



# Geotemporal analysis of perinatal care changes and maternal mental health: an example from the COVID-19 pandemic

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## Abstract

Our primary objective was to document COVID-19 induced changes to perinatal care across the USA and examine the implication of these changes for maternal mental health. We performed an observational cross-sectional study with convenience sampling using direct patient reports from 1918 postpartum and 3868 pregnant individuals collected between April 2020 and December 2020 from 10 states across the USA. We leverage a subgroup of these participants who gave birth prior to March 2020 to estimate the pre-pandemic prevalence of specific birthing practices as a comparison. Our primary analyses describe the prevalence and timing of perinatal care changes, compare perinatal care changes depending on *when* and *where* individuals gave birth, and assess the linkage between perinatal care alterations and maternal anxiety and depressive symptoms. Seventy-eight percent of pregnant participants and 63% of postpartum participants reported at least one change to their perinatal care between March and August 2020. However, the prevalence and nature of specific perinatal care changes occurred unevenly over time and across geographic locations. The separation of infants and mothers immediately after birth and the cancellation of prenatal visits were associated with worsened depression and anxiety symptoms in mothers after controlling for sociodemographic factors, mental health history, number of pregnancy complications, and general stress about the COVID-19 pandemic. Our analyses reveal widespread changes to perinatal care across the US that fluctuated depending on where and when individuals gave birth. Disruptions to perinatal care may also exacerbate mental health concerns, so focused treatments that can mitigate the negative psychiatric sequelae of interrupted care are warranted.

**Keywords** Coronavirus · Pregnancy · Postpartum · Mental health · Prenatal care · Depression

## Introduction

Adequate perinatal care is life saving for birthing people and their children. In uncomplicated pregnancies, the American College of Obstetricians and Gynecologists

(ACOG) and the American Academy of Pediatrics (AAP) advocate for culturally sensitive, responsive, and engaged care that is characterized by consistent touchpoints throughout the peripartum period. Recommended prenatal care entails monthly visits with a provider until 28 weeks' gestation followed by biweekly visits until 36 weeks, and weekly visits thereafter. These visits largely occur in person and there is noted benefit of additional perinatal group classes. During intrapartum care, ACOG and AAP highlight the importance of a partner or other support person remaining present and involved throughout labor, ongoing

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assessment of pain and anxiety management, and facilitation of skin-to-skin contact between parents and newborns after birth (The American College of Obstetricians and Gynecologists and American Academy of Pediatrics 2017).

The early months of the novel coronavirus (COVID-19) were possibly the most universal disruption to perinatal care in recent history. Policy changes resulted in the isolation of birthing people during pregnancy, the birthing process, and postpartum, including separation of newborn infants from mothers, banning support people from delivery rooms, and reduced healthcare appointments. Although these changes are in direct contrast to ACOG and AAP recommendations under non-pandemic circumstances, in many parts of the USA, they were deemed unavoidable precautions necessary for limiting virus spread and for protecting the health of families and providers (Stephens et al. 2020). For example, if mothers was symptomatic and tested positive for COVID-19 during delivery, standing recommendation early in the pandemic was to separate newborn infants from the mother to prevent vertical transmission of COVID-19 (Rochelson et al. 2020). Given the historic and widespread nature of these healthcare alterations, it is necessary to systematically quantify how common perinatal care disruptions were across the US, *when* they happened (e.g., were they restricted just to the peak of the pandemic?), and *how* they influenced the wellbeing of birthing people.

The last 2 years have been a time of heightened social isolation (Zhou et al. 2021) and elevated prevalence of psychiatric concerns among birthing individuals (e.g., Hessami et al. 2020). Among other stressors, interrupted access to expected care may contribute to greater psychological burden and heightened psychiatric symptomology during the perinatal period. To understand the complexity, prevalence, and psychological impact of perinatal healthcare access during the early months of the COVID-19 pandemic, direct patient reports from geographically diverse regions across the USA are needed, with data that reflects access *prior to and after* the pandemic onset. Such understanding is essential for the creation of scientifically informed policies that protect both providers and patients (Kotlar et al. 2021; Niles et al. 2020).

To understand pandemic-related impacts relative to environmental phenomena, and to appreciate the heterogeneity of experiences across the USA, the central analytic strategy of the current study is geotemporal analysis. This approach enables historical documentation of regional differences, enables mapping of differential trajectories, and for each location affords pairing of local policy and health conditions to outcomes studied. The primary goal of the present study was to document perinatal healthcare disruption during the first months of the COVID-19 pandemic in a manner sensitive to its temporal and geographic variability. We also examined the functional significance of these care alterations for the mental health of birthing people across the USA.

## Materials and methods

### Setting, participants, and procedures

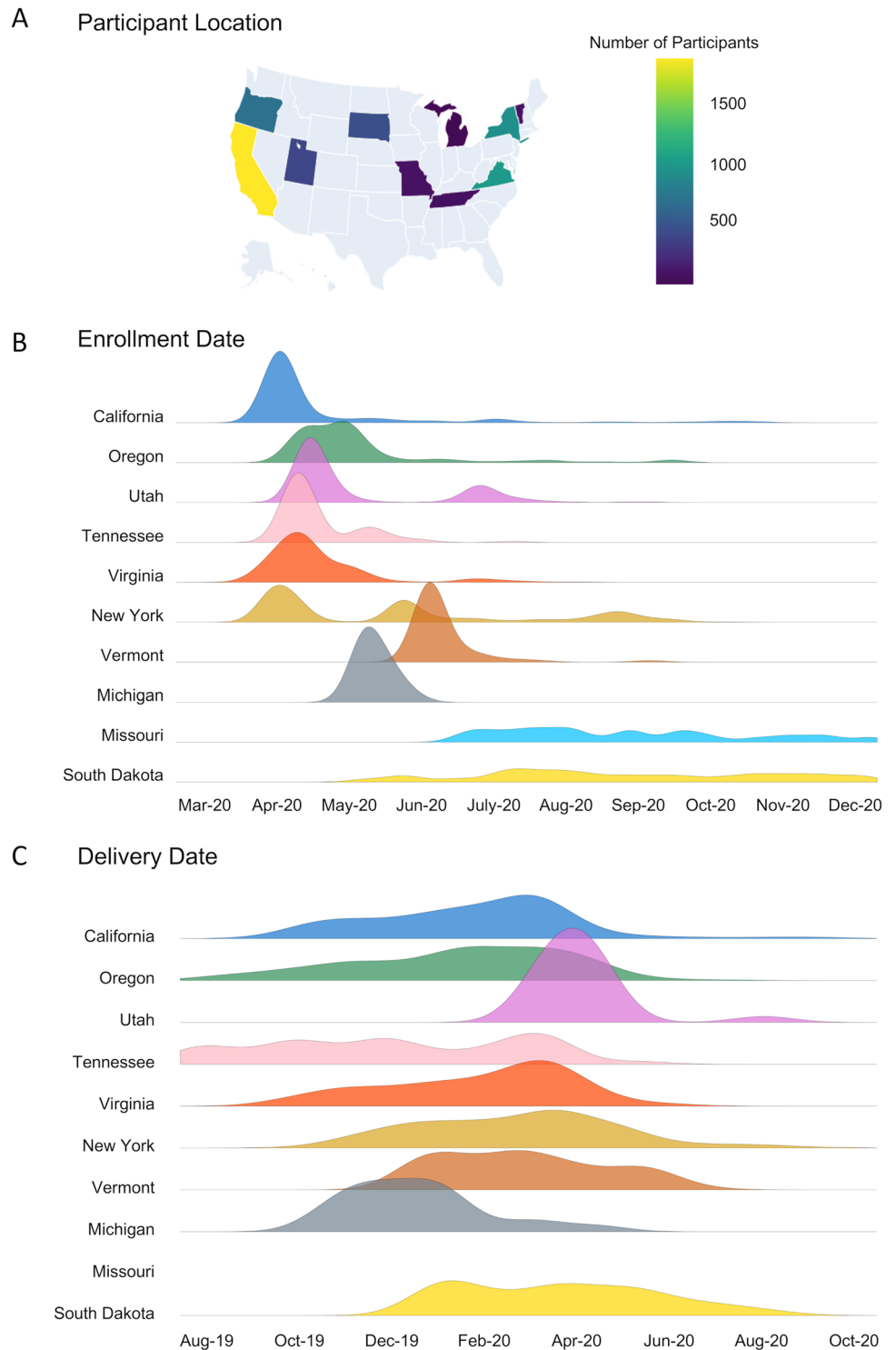
We collected firsthand accounts from nearly 6000 pregnant and postpartum individuals across the USA who gave birth between August 2019 and August 2020. Participants were recruited into independent studies at 15 academic research institutions across the USA that used common research methodology (<https://www.covgen.org/>). All sites used a convenience sampling strategy and sample sizes ranged from 42 to 1368 participants per site, with 60% of sites ( $n=9$ ) contributing at least 300 participants each (Fig. 1a). Sites administered the COPE survey (Thomason et al. 2020) online between March and December 2020 to pregnant and postpartum individuals within 12 months of delivery, with most data collection occurring between March and July (Fig. 1b). Given that identifying information was not shared across sites, the present study did not assess whether an individual subject participated at more than one site. However, geographical restriction to site local catchment areas was confirmed by individual sites. All studies were conducted in compliance with the Helsinki Declaration, approved by the local Institutional Review Board at each site, and informed consent was obtained prior to data collection. The final combined sample consisted of 5786 birthing individuals ( $n=3868$  pregnant,  $n=1918$  postpartum) living in 10 states at the time of data collection. Most postpartum participants gave birth between November 2019 and June 2020 (Fig. 1c). During data validation steps, exclusions were made on the basis of incomplete survey data ( $n=260$ ) and/or participants being greater than 12-month postpartum ( $n=186$ ). Participants were included in a given analysis if data was available for the primary measures of interest in that analysis.

