


Trajectories of perinatal depressive symptoms in the context of the COVID-19 pandemic

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Abstract

This study sought to advance understanding of the potential long-term consequences of the COVID-19 pandemic for child development by characterizing trajectories of maternal perinatal depression, a common and significant risk factor for adverse child outcomes. Data came from 393 women (86% White, 8% Latina; mean age = 33.51 years) recruited during pregnancy ($n = 247$; mean gestational age = 22.94 weeks) or during the first year postpartum ($n = 146$; mean child age = 4.50 months; 55% female). Rates of depression appear elevated, relative to published reports and to a pre-pandemic comparison group ($N = 155$). This study also provides evidence for subgroups of individuals who differ in their depressive symptom trajectories over the perinatal period. Subgroup membership was related to differences in maternal social support, but not to child birth outcomes.

Perinatal depression (depression during pregnancy or in the early postpartum period) afflicts approximately one in five expectant or new mothers (Bennett et al., 2004; e Couto et al., 2016; Gavin et al., 2005; Gaynes et al., 2005; Hahn-Holbrook et al., 2018), making it one of the leading causes of maternal perinatal morbidity. Women's depression in the perinatal period is not only a debilitating health condition for the mother; even subclinical levels of perinatal depressive symptoms can place the developing child at risk for a range of mental and physical health conditions (Field, 2011; Glover, 2015; Monk et al., 2019). Previous research suggests that maternal depressive symptoms typically increase across gestation and then decrease for most women over the first year of the child's life, though there are individual differences in these trajectories that have unique implications for both maternal functioning and child development (Baron et al., 2017; Santos et al., 2017). Whether and how these trajectories are impacted by exposure to

a major stressful event such as the COVID-19 pandemic remains unknown.

COVID-19 and perinatal depressive symptoms

Previous research investigating effects of major stressful events during the perinatal period, including natural disasters (e.g., earthquakes, super storms, and hurricanes) and terrorist attacks (e.g., the 9/11 terrorist attacks on the World Trade Center), suggests that these events are associated with poorer maternal mental health, which has subsequent effects on child development (Berkowitz et al., 2003; Buthmann et al., 2019; Currie & Rossin-Slater, 2013; Dancause et al., 2011; Nomura et al., 2019). There is cross-sectional data indicating that maternal perinatal depression is similarly affected by the COVID-19 pandemic. For example, in a sample of 1987 pregnant women, Lebel et al., (2020) found that 37% of

Abbreviations: CES-D, Center for Epidemiological Studies–Depression Scale; PEACH, Prenatal Environment And Child Health Study; COPE, COVID-19 and Perinatal Experiences Study.

pregnant women reported elevated symptoms of depression warranting clinical attention. Similarly, utilizing cross-sectional data from 267 parents of 0–18-month olds, Cameron et al., (2020) reported that 33% of mothers endorsed clinically significant levels of depression. These rates stand in contrast to typically reported prevalence rates of 15–20% for clinically significant depressive symptoms (Gavin et al., 2005). Though a link between exposure to major stressful events and increased risk for perinatal psychological distress is clear, these studies have rarely captured maternal symptom change over time (particularly as the stressful event is ongoing), nor have they examined factors that may account for the association between exposure to the stressful event and maternal symptom change. More typically, these studies have utilized samples of women who have all been exposed to a major stressful event and then examined the effect of their experienced symptoms on child outcomes. This approach provides only a snapshot of the mother's response to the event, making it difficult to gain a complete understanding of the processes responsible for potential sustained effects on the mother and child, and how these may differ between individuals.

Though the COVID-19 pandemic shares features with the major stressors described above, it also has unique attributes which make studies of its effects particularly important. For example, its duration appears to be longer, it has had surges in severity and intensity (including ongoing concerns about newly emerging strains of the virus), and its end is uncertain. This combination of chronic and highly variable stress is particularly concerning given prior work identifying these characteristics of stress exposure during pregnancy as particularly detrimental for offspring development (Richardson et al., 2006; Schneider & Coe, 1993). Several specific features of the pandemic and associated changes in the broader environment may also be particularly challenging for pregnant women and families with young infants. Not only does infection carry risk for the health of the mother and child during a vulnerable developmental period (Khalil et al., 2020), but the social isolation measures used to control the spread of the coronavirus reduce women's access to healthcare and social supports. Social distancing guidelines require women to distance themselves physically from relatives, friends, pregnancy and parenting groups, and others who they would typically lean on during the transition to parenthood (Gjerdingen et al., 1991). Reduction in social support associated with these guidelines is presumed to contribute to changes in maternal mental health during the COVID-19 pandemic (Caparros-Gonzalez & Alderdice, 2020; Werner et al., 2020), but has not yet been empirically examined, despite evidence that low social support is a major contributor to perinatal depression outside of the context of the pandemic (Westdahl et al., 2007; Xie et al., 2009) and cross-sectional data that suggest that depression and low levels of social support are linked during the pandemic (Lebel et al., 2020).

