	0.202	
Lack of coping	0.01 (0.08)	[−0.16; 0.14]	0.935	
Harmful parental behavior	−0.08 (0.03)	[−0.14; −0.01]	0.027	
Short-time work first survey	−0.29 (0.29)	[−0.87; 0.28]	0.331	
Decrease in income first survey	0.28 (0.27)	[−0.23; 0.86]	0.339	
Short-time work second survey	−0.10 (0.72)	[−1.55; 1.36]	0.863	
Decrease in income second survey	−0.06 (0.93)	[−2.42; 1.48]	0.951	0.079
Emotional problems				
Constant	5.88 (5.99)	[−6.63; 16.94]	0.316	
Secure attachment	1.39 (1.43)	[−1.34; 4.36]	0.333	
Lack of coping	0.49 (0.17)	[0.18; 0.82]	0.011	
Harmful parental behavior	0.00 (0.08)	[−0.15; 0.18]	0.970	
Short-time work first survey	−0.98 (0.66)	[−2.28; 0.31]	0.147	
Decrease in income first survey	−0.48 (0.62)	[−1.61; 0.78]	0.427	
Short-time work second survey	2.41 (1.56)	[−0.57; 5.47]	0.089	
Decrease in income second survey	−0.48 (1.80)	[−4.73; 3.01]	0.753	0.393

on children's health and families' well-being (35, 36), we were able to show for the first time in our study that maternal attachment representation and the associated coping skills and corresponding parental behavior also significantly influence children's mental health during the pandemic.

Our path analyses partly confirmed our assumed model shown in Figure 1. Specifically, we could confirm the pathway in terms of externalizing behavior problems of the child, but also with a CI with the end just above the zero in terms of hyperactivity. Interestingly, there was no significant influence of parental behavior on emotional problems of the child. However, the lack of coping strategies had a direct influence on the child's emotional problems, which means that the intermediate step of our assumed causal chain *via* parental behavior was skipped in this case.

This effect has also been demonstrated in children of parents with cancer (37). The way in which parents with cancer cope with their illness appears to have a direct influence on the mental health of their minor children. In this context, passive-avoidant coping, as also occurs in the case of insecure attachment, seems to contribute to a higher risk of internalizing symptom formation in the children.

First, however, the three previously assumed associations (i.e., from attachment to lack of coping strategies, from lack of coping strategies to parental behavior, and from parental behavior to child mental health) are examined in more detail.

As hypothesized, maternal insecure attachment representation was associated with a greater lack of coping strategies during the pandemic. This is consistent with previous studies (14, 15, 38–40). However, in these studies

different questionnaires were used to assess attachment representation, so that references back to the AAP, which captures attachment representation by an interview must be made with caution. Nevertheless all studies have demonstrated that secure attachment style functions as a protective factor while coping with stress and depressive symptoms during the pandemic and that people with secure attachment style are more likely to effectively regulate their negative emotions and have better strategies for solving problems when they experience fear and threats (18), i.e., sought social support in stressful situations more often than adults with insecure attachment (19). In our study, however, we did not focus on social support as a coping strategy but took a more generalized perspective at the lack of effective coping strategies in the form of thoughts such as "I can't cope with some of my problems." This lack could have resulted from negative experiences, such as not seeking outside help.

Next, a negative association between lack of effective coping strategies and quality of parental behavior was assumed and confirmed. Since maternal attachment was included as a control variable in the regression, an influence of coping on parental behavior can be assumed *via* the importance of attachment representation. This significant prediction is in line with other studies. For example Levy-Shiff (41) found a relationship between appraisal patterns of stress and quality of parental behavior. We may conclude that the lower quality of parental behavior found here arises in the context of a lack of coping strategies due to being overwhelmed by demands.