### Measures

#### COVID-19 impacts

Our primary predictor of interest was the COVID-19 pandemic, which we measured in two ways. First, we split our sample of postpartum individuals into two groups: those who delivered before March 11, 2020 ( $n=1134$ ), and those who delivered after March 11, 2020 ( $n=784$ ). March 11 was chosen because it is when the World Health Organization declared COVID-19 a global pandemic (Cucinotta and Vanelli 2020), which prompted lockdowns in many parts of the USA (Bowman 2020). We also used publicly available national and state-level data from the COVID Tracking Project to measure increases in the percent of positive COVID-19 tests (“The COVID Tracking Project,” 2020).

**Fig. 1** Geotemporal characteristics of the sample. **A** Participants were located in 10 US states distributed across the country. **B** The majority of participants enrolled in the study during the first COVID-19 peak on April 2020. This enrollment distribution was similar for pregnant and postpartum people. Sample sizes are normalized in this figure to best depict temporal variability across states. **C** The vast majority of postpartum individuals from each state gave birth between August 2019 and August 2020. The sample from Missouri was composed entirely of pregnant people



**Perinatal care disruptions**

Two questions on the COPE survey addressed presence of specific perinatal care changes, which are displayed in 1 (Thomason et al. 2020). Specific care changes were

self-reported as being either present (1) or absent (0) in a dichotomous fashion, and the total number of changes was summed to produce a metric capturing the total number of perinatal care changes for each participant.

**Table 1** Questions used to assess perinatal care changesFor postpartum participants:

A. Did any of your birth plans change as a result of the COVID-19 outbreak? (check all that apply)

- (1) Reduced access to preferred medications before or after delivery (i.e., nitrous oxide, epidural)
- (2) Change to planned delivery location
- (3) My elective induction or C-section was not permitted as planned
- (4) My elective vaginal birth changed to induction or C-section
- (5) My healthcare provider (e.g., doctor, doula, midwife) was not available for my baby's birth as planned
- (6) Support people (e.g., partner, family) were not permitted to attend baby's delivery
- (7) I was separated from my baby immediately after delivery

For pregnant participants:

Which of the following changes are you experiencing as a result of the COVID-19 outbreak? (Check all that apply)

- (1) Change in schedule for planned C-section or labor induction
- (2) Changed from planned vaginal birth to induction or C-section
- (3) Changed from planned home birth to a hospital birth
- (4) Changed from plan for hospital delivery to a home birth
- (5) Change in selected hospital or birthing center
- (6) Change in prenatal healthcare provider(s)
- (7) Cancellation of or reduction in frequency of prenatal visit(s)
- (8) Changed format of prenatal care (i.e., no group classes)
- (9) Cancellation of hospital tours
- (10) Transition from in-person prenatal visits to virtual visits
- (11) None apply

Participants endorsed the presence or absence of specific perinatal care changes, displayed in the above table. Postpartum participants were asked the top question and pregnant participants were asked the bottom question. Endorsement of item (3), (4), or (5) by pregnant participants was recoded as a single “change in delivery location” variable. These questions are part of the COPE survey (Thomason et al. 2020)

## Maternal psychiatric symptoms

Maternal anxiety and depressive symptoms were self-reported using the Brief Symptom Inventory global score (BSI-18; Derogatis 2001), which was calculated by averaging the BSI items (range = 0–4). Higher scores indicate greater anxious and depressive symptoms. The question on suicidal intent was not administered as part of this study to enable widespread survey use, including in the context of remote, unsupervised survey completion. The BSI showed excellent internal consistency across both pregnant (Cronbach's  $\alpha = 0.94$ ) and postpartum participants ( $\alpha = 0.93$ ) in the present sample.

## Sociodemographics and covariates

Participants reported the following sociodemographic variables: estimated due date or delivery date, age, race, education, history of mood or anxiety disorder, marital status, whether this was the individual's first pregnancy, and number of children and adults living in the home. All participants reported whether they experienced gestational diabetes, hypertension, short cervix, or small fetal size. Postpartum participants additionally reported if they gave birth preterm (before 37-weeks gestational age) or if their

baby had a low birthweight. Finally, maternal COVID-19 stress was assessed via a single question in which participants rated their overall level of stress about the COVID-19 pandemic (range: 1 (no stress) to 7 (extreme stress)). The total number of pregnancy complications and COVID-19 stress were included as covariates in all models.

## Statistical analysis

The primary aims of this report are to (1) characterize COVID-19 induced perinatal care disruptions over time, (2) examine geographic variability in these disruptions, and (3) determine the significance of perinatal care disruptions for maternal mental health. Analyses were run using SPSS version 21.0 and the Pandas library (version 0.25.1) in Python. All analyses utilized an alpha level of  $p < 0.05$  to determine statistical significance.