Effects on the child

A natural extension of studies documenting an increase in maternal perinatal depression in the context of major stressful events is a test of what the event, and the resulting maternal symptomatology, may mean for the developing child. Birth outcomes—in particular child weight and gestational age (GA) at birth—are among the most widely studied child outcomes in this literature, in part because they can be assessed early in development, relatively close in time to the exposure and allow for differentiating between effects of pre- versus post-natal exposures, and because they have been shown to be markers of risk relevant to children's long-term development (Hack et al., 1995; Petrou et al., 2001; Saigal & Doyle, 2008). Some studies have found that *in utero* exposure to a major stressful event is associated with lower infant birthweight and shorter gestation (Currie & Rossin-Slater, 2013; Dancause et al., 2011; Harville et al., 2010; Oliveira & Quintana-Domeque, 2016). However, not all studies have found such associations (Jeffers & Glass, 2020; Lipkind et al., 2010).

Part of these mixed findings may be due to heterogeneity in maternal psychological responses to major stressful events that has not been captured by many of these studies. That is, previous studies in this area often have examined exposure to an event without taking into account differences in maternal depressive symptomatology in the context of that event (which may reflect or be related to factors such as differences in perception of the stressful event or individual differences in coping). Since increased maternal symptomatology during pregnancy is presumed to be causally related to birth outcomes via stress-sensitive aspects of maternal-placental-fetal biology during pregnancy (Entringer et al., 2015; Glover, 2015), this is an important oversight. Indeed, maternal depressive symptoms (outside of the context of major stressors) have been linked with lower birthweight and shorter GA at birth (see (Grote et al., 2010) for a meta-analysis), though again not all studies report this association. In their systematic review of maternal depression during pregnancy and birth outcomes, Accortt et al., (2015) found that 25% of the reviewed studies report an association between pregnancy depression and GA, while 50% of the reviewed studies report depression effects on birthweight. Thus, the extent to which major stressful events, and the COVID-19 pandemic in particular, are related to child weight and GA at birth, and the role that maternal perinatal depression may play in such associations, remains unclear.

The current study

The goal of the current study was to (1) characterize trajectories of maternal perinatal depression in the context of the COVID-19 pandemic (a time when maternal

symptomatology has unique and profound significance for the developing child), (2) identify factors related to heterogeneity in these trajectories (with hypotheses centered on changes in social support), and (3) examine possible effects on birth outcomes (assessed here by GA and weight at birth).

In addition to presenting data from a sample of women recruited and assessed during the COVID-19 pandemic, this study reports data from a pre-pandemic cohort, to provide additional context for interpreting the pandemic-related data.

METHOD

Participants

Data ($N = 393$) came from an ongoing longitudinal study investigating the effects of the COVID-19 pandemic on pregnant women and mothers of young children. Participants were recruited beginning in April of 2020 (recruitment is ongoing) from an academic medical center located in Portland, Oregon. Eligible participants were identified via electronic medical records and via an electronic pediatric newsletters sent to parents with young children. Eligible participants were at least 18 years old at the time of enrollment and were either pregnant ($n = 247$; mean gestational age = 22.94 weeks) or the parent of an infant younger than 12 months ($n = 146$; mean child age = 4.50 months). In the current report, we

refer to these individuals as comprising our “Pregnancy Cohort” (those who enrolled during pregnancy) and our “Postpartum Cohort” (those who enrolled after the child's birth). Recruitment began in April, 2020 (approximately one month after the governor of Oregon enacted a stay-at-home order, on 03/23/2020) and is ongoing.

Procedures

At enrollment and every 2 weeks after that for 12 weeks, participants completed questionnaires that queried demographics, changes in their lives related to the COVID-19 pandemic, their perinatal health, and their mood, stress, and social support. See Figure 1 for a visualization of this data collection protocol. Because data collection is still ongoing, data through the eighth week of follow-up were used, given greater density of data at these assessments at this time. Medical records were reviewed for information about the child's birth.

Measures

COPE survey

A comprehensive battery of questionnaires developed by the COVGEN alliance (www.covgen.org) was administered to participants at enrollment (COPE-IS) (Thomason et al., 2020). These questionnaires are