In the final step of analysis, the impact of the other variables on the child's mental health were considered. In particular, externalizing behavior problems as well as hyperactivity symptoms of the child were predicted by harmful parental behavior. Previous research has shown, that conduct disorders are associated with punitive parenting strategies with the strongest effect size among several mental disorders in children (42). However, no association with emotional problems was found, which is not along our assumptions. Morris and colleagues (43) showed that emotion regulation problems in children could be improved particularly through changes in parental behaviors. In our sample, children's emotional symptoms did not show any association with parental behavior, but directly with the lack of coping strategies. This was also partially found by Wood and colleagues (44), who could not show a relationship between parenting and child anxiety. To the best of our knowledge, no research has been conducted analyzing the association between maternal coping and child emotional disturbance using a community sample. We may assume that the perception of higher demands and strain on parents in stressful times like the pandemic trigger anxiety and stress also in children.

There is a correlation in the results of this study that seems counterintuitive at first glance, yet could be a very interesting issue for future research. The data of this study suggest that parent's short-time work leads to a decrease in parenting skills and not, as one might assume, to an increase in time spent with children and thus an improvement in the parent-child relationship. This seems illogical at first, since parents on short-time work should actually have more time available for their children than, for example, parents who work from home. However, there are indeed reasons, some of which can be attributed to the specific situation during the SARS-CoV-2 pandemic in which the study was conducted. For example, short-time work during a crisis like the corona pandemic seems to be a strong threat to family income and in some cases can even threaten entire livelihoods (45). However, not only the reduced salary is a worrying factor for many parents, but also the job insecurity that comes with short-time work in such a crisis situation. Even though the short-time allowance was designed to avoid layoffs, many workers were still afraid of unemployment. In addition to the very existential and occupational factors, family and health worries may also have placed a heavy burden on parents during the pandemic and can ultimately lead to chronic stress. All these factors, individually or in sum, can negatively strain the parental behavior, for example, through the mechanism of negative parental emotions (46). At the same time, the sensitivity of the parental behavior can suffer from the psychological stress of the parents, as they themselves suffer from strong fears, burdens and stress (46). It can also be assumed that parents spend less time with their children, although they would actually have more time to spend with them. However, because they are so busy with their own emotions and thoughts, they cannot use this free time as time with their children, but need it for themselves. These are some possible explanations that can be considered to explain the unexpected connection between short-time work and parent-child relationships, but further research is needed to understand this connection.

Limitations

We have to consider several limitations in the present study: First, the sample is restricted to participants from an online survey, which inhibits the generalization and the sample cannot be considered representative (47). Moreover, due to the short time period of data collection at the beginning of the pandemic we were working with a relatively small sample size of $N = 73$ participants. Therefore, statistical power of the results might be limited (48). Further research should investigate models with a larger sample size to verify the results. In addition, our sample includes a high percentage of the mothers with a high level of education, which has not

been reported in other German cohort studies (49, 50). This might limit the representativeness of the study. In addition, the use of self-report measurements for maternal coping strategies, parental behavior as well as child's psychological health may lead to biased answers due to social desirability. There are currently no studies that show correlations between the attachment status and self-reported attachment style measured by interview methods in the AAP, therefore it must be emphasized in this study that the AAP is an instrument for measuring attachment whose correlations with other methods for measuring attachment characteristics are still unknown. Additionally, we did not use all items of the scales "hyperactivity" and "externalizing problems" in our study because we wanted to minimize the burden on the mothers. Therefore, a general classification of symptom severity for these two scales was not possible and our results from the SDQ cannot be compared with the results of other studies. Furthermore, other variables might play a role in the calculated path way, that have not been included and therefore have confounded the results. For example, single motherhood or factors associated with the father could have an influence on parenting and the child`s mental health. The major limitation of the study are the survey dates. Lack of coping strategies, harmful parental behavior, and the child's mental health were collected at the same time point. Therefore, no conclusion can be drawn as to which variable may have influenced which, which implies that causality cannot be assumed. Future research should attempt to obtain a larger sample with higher representativeness. In addition, surveying individual forms of coping strategies such as seeking help in the social environment could lead to even more differentiated results.