## Analytic plan for aim 1: temporal analyses

We split our sample of postpartum individuals into two groups: those who delivered before March 11, 2020 ( $n = 1134$ ), and those who delivered after March 11, 2020 ( $n = 784$ ). March 11 was chosen because it is when the

World Health Organization declared COVID-19 a global pandemic (Cucinotta and Vanelli 2020), which prompted lockdowns in many parts of the USA (Bowman 2020). Prevalence rates of specific perinatal care changes were qualitatively and quantitatively compared for these two groups (see Appendix Table 1 for quantitative comparisons). Prevalence estimates and accompanying 95% confidence intervals were calculated based on 5000 bootstrapped samples. A 3-week moving average of care disruption prevalence was additionally calculated to plot continuous changes in perinatal care from August 2019 to August 2020.

### Analytic plan for aim 2: geographic analyses

Geographic analyses were conducted using binomial logistic regressions to test whether differences in perinatal care between states persisted after controlling for participant demographics that differed between data collection sites (indicated in Appendix Table 2). Additional details about geographic analyses are provided in the Appendix.

### Analytic plan for aim 3: mental health analyses

A hierarchical linear regression tested the association between maternal anxiety and depressive symptoms and perinatal care changes, which was run with 5000 bootstrapped samples to ensure effects were not driven by outliers. This model controlled for sociodemographic factors that were significantly correlated with maternal depressive and anxiety symptoms among postpartum participants. All care changes were included in the same model to minimize Type I error resulting from multiple tests and to provide a more stringent test for which disruptions were linked to mental health in postpartum participants. A separate hierarchical linear regression examined whether prenatal care changes impacted the health of expectant mothers who had not yet delivered at the time of the COVID-19 pandemic ( $n = 3868$ ). This model controlled for variables that were correlated with anxiety and depressive symptoms among pregnant participants. Sensitivity power analyses suggest our analytic approach and sample size yielded 95% power to detect a minimum effect size of  $f^2 = 0.007$  (or  $\beta = 0.007$ ) for our postpartum sample and a minimum effect size of  $f^2 = 0.003$  ( $\beta = 0.003$ ) for our pregnant sample.

## Results

### Participant characteristics

The final sample comprised of 3868 pregnant and 1918 postpartum individuals. Participants were predominantly

White, partnered, and highly educated (Table 2). Among postpartum individuals, participants who gave birth during the COVID-19 pandemic had younger children, were less likely to have a 4-year college degree, were less likely to have a self-reported history of a mood or anxiety disorder, and had more children living in the home compared to individuals who delivered prior to the declaration of COVID-19 as a global pandemic.

### Perinatal care changes during the COVID-19 pandemic

Among individuals who delivered between March 2020 and August 2020, 63% ( $n = 491$ , 95% CI [59.18, 66.07]) reported at least one change to their perinatal care. For comparison, only 4% ( $n = 50$ , 95% CI [3.26, 5.64]) of those who delivered prior to COVID-19 lockdowns reported any perinatal care changes (see Table 3 for the prevalence of specific care alterations). For individuals who delivered in the early months of the pandemic, the three most commonly endorsed care changes were not having support people at delivery (42%, 95% CI [38.52, 45.54],  $n = 329$ ), the primary health-care provider not being available for delivery (16%, 95% CI [13.08, 18.12],  $n = 114$ ), and changing from a spontaneous vaginal birth to a planned C-section or induction (12%, 95% CI [9.82, 14.29],  $n = 94$ ).

Unsurprisingly, our data demonstrate the timing of perinatal care changes was closely coupled with timing of COVID-19 peak incidence (see Appendix) and that perinatal care alterations were especially prevalent at certain times during the pandemic. For instance, although 40% of people who delivered between March and August 2020 reported that support people were barred from delivery, isolation during delivery affected as many as 60% of people who delivered during the first COVID-19 peak within the USA (Fig. 2b). During this window of time, nearly 100% of people experienced at least one alteration to their birthing protocol.

### Geographic variability in perinatal care disruptions across the USA

Our analysis of geographic variability in COVID-19 related perinatal care alterations confirms uneven impacts across the USA (Fig. 3a). Individuals who delivered in New York were 4.3 times more likely to be separated from their baby after birth compared to individuals who delivered in any other state ( $b = 1.46$ ,  $SE = 0.38$ , Wald's  $X^2 = 14.76$ ,  $p < 0.0001$ , Nagelkerke  $R^2 = 0.19$ ). Changes in delivery location also disproportionately affected individuals who delivered in New York (odds ratio = 3.23,  $b = 1.17$ ,  $SE = 0.37$ , Wald's  $X^2 = 10.15$ ,  $p < 0.01$ , Nagelkerke  $R^2 = 0.15$ ) or in Utah (odds

**Table 2** Demographic characteristics of pregnant people and postpartum people who delivered before and after the beginning of the COVID-19 pandemic

	Pregnant people ( <i>n</i> = 3,868)		Postpartum people			
			Delivered before March 11, 2020 ( <i>n</i> = 1,134)		Delivered after March 11, 2020 ( <i>n</i> = 784)	
	<i>N</i>	<i>M</i> ± <i>SD</i> (or %)	<i>N</i>	<i>M</i> ± <i>SD</i> (or %)	<i>N</i>	<i>M</i> ± <i>SD</i> (or %)
<b>Demographic variables</b>						
Estimated gestational age in weeks	-	25.2 ± 9.1	-	-	-	-
1st trimester (%)	424	13%	-	-	-	-
2nd trimester (%)	1206	36%	-	-	-	-
3rd trimester (%)	1722	51%	-	-	-	-
Child age in months	-	-	-	3.5 <sup>a</sup> ± 2.1	-	0.6 <sup>a</sup> ± 0.9
Maternal age in years	-	32.1 ± 4.7	-	33.0 ± 4.6	-	32.6 ± 4.6
Maternal race/ethnicity (% <i>BIPOC</i> )	927	27%	250	23%	175	24%
Black (%)	245	7%	54	5%	38	5%
Hispanic/Latin (%)	321	9%	72	7%	61	8%
Asian (%)	287	8%	106	10%	63	9%
Native American/Alaskan Native (%)	30	<1%	7	<1%	13	2%
Native Hawaiian/Pacific Islander (%)	28	<1%	2	<1%	6	<1%
Mixed race/other (%)	77	2%	15	1%	11	2%
Maternal education (% 4-year college graduate)	2386	77%	796	82% <sup>a</sup>	509	78% <sup>a</sup>
<High school (%)	51	2%	15	2%	18	3%
High school diploma/GED (%)	150	5%	38	4%	34	5%
Some college or trade school (%)	505	16%	126	13%	95	15%
4-year college (%)	1014	33%	306	31%	224	34%
Post-college graduate degree (%)	1372	44%	490	50%	285	43%
Maternal history of mood/anxiety disorder (%)	815	25%	289	28% <sup>a</sup>	127	19% <sup>a</sup>
# Pregnancy complications ( <i>pregnant 0–4 range, postpartum 0–6 range</i> )	-	0.2 ± 0.4	-	0.4 ± 0.7	-	0.4 ± 0.7
First pregnancy (%)	685	48%	553	50%	347	47%
Number of children in the home	-	0.8 ± 1.1	-	1.7 <sup>a</sup> ± 1.0	-	1.8 <sup>a</sup> ± 1.1
Number of adults in the home	-	2.2 ± 1.1	-	2.3 ± 1.1	-	2.3 ± 0.9
Married or partnered (%)	2880	93%	901	92%	616	94%
<b>Perinatal care disruption variables</b>						
Has your perinatal care changed because of COVID-19? ( <i>1 = significantly worsened, 5 = significantly improved</i> )	-	2.6 ± 0.7	-	2.9 <sup>a</sup> ± 0.8	-	2.7 <sup>a</sup> ± 1.0
Number of prenatal care disruptions ( <i>0–8 range</i> )	-	1.8 ± 1.5	-	-	-	-
Number of birth plan disruptions ( <i>0–7 range</i> )	-	-	-	0.0 <sup>a</sup> ± 0.2	-	0.9 <sup>a</sup> ± 0.9
<b>Psychological distress variables</b>						
Mean raw BSI global score ( <i>0–4 range</i> )	-	0.6 ± 0.6	-	0.6 <sup>a</sup> ± 0.5	-	0.5 <sup>a</sup> ± 0.6
COVID-related distress ( <i>1 = nothing, 7 = extreme</i> )	-	4.4 ± 1.5	-	4.4 ± 1.4	-	4.5 ± 1.6