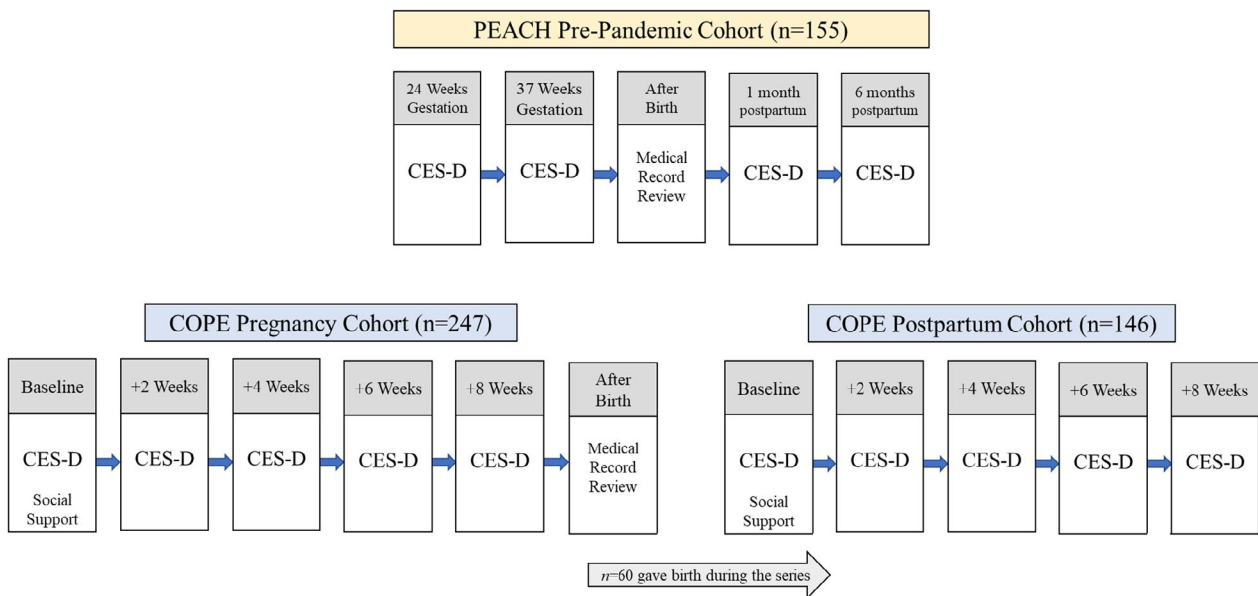


FIGURE 1 Visual depiction of the visit flow for the PEACH and COPE studies. *Note:* PEACH, Prenatal Environment and Child Health Study. COPE, COVID-19 and Perinatal Experiences Study. CES-D, Center for Epidemiological Studies Depression Scale. Social Support =The Medical Outcomes Social Support Questionnaire. In the COPE study, pregnant participants ($n = 247$) enrolled at an average of 22.94 weeks gestation ($SD = 9.26$). New mothers ($n = 146$) enrolled during the first 12 months of their child's life (mean child age = 4.5 months, $SD = 4.10$). Sixty participants began the series when pregnant but gave birth before completing all 8 weeks of data collection. As described in the text, their prenatal data were used in the prenatal analyses and their postpartum data were used in the postpartum analyses

designed to capture objective pandemic-related exposures and life changes, and the subjective experience of these events. This includes assessment of the number of individuals that the participant knows with a suspected or confirmed case of COVID-19, changes to economic security and medical care, and adherence to social distancing guidelines, including restriction of social activities (e.g., going to stores, outdoor spaces, playgrounds, theaters, religious services), travel, and contact with other supports (family who live outside of the home, daycare providers). Participants provided ratings regarding subjective experiences of stress, mental health symptomatology, and coping strategies.

Demographic survey

A brief questionnaire covering basic demographic information, such as maternal age (years), race, ethnicity, maternal education (1 = *less than 10th grade* to 8 = *graduate degree*), household income (1 = *less than \$10,000* to 16 = *\$250,000+*), and child sex accompanied the COPE Survey.

Maternal depressive symptoms

Maternal depressive symptoms were assessed using the 20-item Center for Epidemiological Studies–Depression Scale (CES-D) (Radloff, 1977). Participants were presented with a list of statements (e.g., “I was bothered by things that usually don't bother me”) and were asked to rate (on a scale of 0 = *rarely or none of the time* to 3 = *most or all of the time*) how often they felt that way during the past week. Maternal CES-D scores of 16–27 indicate mild to moderate depression and scores of 28 and above are indicative of moderate to severe depression.

At the time of this report, 90% of the sample had completed the CES-D at two or more time points and 40% had completed the CES-D at 8 weeks post enrollment. Whether participants completed the 8-week assessment was not associated with prenatal ($p = 0.23$) or postnatal ($p = 0.95$) class membership, nor was it related to social support, baseline CES-D scores, or any of the demographic variables considered in the current study ($ps > 0.16$).

Social support

The Medical Outcomes Study Social Support Survey (Sherbourne & Stewart, 1991) was administered at the baseline assessment. This 20-item questionnaire asks participants to rate (1 = *Rarely or None of the Time* to 5 = *All of the Time*) how often they have access to certain types of support (e.g., “someone you can count on to listen when you need to talk”). Additionally, it asks the

participant to list how many relatives and close friends they have that they feel close to. This measure yields measures of tangible support (e.g., “Someone to take you to the doctor if you needed it”), affectionate support (e.g., “Someone who shows you love and affection”), positive social interaction (e.g., “Someone to have a good time with”), and emotional/informational support (e.g., “Someone to give you good advice about a crisis”).