Implications and future research

Our study suggests that there is a complex interplay between attachment, coping, parental behavior, and child's mental health. To summarize this complexity, there is a sequence of the presence of different risk factors in mothers (i.e., attachment style, lack of coping strategies, harmful parental behavior) that cumulatively contribute to their children showing effects in the area of their own mental health.

Moreover, we found that harmful parental behaviors or parental behavior of lower quality in particular can lead to externalizing, problematic behaviors in children and that the lack of engaging parental coping can lead to internalizing behavior problems in children. Our findings suggest that pandemic disasters and subsequent containment efforts create a condition, which, especially in connection with an insecure attachment representation of the mother, can negatively influence the mental health of the children. In this context, parental coping strategies and parental behavior seem to be the most important starting points for appropriate interventions.

Because of the increased dependence of children on their parents for stress regulation and the influence of parental stress on children's mental health, special response strategies are needed to address the mental health needs of young children and their families. Pandemic mitigation measures must take these needs into account. Because pandemic disasters are unique and there are no held-forward interventions for prolonged support and recovery our findings reinforce existing calls (51, 52) to expand preventive services to promote and maintain stress coping skills for both children and parents in order to maintain children's mental health in times of crisis. For example, Rauchfuß (53) already examined the topic of resource-based intervention in pregnancy in the context of preventing stress and thus preterm birth. Such an intervention, adapted to the living environment of mothers, would be a conceivable step towards improving their coping strategies.

Conclusion

In this study, we showed the role of intrafamilial resources (e.g., secure attachment, engaged coping) on children's mental health and that the pandemic appeared to have a particularly negative impact on mothers with an insecure attachment style and thus on their children. This also revealed that externalizing behavior problems in children are predicted primarily by harmful parental behavior, whereas internalizing behavior problems depend primarily on parental coping ability. Therefore, tailored interventions for families should be offered that both focus on the different types of mental health problems in children and support parents in their coping skills as well as in their parental skills.

Data availability statement

The original contributions presented in the study are included in the article/Supplementary Material, further inquiries can be directed to the corresponding author/s.

Ethics statement

The study involving human participants were reviewed and approved by the Ethics Committee of (Ulm) University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

MG, FKD and AB analyzed and interpreted the data regarding the effect of maternal daily perceived stress on child's mental health during SARS-CoV-2-pandemic. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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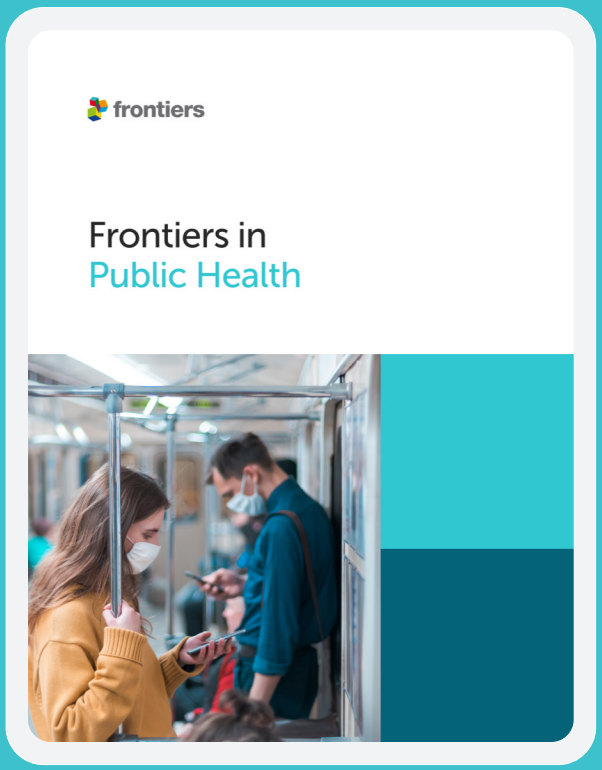

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