Participants who delivered after March 11, 2020, had younger children, were less likely to have a 4-year college degree, were less likely to have a self-reported history of a mood or anxiety disorder, and had more children living in the home compared to individuals who delivered prior to March 11, 2020. There were no other sociodemographic differences between participants who delivered before versus after March 11, 2020. *N* indicates the number of participants in the displayed category and % indicates the percentage of those participants who are in the displayed category. <sup>a</sup>Groups differ at  $p < 0.05$ . *BIPOC* = Black, Indigenous, and people of color

ratio = 6.65,  $b = 1.90$ ,  $SE = 0.71$ , Wald's  $X^2 = 7.20$ ,  $p < 0.01$ , Nagelkerke  $R^2 = 0.13$ ).

An individual's healthcare provider being unavailable for the birth was 2.4 times more likely in Virginia compared to other states ( $b = 0.87$ ,  $SE = 0.23$ , Wald's  $X^2 = 14.59$ ,

$p < 0.0001$ , Nagelkerke  $R^2 = 0.19$ ). Conversely, being isolated during delivery was less common in Virginia (odds ratio = 0.43,  $b = -0.85$ ,  $SE = 0.07$ , Wald's  $X^2 = 144.54$ ,  $p < 0.0001$ , Nagelkerke  $R^2 = 0.29$ ). Notably, all models controlled for maternal education, mental health history, age,

**Table 3** Prevalence estimates for perinatal care disruptions in the sample before and after March 11, 2020

	<i>N</i>	Mean %	95% confidence interval
Born before March 11, 2020 ( <i>n</i> = 1134)			
Any disruption to labor or delivery care	50	4.41%	(3.26%, 5.64%)
Reduced access to delivery medications (e.g., nitrous oxide, epidurals)	7	0.64%	(0.18%, 1.11%)
Changed delivery location	5	0.45%	(0.09%, 0.88%)
Changed delivery schedule	0	0%	(0%, 0%)
Changed from spontaneous vaginal birth to planned C-section or induction	9	0.79%	(0.35%, 1.32%)
Health care provider was not available for delivery	5	0.45%	(0.09%, 0.91%)
Support people (e.g., partner, family) were not permitted to attend delivery	13	1.14%	(0.62%, 1.76%)
Separated from baby immediately after delivery	4	0.35%	(0.09%, 0.71%)
Born after March 11, 2020 ( <i>n</i> = 784)			
Any disruption to labor or delivery care	491	62.67%	(59.18%, 66.07%)
Reduced access to delivery medications (e.g., nitrous oxide, epidurals)	64	8.74%	(6.70%, 10.81%)
Changed delivery location	42	5.35%	(3.83%, 7.02%)
Changed delivery schedule	10	1.28%	(0.51%, 2.17%)
Changed from spontaneous vaginal birth to planned C-section or induction	94	11.98%	(9.82%, 14.29%)
Health care provider was not available for delivery	114	15.57%	(13.08%, 18.12%)
Support people (e.g., partner, family) were not permitted to attend delivery	329	41.98%	(38.52%, 45.54%)
Separated from baby immediately after delivery	33	4.22%	(2.81%, 5.74%)
Pregnant during March 2020–December 2020 ( <i>n</i> = 3,868)			
Any disruption to prenatal care	3011	78.05%	(76.72%, 79.34%)
Changed birth schedule	58	1.52%	(1.15%, 1.93%)
Changed from spontaneous vaginal birth to planned C-section or induction	56	1.46%	(1.09%, 1.85%)
Changed birth location	219	6.57%	(5.76%, 7.40%)
Changed prenatal health care provider(s)	514	14.95%	(13.80%, 16.16%)
Canceled prenatal visits	1607	41.78%	(40.21%, 43.31%)
Changed format of prenatal care (e.g., no group classes)	1688	48.94%	(47.26%, 50.60%)
Canceled hospital tours	1393	40.48%	(38.84%, 42.13%)
Prenatal visits became virtual	1556	40.41%	(38.86%, 41.98%)

*N* is the absolute number of participants reporting each disruption in the sample. Mean % is the percent of participants reporting each disruption averaged across 5000 bootstrapped samples, and the corresponding 95% confidence interval for the percent estimate

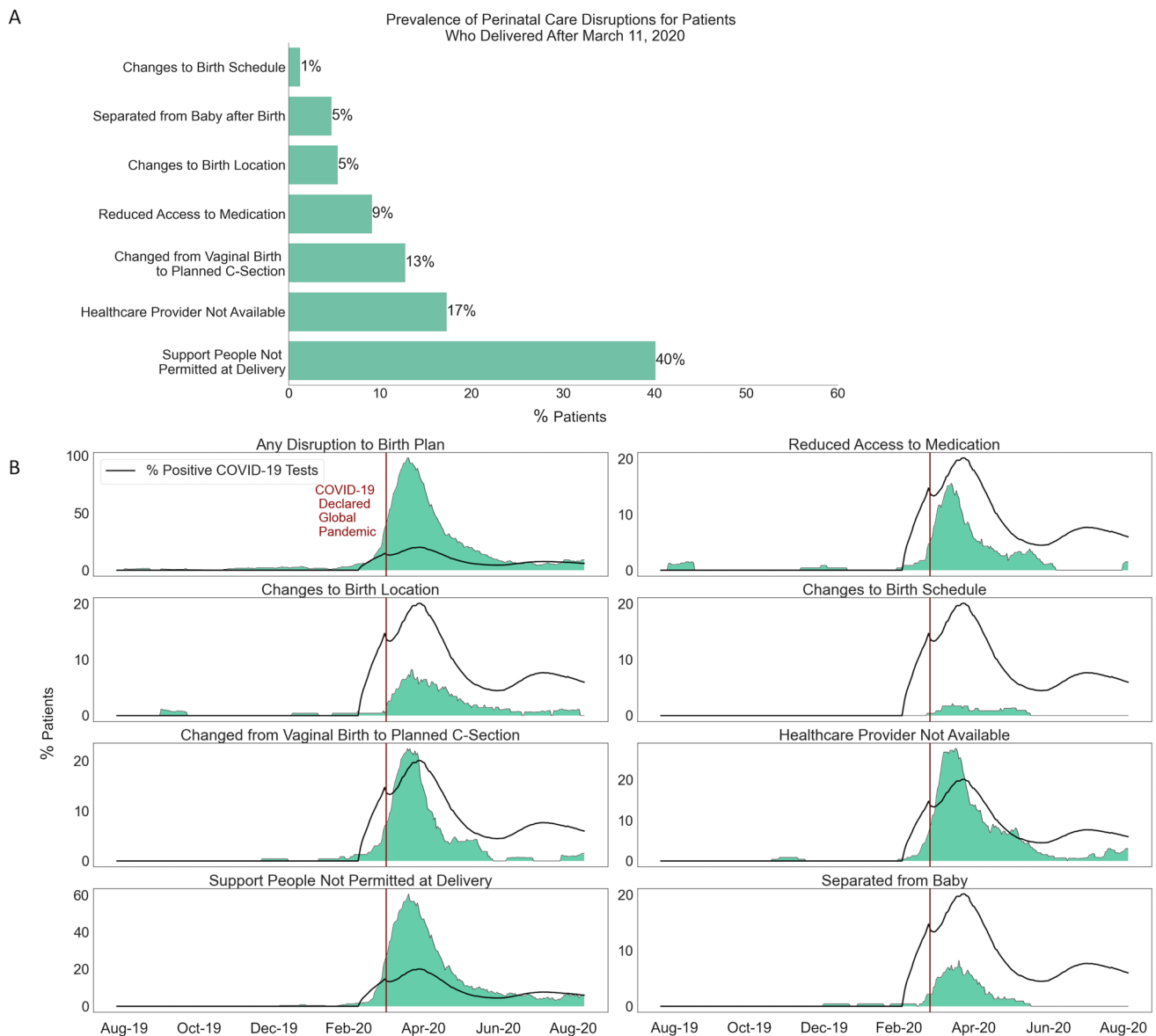
race, number of pregnancy complications, whether this was the mother's first pregnancy, marital status, number of adults living in the home, and infant postnatal age given that these factors varied across data collection sites (as noted in Appendix Table 1). There were no other geographic differences in perinatal care disruptions.