Birth outcomes

GA at birth (in weeks), child weight (kg) and length (cm) at birth, APGAR scores (on a scale of 0–10, with higher scores being more optimal; recorded at 1 and 5 min after birth), and mode of delivery (cesarean section vs. vaginal delivery) were obtained via medical records or by parent report if medical reports were not available ($n = 43$; 23%). Gestational age at birth was extracted from the delivering physician's discharge summary; this value was calculated by comparing the estimated due date (that was confirmed via ultrasound earlier in pregnancy) and the date of delivery. When medical records were unavailable, gestational age was calculated similarly, by comparing the mother-reported estimated due date with her self-reported date of delivery. Based on previous reports (Accortt et al., 2015), child GA and weight at birth were the focal variables. At the time of this report, there were 61 (of the $n = 247$ who enrolled prenatally) participants who had not yet given birth. Twin pregnancies ($n = 2$ who enrolled during pregnancy) were not included in the analyses examining birth outcomes.

Analytic strategy

Data were analyzed separately for pregnancy versus postpartum depression symptomatology as external challenges, subjective experiences of stress and underlying biological contributors to mental health symptomatology can differ significantly between pregnancy versus during the first year of the child's life. The average trajectory of maternal depressive symptoms was modeled using latent curve modeling (LCM) (Bollen & Curran, 2006). Unconditional models were estimated to establish the functional form of the trajectory and to provide descriptive data about the average trajectory. Based on visual examination of the raw data, both linear and quadratic effects were tested. Models were estimated using *Mplus 8.5* (Muthén & Muthén, 1998–2017) using the robust maximum likelihood estimator. Full information maximum likelihood (Allison, 2003) was used to handle missing data. Model fit was evaluated using the Comparative Fit Index (CFI), Tucker-Lewis Index (TLI), and the Root Mean Square Error of Approximation (RMSEA). CFI and TLI values above 0.90 and RMSEA values below 0.05 indicate adequate model fit (Browne &

Cudeck, 1993; Hu & Bentler, 1999). For individuals who enrolled during pregnancy and who gave birth during the series ($n = 60$), their pregnancy data was used in the pregnancy models and their postpartum data were used in the postpartum models.

Latent class growth analysis (LCGA) (Jung & Wickrama, 2008) was used to test whether there were subgroups of individuals who differed in their initial levels of depression and/or their slope of depression. To determine the best class solution, Bayesian Information Criteria (BIC) values and the results of Vuong-Lo-Mendell-Rubin likelihood ratio tests (VLMR LRT) for the k -class vs. $k-1$ class model were examined. The best class solution is generally one that has a lower BIC value, paired with a significant VLMR LRT, and where all resulting classes contain at least 5% of the sample (Asparouhov & Muthén, 2012; Jung & Wickrama, 2008). Entropy, an index of precision of class assignment, was also reported (higher values suggest greater precision of class assignment) (Jung & Wickrama, 2008). One-through ten-class unconditional LCGA models were fit to the data.

After the best-class solution was selected, the resulting classes were compared to one another on demographic variables and hypothesized psychosocial contributors to heterogeneity in trajectories of depression using analysis of variance (ANOVA) and chi squared tests. A Bonferroni correction for multiple comparisons was applied as appropriate. Next, birth outcomes were compared across classes capturing heterogeneity in maternal depressive symptoms during pregnancy, as well as compared to our pre-pandemic sample (described below).

The majority of the analyses conducted as part of this study were specifically designed to test our research questions, and thus were confirmatory in nature. In our person-centered trajectory analyses, we did not have a specific hypothesis surrounding how many classes these data-driven analyses would yield, however we did hypothesize that there would be multiple subgroups who displayed different initial levels of depression and that showed different patterns of change over time, which the LCGA framework is specifically designed to identify. The analyses comparing the various classes on social support and on birthweight and gestational age at birth were also confirmatory and were used to test specific predictions about the impact of maternal depression on these focal outcomes. The analyses that compared the classes on other demographic variables and on other birth outcomes were more exploratory in nature, intended to provide the reader with important context for our primary results rather than to test a specific hypothesis.

Pre-pandemic comparison group

In addition to the ongoing cohort recruited during the COVID-19 pandemic ($N = 393$), data from

another ongoing longitudinal study, the Prenatal Environment and Child Health (PEACH) Study is also reported. Beginning in the winter of 2018, pregnant women were recruited in the first or second trimester, using methods similar to those used to recruit the COVID-19 study cohort (i.e., patients receiving care through the academic medical system, identified via medical records and advertisements at the medical center). Of note, the PEACH study did have some additional exclusion criteria (e.g., enrollment was limited to singleton pregnancies, mothers who were less than 40 years old at enrollment, and we excluded individuals with conditions that may influence systemic inflammation). Demographics of this pre-pandemic cohort were similar to that of the COVID-19 cohort (see Table 1), with the exception of maternal age. Mothers in the pre-pandemic cohort tending to be younger at study enrollment, $mean = 32.19$ (vs. $mean = 33.52$ in the COVID-19 cohort), $p = 0.003$. Maternal depressive symptoms were not sampled as densely in the PEACH study (the CES-D was administered at 24 and 37 weeks gestation and when the child was 1 and 6 months old; see Figure 1) which precluded modeling of trajectories using LCM or LCGA. However, given that this cohort was recruited from the same hospital system using similar recruitment methods, these data provide important pre-pandemic context for interpreting the COVID-19 cohort data. Prevalence estimates of mild/moderate and moderate/severe depression in the PEACH pre-pandemic cohort are reported, as are average CES-D scores at each time point. Paired-samples t -test were used to examine whether depressive symptoms increased from 24 to 37 weeks gestation, or decreased from 1 to 6 months of child age, as would be predicted by the literature (Baron et al., 2017). Birth outcomes for this cohort were pulled from medical records, as above.