We next qualitatively examined geographic differences in the temporal variability of reported perinatal care alterations. These plots were restricted to states with more than 300 postpartum participants to produce more reliable estimates: California, New York, Virginia, and Oregon (Fig. 3b). Overall, there was surprising consistency in the temporal patterns of care alterations across states, with several important nuances. For example, changing one's birth location and being separated from one's baby were more common in New York compared to other US states, but these practices were largely constrained to March through May 2020, when New York had particularly high rates of COVID-19 related

hospitalizations and was severely lacking personal protective equipment (Hermann et al. 2020). In contrast, COVID-19 rates in Virginia displayed smaller peaks than many other states but remained persistent over time.

### Perinatal care disruptions and maternal mental health for postpartum individuals

We next examined whether COVID-19-induced perinatal care alterations impacted maternal anxiety and depressive symptoms. The overall number of birth plan alterations was not associated with greater maternal anxiety and depression after controlling for number of adults living in the home, maternal age, mental health history, number of pregnancy complications, and general stress about the COVID-19 pandemic ( $\beta = 0.01$ ,  $b = 0.01$ , 95% CI  $b [-0.03, 0.04]$ ,  $p = 0.70$ ,  $\Delta R^2 < 0.01$ ). However, specific care disruptions were associated with maternal mental health. Being separated from



**Fig. 2** Prevalence and timing of perinatal care disruptions for postpartum participants. **A** The prevalence of perinatal care disruptions for individuals who delivered between March 2020 and August 2020 in the USA. **B** A 3-week moving average was calculated for the percent of participants reporting each disruption (shown in teal) and the

percent of positive COVID-19 test results nationally (indicated by the black overlaid line) from August 2019 to August 2020. Perinatal care disruptions were particularly high at specific points within the COVID-19 pandemic, with peak incidence occurring from March to May 2020

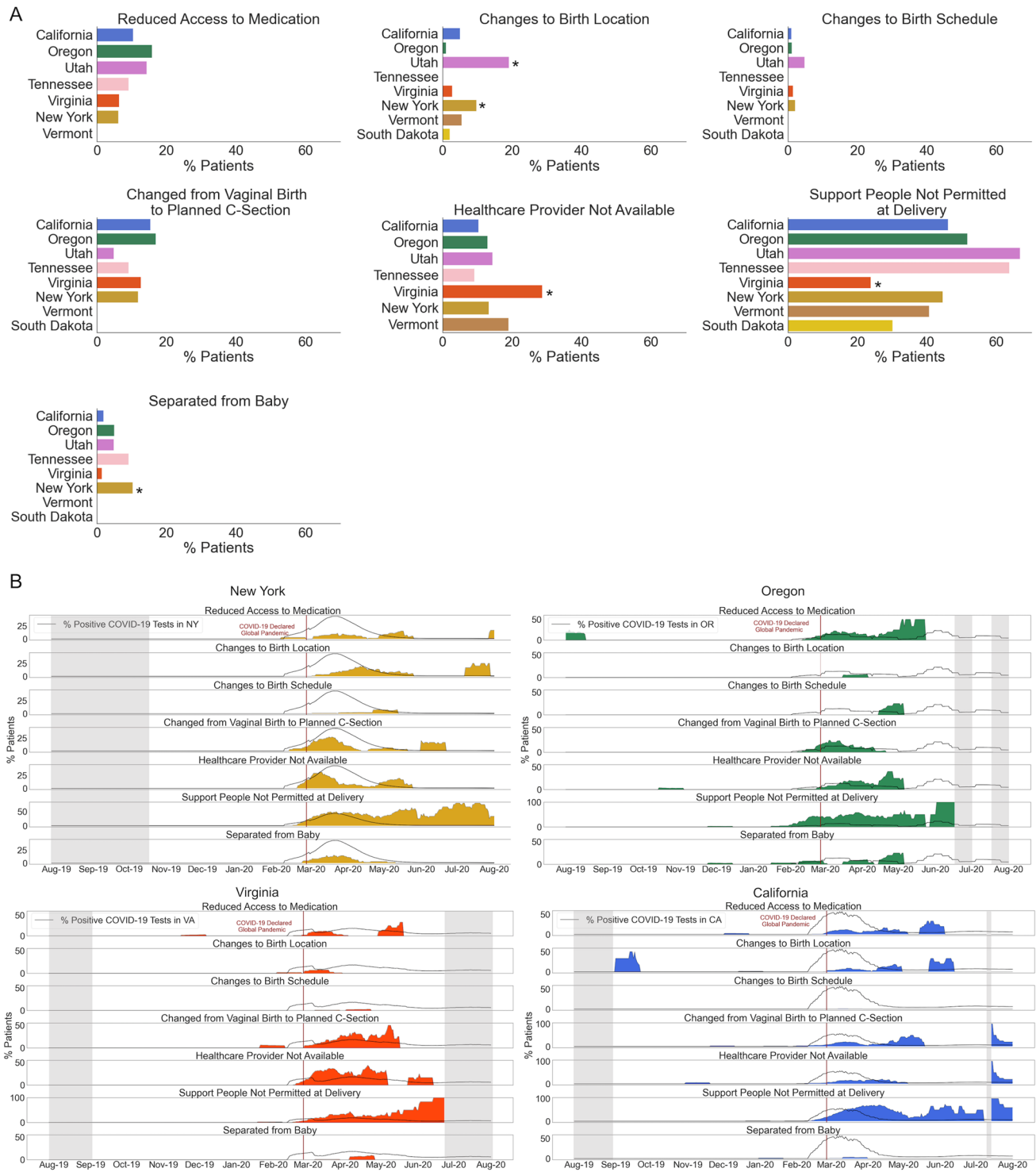
one's baby immediately after delivery was significantly associated with a small increase in maternal anxiety/depression symptomatology (absolute unadjusted mean difference = 0.29) after controlling for the aforementioned covariates and all other measured perinatal care changes (Table 4).

### COVID-19 impacts on pregnant individuals

Data from 3868 participants across the USA demonstrate that 78% (95 CI [76.72, 79.34]) of pregnant people

( $n = 3011$ ) reported at least one change in their perinatal care from March to August 2020. Not surprisingly, the first and second most common disruptions were changes in the format of prenatal care (e.g., no group classes) and canceled visits (Table 3). Prevalence estimates for prenatal care changes by participant trimester are provided in Appendix Fig. 2. Individuals who reported more changes to their prenatal care during the early months of the COVID-19 pandemic also reported worsened depression and anxiety symptoms ( $\beta = 0.06$ ,  $b = 0.02$ , 95% CI  $b$  [0.01, 0.04],  $p = 0.001$ ,





**Fig. 3** Geographic variability in perinatal care disruptions across the USA. **A** There was significant variability in the prevalence of perinatal care disruptions based on where patients delivered. \*Indicates significant geographic differences ( $p < 0.05$ ) that persisted after controlling for demographic differences between data collection sites. **B** There was also variability in when these perinatal care disruptions were most prevalent depending on the state participants gave birth in. The filled in colored lines indicate the percent of participants

who endorsed a care disruption on each delivery date in New York, Oregon, Virginia, and California. The black line overlaid on each distribution is the percent of COVID-19 tests coming back positive for each state respectively between August 2019 and August 2020 on that date. A 3-week moving average was calculated for the percent of participants experiencing each perinatal care disruption and percent positive COVID-19 tests. The gray bands indicate periods of time when no participants in the sample gave birth (i.e., periods of missing data)

**Table 4** Associations between perinatal care disruptions and maternal anxiety and depressive symptoms

	unadj. mean difference	unadj. p	adj. $\beta$	adj. 95% CI b	adj. p	R <sup>2</sup>	$\Delta R^2$	F
<i>Outcome: psychological distress among postpartum participants</i>								
Step 1								
# pregnancy complications	<b><math>\beta = 0.10</math></b>	< <b>0.001</b>	<b>0.08</b>	<b>0.02, 0.10</b>	< <b>0.01</b>	0.26	0.26	99.01
Maternal history of mood/anxiety	<b>0.32</b>	< <b>0.001</b>	<b>0.18</b>	<b>0.14, 0.27</b>	< <b>0.0001</b>			
Maternal age	$\beta = -0.04$	0.16	-0.05	-0.01, 0.00	0.06			
# adults in home	<b><math>\beta = 0.08</math></b>	<b>0.001</b>	<b>0.07</b>	<b>-0.001, 0.07</b>	< <b>0.01</b>			
COVID-19 Stress	<b><math>\beta = 0.46</math></b>	< <b>0.001</b>	<b>0.44</b>	<b>0.14, 0.18</b>	< <b>0.01</b>			
Step 2								
Reduced delivery medication access	0.17	0.07	0.04	-0.01, 0.30	0.07	0.27	0.01	2.89
Changed delivery location	0.01	0.88	-0.01	-0.20, 0.11	0.49			
Changed delivery schedule	0.31	0.35	0.03	-0.14, 0.77	0.15			
Changed from vaginal birth to C-section	0.11	0.13	-0.02	-0.14, 0.11	0.89			
Healthcare provider not available	0.03	0.52	-0.04	-0.17, 0.01	0.05			
No support people at delivery	0.07	0.04	-0.03	-0.11, 0.04	0.26			
Separated from baby after birth	<b>0.29</b>	<b>0.04</b>	<b>0.05</b>	<b>0.01, 0.42</b>	<b>0.03</b>			
<i>Outcome: psychological distress among pregnant participants</i>								
Step 1								
# pregnancy complications	<b><math>\beta = 0.10</math></b>	< <b>0.001</b>	<b>0.06</b>	<b>0.03, 0.14</b>	< <b>0.01</b>	0.24	0.24	100.29
Maternal history of mood/anxiety	<b>0.28</b>	< <b>0.001</b>	<b>0.15</b>	<b>0.14, 0.23</b>	< <b>0.01</b>			
Maternal BIPOC race	<b>0.09</b>	< <b>0.001</b>	<b>0.06</b>	<b>0.03, 0.12</b>	< <b>0.01</b>			
Maternal education (college graduate)	<b>0.16</b>	< <b>0.001</b>	<b>-0.07</b>	<b>-0.16, -0.05</b>	< <b>0.01</b>			
Maternal age	$\beta = -0.07$	< 0.001	-0.03	-0.01, 0.001	0.10			
# Adults in home	$\beta = 0.05$	0.01	0.02	-0.01, 0.03	0.25			
Estimated gestational age	<b><math>\beta = -0.01</math></b>	<b>0.49</b>	<b>-0.04</b>	<b>-0.01, 0.00</b>	<b>0.03</b>			
COVID-19 stress	<b><math>\beta = 0.44</math></b>	< <b>0.001</b>	<b>0.42</b>	<b>0.15, 0.18</b>	< <b>0.01</b>			
Step 2								
Changed delivery schedule	0.09	0.26	-0.01	-0.21, 0.11	0.52	0.24	< 0.01	1.16
Changed from vaginal birth to C-Section	0.19	0.03	0.02	-0.15, 0.19	0.19			
Changed delivery location	0.13	0.01	0.01	-0.08, 0.09	0.83			
Changed healthcare provider	0.08	0.005	0.02	-0.02, 0.09	0.19			
Canceled prenatal visits	<b>0.11</b>	< <b>0.001</b>	<b>0.04</b>	<b>0.01, 0.09</b>	<b>0.01</b>			
Changed format of prenatal care	0.09	< 0.001	0.03	-0.01, 0.07	0.19			
Canceled hospital tours	0.08	< 0.001	0.02	-0.02, 0.07	0.29			
Changed to virtual visits	0.01	0.69	0.00	-0.04, 0.04	0.91			

Step 1 of each model controlled for variables that were significantly associated with maternal depressive/anxiety symptoms. Step 2 added all prenatal or birth disruptions together in the same model to evaluate which disruptions are associated with maternal symptoms *after* controlling for the covariates included in step 1. Significant predictors of maternal depressive and anxiety symptoms in adjusted models are bolded. Unadjusted models are additionally reported, with unadjusted mean difference reported for categorical predictors and unadjusted  $\beta$  reported for continuous predictors as indicated

$\Delta R^2 < 0.01$ ). This effect was small, but statistically significant after controlling for age, estimated gestational age, race, education, number of adults living in the home, COVID-19 stress, number of pregnancy complications, mental health history, and all other prenatal care changes. In examining the influence of specific types of prenatal care disruptions on maternal mental health, canceled prenatal visits were the only care disruption individually associated with worsened anxiety and depressive symptoms among pregnant participants (absolute unadjusted mean difference = 0.11; Table 4).

## Discussion

In this large birth cohort study, we observed widespread and diverse disruptions to perinatal care across the USA during the early months of the COVID-19 pandemic across states with different COVID-19 trajectories. Some, but not all, of these healthcare alterations were tied to maternal psychological well-being even after controlling for concurrent stress about the pandemic, prior mental health history, and pregnancy complications. Identifying the prevalence and impact of healthcare changes during the early months of the COVID-19 pandemic serves as a historical record that can aid researchers and clinicians who work to promote the health of infants born during this time as well as the health of mothers who carried and gave birth under extreme stress.