Because of its global nature, it is challenging to define the “beginning” of the pandemic, as it may relate to maternal perinatal psychological distress among individuals living in Oregon. To account for this challenge and to offer conservative comparisons, the following are presented: average CES-D values and point- and period-prevalence estimates of mild/moderate and moderate/severe depression for PEACH participants who completed visits before 3/23/2020 (the date that Oregon's governor issued a stay-at-home order), 2/28/2020 (the date of the first presumptive case in Oregon), and before 1/30/2020 (the date the World Health Organization declared that the COVID-19 pandemic was a global health emergency). To maximize the available data and to obtain more accurate point-estimates of prevalence, all pre-pandemic data available for a given time point were summarized. That is, data were not limited to individuals who completed all depression assessments prior to the pandemic, which means that an individual may have contributed data at one time point and not others.

TABLE 1 Demographic and birth outcome data for the COPE and PEACH cohorts

	COPE pandemic cohort	PEACH pre-pandemic cohort	<i>p</i> value from <i>t</i> - or χ^2 test
	Mean (<i>SD</i>) or %	Mean (<i>SD</i>) or %	
Demographics			
Maternal age (years)	33.51 (4.66)	32.19 (4.51)	<i>p</i> = 0.003
Household income ^a	\$120–140,000	\$75,000–\$99,000	–
Education (% Bachelors or higher)	83%	84%	<i>p</i> = 0.82
Ethnicity (% Latina)	8%	5%	<i>p</i> = 0.33
Race (% non-white)	14%	12%	<i>p</i> = 0.61
Child sex (% female)	56%	51%	<i>p</i> = 0.83
Birth outcomes			
Birthweight (kg)	3.30 (0.56)	3.36 (0.54)	<i>p</i> = 0.98
Length at birth (cm)	50.36 (2.50)	50.77 (2.80)	<i>p</i> = 0.19
GA at birth	39.02 (1.70)	39.20 (2.01)	<i>p</i> = 0.39
Mode of delivery (% C-section)	31%	33%	<i>p</i> = 0.77
1 min APGAR	7.91 (1.55)	7.88 (1.45)	<i>p</i> = 0.84
5 min APGAR	8.81 (0.82)	8.77 (0.73)	<i>p</i> = 0.65

Note: COPE, COVID-19 and Perinatal Experiences Study. PEACH, Prenatal Environment And Child Health Study. Consistent with the analyses presented in the text, birth outcomes for the COPE study are only reported for children whose mothers enrolled in the study during pregnancy. Demographics for the PEACH pre-pandemic cohort are based on *N* = 155 with any depression data collected prior to 3/23/2020. GA, gestational age. C-section, caesarian section.

^aThe scales on which family income was rated differed between the two studies, which precluded our ability to test whether income differed significantly across cohorts.

RESULTS

Sample description

Of the 393 women enrolled in this study at the time of this report, 247 (63%) were pregnant at the first assessment (mean GA = 22.94 weeks, *SD* = 9.26, range = 6.57–40.57) and 146 (37%) had already given birth (mean child age = 4.50 months, *SD* = 4.10, range = 0.13–14.53 months). Most participants began the surveys immediately upon enrollment, however there was one participant who consented to the study when their child was fewer than 12 months old but who did not begin the surveys until their child was 14 months old (this participant's depressive symptom data were still included in this study). See Table 1 for demographic information about the cohort. As can be seen in this table, 86% of women self-identified as White and 8% as Latina, and 56% of the children were female. The demographics of this sample are broadly consistent with those of the patient population from which they were recruited. Of note, the pregnancy and postpartum cohorts did not differ on any of these variables (*ps* > .14). Four mothers enrolled in the study reported being pregnant with or having given birth to twins (2 who enrolled during pregnancy and 2 who enrolled after birth); the remaining children were singletons. Forty-nine percent of participants reported that this was their first pregnancy.

Rates of clinically significant depression symptoms

At the baseline assessment, 134 (34%) participants met criteria for mild/moderate depression (defined as 16 or greater on the CES-D), with similar prevalence rates for pregnant women (35%) and postpartum women (33%). The rate of moderate/severe depression (defined as 28 or greater on the CES-D) was 10% (*n* = 41) for the overall sample at baseline assessment, with slightly higher rates for pregnant (12%) versus postpartum women (8%).

Period prevalence estimates (based on maternal depression scores at all five time points) during pregnancy were 45% (*n* = 175) for mild/moderate depression and 18% (*n* = 45) for moderate/severe depression. The period prevalence estimate for the postpartum period were 45% (*n* = 66) for mild/moderate depression and 14% (*n* = 20) for moderate/severe depression. Together, this amounted to a perinatal period prevalence (captured in this study as during pregnancy or the first-year postpartum) of 45% (*n* = 175) for mild/moderate depression and 17% (*n* = 65) for moderate/severe depression.

Average trajectories: Results from latent curve models

The raw CES-D means are presented in Table 2.

TABLE 2 Mean maternal depression (CES-D) scores at each assessment for individuals enrolled during pregnancy and postpartum

	Baseline		2 weeks		4 weeks		6 week		8 weeks	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Pregnancy	14.39	10.70	12.64	9.61	11.78	8.93	11.60	10.70	11.53	10.10
Postpartum	13.44	9.55	12.62	10.41	11.30	10.24	12.44	11.02	12.05	11.42

Note: CES-D, Center for Epidemiological Studies–Depression Scale. Results from *t*-tests comparing the means for the pregnancy and postpartum cohorts at each time point were not significant *ps* > .39.

Average pregnancy trajectory

In the pregnancy sample, the linear model fit the data well, $\chi^2 = 10.29$ (df = 10), *p* = 0.42, CFI = 0.999, TLI = 0.999, RMSEA = 0.01. The LCM that included a quadratic slope term also fit the data well, $\chi^2 = 9.72$ (df = 9), *p* = 0.37, CFI = 0.997, TLI = 0.997, RMSEA = 0.02, though not statistically significantly better than the linear model (adjusted chi square change = 0.43, *p* = 0.51). Further, the quadratic slope term was not significant in this model, so the quadratic model was rejected in favor of the more parsimonious linear model.

Results from the linear model suggest that pregnant women, on average, endorse elevated but subclinical levels of depression at enrollment (intercept = 14.39), and that these symptoms decreased over time (slope = -0.46, *p* = 0.02). There was significant variability in the intercept (*p* < 0.001), but not in the slope (*p* = 0.45). See Figure 2 for a visual depiction of this trajectory.

GA at the baseline assessment and the number of weeks between the onset of the pandemic and the baseline assessment were not related to the intercept or slope of maternal depressive symptoms (*ps* > 0.33). This confirms the *a priori* decision to use the number of weeks from enrollment (vs. GA or weeks from the onset of the pandemic) as the time increment in these models.

Average postpartum trajectory

The linear model fit the postpartum data well, $\chi^2 = 9.22$ (df = 10), *p* = .51, CFI = 1.00, TLI = 1.00, RMSEA < 0.001. The LCM including a quadratic slope term also fit the data well, $\chi^2 = 6.61$ (df = 6), *p* = 0.37, CFI = 0.997, TLI = 0.998, RMSEA = 0.03, though not statistically significantly better than the linear model (adjusted chi square change = 0.90, *p* = 0.92). The quadratic slope term was again not significant, so the quadratic model was rejected in favor of the more parsimonious linear model.

Results from the linear model suggest that postpartum women, on average, endorse elevated but subclinical levels of depression at enrollment (intercept = 13.15), and that these symptoms decreased over time (slope = -0.40, *p* = 0.02). There was significant variability in the intercept (*p* < 0.001), and in the slope (*p* = 0.03).

Child age at the baseline assessment was related to the intercept of postpartum depressive symptoms (such that mothers whose children were older at enrollment, on average, reported greater depressive symptoms at baseline, *B* = 0.55, *p* = 0.03). Child age was not related to the slope (*p* = 0.72). Weeks since the onset of the pandemic was not related to the intercept or slope of maternal postpartum depression symptoms (*ps* > 0.81).

Subgroups: Results from latent class growth analysis models

BIC, VLMR LRTs, the percentage of individuals in the smallest class, and entropy values for the one through ten class LCGAs are presented in Table 3.

Pregnancy subgroups

Results from the LCGAs conducted with the pregnancy cohort suggested a 4-class solution. Although the 5-class solution had a slightly lower BIC (4488.46 for the 4-class vs. 4496.39 for the 5-class), the VLMR LRT for the 5- vs. 4-class solution was not significant, which suggests the 4-class solution is preferable. The resulting classes are depicted in Figure 3. Class 1 (8%) was termed “Severe, Persisting.” This class began with very high depressive symptoms that appeared to increase over time, though not statistically significantly so (intercept = 35.60, slope = 0.64, *p* = 0.41). Class 2 (23%), “Moderate, Persisting,” began with clinically significant depressive symptoms (intercept = 22.36) that also did not change significantly over time (slope = -0.19, *p* = 0.70). Class 3 (27%) “Subclinical, Remitting” resembled the average trajectory produced in the LCM, beginning with an average of 11.90 symptoms that decreased over time (slope = -0.69, *p* < 0.01). Class 4 (41%), “Low, Remitting” showed a similar pattern of change (slope = -0.79) but began with fewer symptoms (intercept = 5.47).