For postpartum participants, being separated from one's baby after birth was most strongly associated with worsened anxiety and depressive symptoms. Limited information about vertical disease transmission as well as limited availability of personal protective equipment and testing at the start of the COVID-19 pandemic played a major role in the implementation of birth protocol changes. Early in the outbreak, infants were separated from parents immediately after birth if the mother tested positive for COVID-19 (Boelig et al. 2020; Rochelson et al. 2020). Although infant parent separation is generally not advisable, as the pandemic reached US soil, uncertainty about potential risks outweighed favored practices. Over time data began to suggest that separations and restrictions were not necessary to keep families safe (Salvatore et al. 2020). In fact, data released later in the pandemic revealed that even in a worst-case scenario (100% transmission from COVID-19 positive mothers to their infants), the benefit of skin-to-skin contact is 65-fold higher than the mortality risk of COVID-19 (Minckas et al. 2021).

Our findings also reveal that individuals who were pregnant during the first 6 months of the COVID-19 pandemic may also have been negatively impacted by restrictive healthcare changes. In particular, more disruptions to care and the cancellation of prenatal appointments, which was one of the most prevalent care alterations reported,

were linked with worsened anxiety and depressive symptoms among pregnant people. Interestingly, changing the format of prenatal care to virtual appointments was *not* associated with worsened mental health outcomes. These findings provide hopeful evidence that utilizing telehealth alternatives that reduce virus exposure while still providing clinical touchpoints may ameliorate the psychiatric strain of reduced provider availability; insurance reimbursement for virtual prenatal visits may be of particular benefit to pregnant individuals at times of heightened concern about illness transmission.

It is important to note that the absolute difference in maternal psychiatric distress following prenatal and birth protocol alterations was relatively small, albeit statistically significant. Perinatal care disruptions are only one factor among many that influence maternal mental health. Indeed, 49% of our sample reported that their perinatal care did not worsen during the COVID-19 pandemic (see Appendix). Healthcare providers worked diligently to provide the best patient care possible under difficult and traumatic circumstances, and their patients benefited from those efforts. Nonetheless, healthcare disruptions contribute to maternal mental health, especially when they occur in a larger context of extreme social isolation. Social support acts as an important buffer against the biological embedding of adversity (Schofield et al. 2013) and is associated with increased likelihood of disclosing mental health symptoms to a provider (Prevatt and Desmarais 2018). Birthing people are likely to benefit from policies that increase accessibility of such support during and after childbirth, for example insurance coverage for doula care.

Although not associated with maternal mental health after adjusting for covariates, 12% ( $n = 94$ ) of birthing people reported switching from vaginal to cesarean delivery after March 11, 2020. This rate is significantly higher than in our pre-pandemic comparison group ( $< 1\%$ ). Cesareans are major surgeries that place significant stress on patients and healthcare systems alike. Patients who undergo emergency c-sections report greater post-traumatic stress symptoms, have more difficulty initiating breastfeeding, and require more hospital resources (Grisbrook et al. 2022; Hobbs et al. 2016). It is suspected that increases in cesarean delivery during the early months of the COVID-19 pandemic resulted from medical complications that were exacerbated by delayed or interrupted prenatal care, iatrogenic attempts to minimize respiratory stress and inflammation during labor for infected patients, and/or desire to decrease maternal hospital stays, risk of patient-to-provider viral transmission, and use of scarce personal protective equipment (Arab and Atallah 2021). Future research is needed to determine whether *the reason* for cesarean delivery moderates the influence of this major surgery on maternal-child health outcomes during the COVID-19 pandemic.

Our data collection relied upon convenience sampling and is therefore not representative of the national population; given the relatively high socioeconomic status of our pooled sample, our statistics may *underestimate* the true prevalence of perinatal healthcare disruptions, particularly for underserved patient populations (Lomonaco-Haycraft et al. 2018; Minkoff 2020; Tai et al. 2021). One important question not addressed in the current study is the role of sociodemographic variation in experienced disruptions and mental health outcomes. This topic is of great importance given the pervasive health inequities highlighted by the COVID-19 pandemic. For example, in the USA, Black and Latinx individuals have died of COVID-19 at almost 5 times the rate of White individuals (Tai et al. 2021). Public health professionals stress that this disparity is driven by health inequities resulting from widespread systemic racism. Conditions related to years of disinvestment and active oppression of Black and Brown communities have led to lower access to and utilization of healthcare facilities (Feagin and Bennefield 2014), fewer healthy supermarkets (Noonan et al. 2016), and more crowded living conditions, all of which can increase risk for severe cases of COVID-19. This systemic bias is also coupled with day-to-day experiences of racial discrimination for Black, Brown, Native American, and Asian individuals in the USA, which can also become biologically embedded to shape health outcomes (Carter et al. 2017; Conratt et al. 2020). Future research is needed to examine the extent to which certain sociodemographic communities have been disproportionately affected by pandemic-related disruptions to perinatal care, and whether these disruptions are more strongly tied to maternal health in certain communities (Minkoff 2020).

Our questionnaire relied upon retrospective report of whether specific perinatal care alterations occurred in a dichotomous manner and lacked detailed information about the clinical features of each change, such as length of mother-infant separation or which support people were barred from delivery that may contribute to worsened maternal mental health. We also lacked information about the COVID-19 status of expectant and postpartum mothers in our sample. Perinatal care alterations are likely to be especially prevalent among infected individuals, and the combined stress of being ill in addition to modified healthcare support may further exacerbate psychiatric symptomology. However, additional research is needed to assess this possibility.

This study provides large-scale characterization of geotemporal alterations in perinatal care during the first months of the COVID-19 pandemic across the USA. Care alterations were most prevalent during periods of heightened infection rates and were largely unrelated to maternal mental health outcomes. However, canceled prenatal appointments and mother-infant separation after birth were linked

to worsened anxiety and depression symptoms, even after controlling for history of mental health concerns, general stress about the pandemic, pregnancy complications, and the presence of other perinatal care changes. The COVID-19 pandemic, and the findings from this study, highlights the importance of flexible healthcare options. Leveraging different care modalities to improve accessibility is a critical avenue for promoting the psychological wellbeing of pregnant and postpartum people and their partners.

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**Author contribution** All authors contributed to data collection, provided critical feedback that shaped conceptualization of the written paper, and approved the final manuscript. CLH analyzed the data. CLH, DW, MET, and NHB conceptualized the study. CLH, DW, CL, MET, and NHB wrote the manuscript. CLH, DW, MET, and NHB have access to all data analyzed in this manuscript. The authors from each site have access to the data collected at that site.

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**Data availability** Data used to estimate COVID-19 prevalence rates in the USA are publicly available for free download via *The Atlantic's* COVID Tracking Project (<https://covidtracking.com/data/download>).

The remaining data used in analyses for this study are available from the authors upon reasonable request.