Postpartum subgroups

Results from the postpartum LCGAs pointed to a 3-class solution. While the higher-order classes each had lower BIC values (and some had significant VLMR LRTs), the 4- and

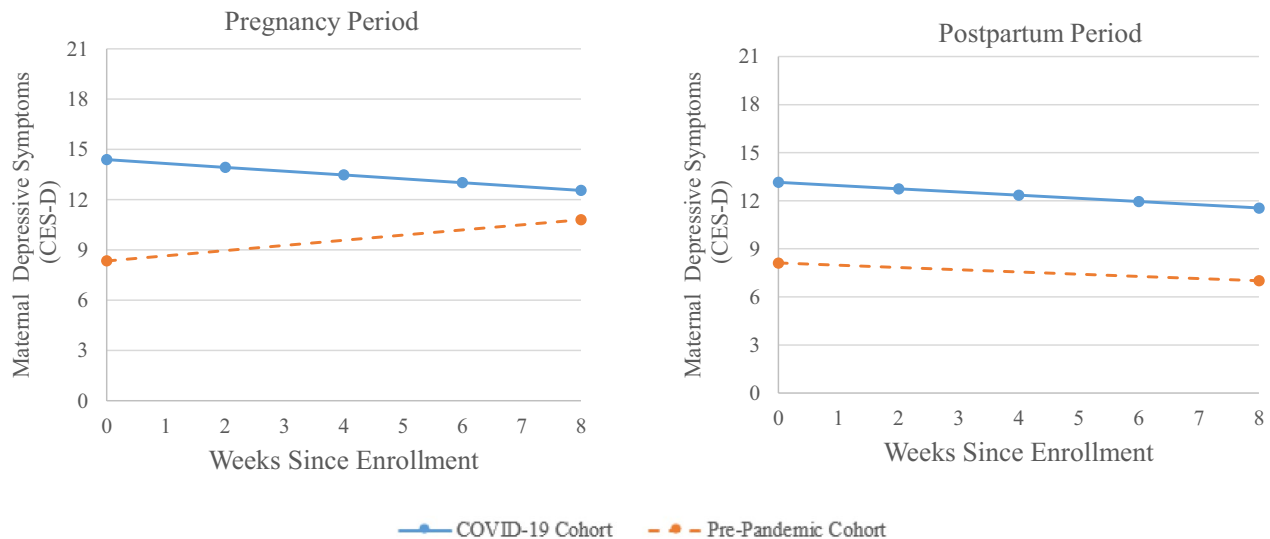


FIGURE 2 Maternal depressive symptoms over the pregnancy and postpartum periods, for the COVID-19 cohort and the pre-pandemic cohort. *Note:* CES-D, Center for Epidemiological Studies–Depression Scale. The values depicted for the pre-pandemic cohort are raw means from the 24 and 37 week gestation visits (for the pregnancy figure) and from 1 and 6 months postpartum visits (for the postpartum figure). The values depicted for the COVID-19 cohort are model implied values from latent curve models, where the mean gestational age at enrollment was approximately 23 weeks and the mean child age at enrollment was approximately 4.5 months. No formal statistical comparisons were made between these cohorts, given the differences in timing and frequency of sampling

TABLE 3 Results from latent class growth analyses examining heterogeneity in perinatal depressive symptoms

	Pregnancy				Postpartum			
	BIC	VLMR LRT	Smallest class %	Entropy	BIC	VLMR LRT	Smallest class %	Entropy
1-Class	4999.05	–	–	–	4175.44	–	–	–
2-Class	4657.12	0.0008	28	0.84	3848.05	0.1888	20	0.89
3-Class	4549.10	0.001	8	0.86	3706.88	0.0503	10	0.83
4-Class	4496.39	0.001	8	0.74	3635.67	0.0033	2	0.75
5-Class	4488.46	0.1384	7	0.73	3590.07	0.0258	2	0.84
6-Class	4491.33	0.5879	2	0.73	3579.64	0.2549	2	0.78
7-Class	4495.69	0.0661	2	0.73	3577.70	0.5731	3	0.79
8-Class	4499.74	0.8771	2	0.68	3577.11	0.363	2	0.79
9-Class	4504.79	0.6249	2	0.67	3584.19	0.0189	1	0.75
10-Class	4517.95	0.2292	2	0.67	3598.55	0.8496	0.5	0.76

Note: The bolded values indicate the solution that was selected.

higher-class solutions all contained a very small class that was less than 5% of the sample. As such, the 3-class solution was selected as the best fitting model, a decision that was confirmed by a significant VLMR LRT comparing the 3- to 2-class solution ($p < 0.05$) and a BIC value that was lower than that for the 2-class solution (2706.88 for the 3-class vs. 3848.05 for the 2-class solution). Interestingly, these classes corresponded closely to those produced using the pregnancy data (see Figure 2 for a visual depiction). For example, Class 1 (11%) “Severe, Persisting” endorsed very high depressive symptoms (intercept = 30.73) that did not change over time (slope = 0.55, $p = 0.29$), much like the pregnancy Class 1. Class 2 (38%) began with clinically significant levels of depressive symptoms (intercept = 16.67) that decreased over time (slope = -0.64 , $p = 0.049$) (this

appears to be similar to pregnancy Classes 2 and 3). Class 3 (52%) “Low, Remitting” began with few symptoms (intercept = 6.21) that decreased over time (slope = -0.54 , $p = 0.004$), much like pregnancy Class 4.