## Declarations

**Conflict of interest** The authors declare no competing interests.


## References

- Boelig RC, Manuck T, Oliver EA, Di Mascio D, Saccone G, Bellussi F, Berghella V (2020) Labor and delivery guidance for COVID-19. *Am J Obstet Gynecol* 222(2):100110. <https://doi.org/10.1016/j.ajogmf.2020.100110>
- Carter RT, Lau MY, Johnson V, Kirkinis K (2017) Racial discrimination and health outcomes among racial/ethnic minorities: a meta-analytic review. *J Multicult Couns Dev* 45(4):232–259. <https://doi.org/10.1002/jmcd.12076>
- Conradt E, Carter SE, Crowell SE (2020) Biological embedding of chronic stress across two generations within marginalized communities. *Child Dev Perspect* 14(4):208–214. <https://doi.org/10.1111/cdep.12382>
- Cucinotta D, Vanelli M (2020) WHO declares COVID-19 a pandemic. *Acta Biomedica* 91(1):157–160. <https://doi.org/10.23750/abm.v91i1.9397>
- Feagin J, Bennefield Z (2014) Systemic racism and U.S. health care. *Soc Sci Med* 103:7–14. <https://doi.org/10.1016/j.socscimed.2013.09.006>
- Grisbrook M-A, Dewey D, Cuthbert C, McDonald S, Ntanda H, Giesbrecht GF, Letourneau N (2022) Associations among caesarean section birth, post-traumatic stress, and postpartum depression symptoms. *Int J Environ Res Public Health* 19(8):4900. <https://doi.org/10.3390/IJERPH19084900>
- Hermann A, Deligiannidis KM, Bergink V, Monk C, Fitelson EM, Robakis TK, Birndorf C (2020) Response to SARS-Covid-19-related visitor restrictions on labor and delivery wards in New York City. *Arch Women Ment Health* 23(6):793–794. <https://doi.org/10.1007/s00737-020-01030-2>
- Hobbs AJ, Mannion CA, McDonald SW, Brockway M, Tough SC (2016) The impact of caesarean section on breastfeeding initiation, duration and difficulties in the first four months postpartum. *BMC Pregnancy Childbirth* 16(1):1–9. <https://doi.org/10.1186/S12884-016-0876-1/TABLES/3>
- Minkoff H (2020) You don't have to be infected to suffer: COVID-19 and racial disparities in severe maternal morbidity and mortality. *Am J Perinatol* 37(10):1052–1054. <https://doi.org/10.1055/s-0040-1713852>
- Prevatt BS, Desmarais SL (2018) Facilitators and barriers to disclosure of postpartum mood disorder symptoms to a healthcare provider. *Matern Child Health J* 22(1):120–129. <https://doi.org/10.1007/s10995-017-2361-5>
- Stephens AJ, Barton JR, Bentum NAA, Blackwell SC, Sibai BM (2020) General Guidelines in the Management of an Obstetrical Patient on the Labor and Delivery Unit during the COVID-19 Pandemic. *Am J Perinatol* 37(8):829–836. <https://doi.org/10.1055/s-0040-1710308>
- Tai DBG, Shah A, Doubeni CA, Sia IG, Wieland ML (2021) The disproportionate impact of COVID-19 on racial and ethnic minorities in the United States. *Clin Infect Dis Offic Pub Infectious Dis Soc Am* 72(4):703–706. <https://doi.org/10.1093/cid/ciaa815>
- Arab W, Atallah D (2021) Cesarean section rates in the COVID-19 era: False alarms and the safety of the mother and child. *Cent Eur J Nurs Midwifery*. <https://doi.org/10.18332/ejm/134998>
- Bowman S (2020) CDC Recommends Against Gatherings Of 50 Or more; states close bars and restaurants. NPR. Retrieved from <https://www.npr.org/2020/03/15/816245252/cdc-recommends-suspending-gatherings-of-50-or-more-people-for-the-next-8-weeks>,
- Derogatis LR (2001) Brief Symptom Inventory 18: administration, scoring and procedures manual. Minneapolis: NCS Pearson.
- Hessami K, Romanelli C, Chiurazzi M, Cozzolino M (2020) COVID-19 pandemic and maternal mental health: a systematic review and meta-analysis. *J Maternal-Fetal Neonatal Med* 0(0):1–8. <https://doi.org/10.1080/14767058.2020.1843155>
- Kotlar B, Gerson E, Petrillo S, Langer A, Tiemeier H (2021) The impact of the COVID-19 pandemic on maternal and perinatal health: a scoping review. In *Reproductive Health* 18. <https://doi.org/10.1186/s12978-021-01070-6>
- Lomonaco-Haycraft KC, Hyer J, Tibbits B, Grote J, Stainback-Tracy K, Ulrickson C, Hoffman MC (2018) Integrated perinatal mental health care: a national model of perinatal primary care in vulnerable populations. *Prim Health Care Res Dev* 1–8. <https://doi.org/10.1017/S1463423618000348>
- Minckas N, Medvedev MM, Adejuyigbe EA, Brotherton H, Chellani H, Estifanos AS, Lawn JE (2021) Preterm care during the COVID-19 pandemic: a comparative risk analysis of neonatal deaths averted by kangaroo mother care versus mortality due to SARS-CoV-2 infection. *EClinicalMed* 33:100733. <https://doi.org/10.1016/j.eclinm.2021.100733>
- Niles PM, Asiodu IV, Crear-Perry J, Julian Z, Lyndon A, McLemore MR, Vedam S (2020) Reflecting on equity in perinatal care during a pandemic. *Health Equity* 4(1):330–333. <https://doi.org/10.1089/heap.2020.0022>
- Noonan AS, Velasco-Mondragon HE, Wagner FA (2016) Improving the health of African Americans in the USA: an overdue opportunity for social justice. *Public Health Rev* 37(1). <https://doi.org/10.1186/s40985-016-0025-4>
- Rochelson B, Nimaroff M, Combs A, Schwartz B, Meirowitz N, Vohra N, Chervenak F (2020) The care of pregnant women during the COVID-19 pandemic—response of a large health system in metropolitan New York. *J Perinatal Med* 48(5):453–461. <https://doi.org/10.1515/jpm-2020-0175>
- Salvatore CM, Han JY, Acker KP, Tiwari P, Jin J, Brandler M, DeLaMora P (2020) Neonatal management and outcomes during the COVID-19 pandemic: an observation cohort study. *Lancet Child Adolesc Health* 4(10):721–727. [https://doi.org/10.1016/S2352-4642\(20\)30235-2](https://doi.org/10.1016/S2352-4642(20)30235-2)
- Schofield TJ, Lee RD, Merrick MT (2013) Safe, stable, nurturing relationships as a moderator of intergenerational continuity of Child Maltreatment: A meta-analysis. *J Adolesc Health* 53. <https://doi.org/10.1016/j.jadohealth.2013.05.004>
- The American College of Obstetricians and Gynecologists, American Academy of Pediatrics (2017) Guidelines for perinatal care, 8th ed. In: Kilpatrick SJ, Papile L-A (Eds). Retrieved from <https://www.acog.org/clinical-information/physician-faqs/-/media/3a22e153b67446a6b31fb051e469187c.ashx>
- The COVID Tracking Project (2020) Retrieved January 15, 2021, from The Atlantic website: <https://covidtracking.com/>
- Thomason ME, Graham A, VanTieghem MR (2020) The COPE-IS: coronavirus perinatal experiences - impact survey. <https://osf.io/uqhcv/>
- Zhou J, Havens KL, Starnes CP, Pickering TA, Brito NH, Hendrix CL, Smith BA (2021) Changes in social support of pregnant and postnatal mothers during the COVID-19 pandemic. *Midwifery* 103(March). <https://doi.org/10.1016/j.midw.2021.103162>

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