Differences between subgroups

Pregnancy subgroups

Demographics

The pregnancy classes did not differ on a number of demographic variables, including the number of weeks between the onset of the pandemic and when the participant enrolled in the study, maternal age and GA at enrollment,

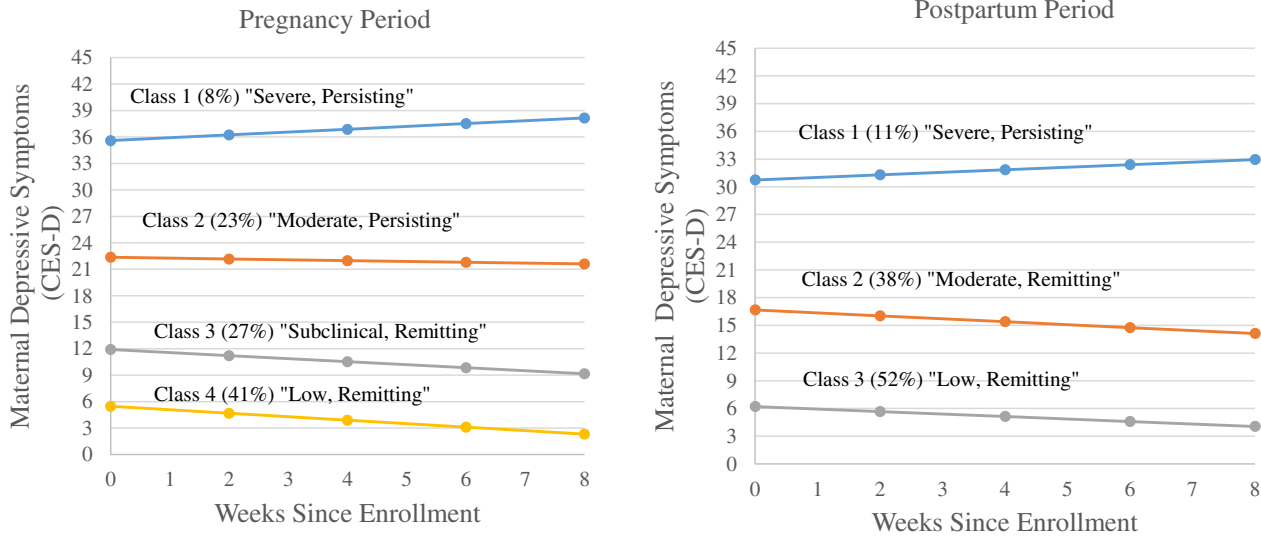


FIGURE 3 Visual depiction of the results from latent class growth analyses. *Note:* CES-D, Center for Epidemiological Studies–Depression Scale

TABLE 4 Social support and birth outcome information for the pregnancy latent class growth analysis classes

	Pregnancy				<i>p</i>	
	Class 1	Class 2	Class 3	Class 4		
	Severe, persisting	Moderate, persisting	Subclinical, remitting	Low, remitting		
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)		
Number of relatives	2.65 (2.39)	4.35 (3.15)	5.57 (4.10)	5.23 (4.10)	0.01	C1<C3=C4
Number of friends	2.30 (1.72)	4.15 (4.10)	5.78 (3.31)	5.61 (3.96)	<0.001	C1<C3=C4
Tangible support	3.47 (0.80)	4.25 (0.94)	4.66 (0.57)	4.54 (0.67)	<0.001	C1<C2<C3<C4
Affectional support	3.90 (1.11)	4.58 (0.64)	4.94 (0.22)	4.69 (0.57)	<0.001	C1<C2=C4<C3
Positive social interaction	3.64 (0.88)	4.26 (0.83)	4.71 (0.41)	4.50 (0.60)	<0.001	C1<C2<C3=C4
Emotional/informational support	3.48 (0.99)	4.16 (0.84)	4.74 (0.43)	4.41 (0.72)	<0.001	C1<C2=C4<C3
Birthweight (kg)	3.30 (0.49)	3.27 (0.51)	3.30 (0.43)	3.30 (0.66)	0.99	–
Birth length (cm)	49.83 (3.32)	49.93 (2.73)	50.43 (2.17)	50.52 (2.55)	0.72	–
Gestational Age at birth (weeks)	39.16 (1.32)	39.06 (1.66)	39.27 (1.24)	39.00 (1.69)	0.40	–
Mode of delivery (% C-section)	29%	33%	26%	34%	0.82	–
APGAR 1 min	8.60 (0.55)	7.58 (2.10)	8.06 (1.37)	7.91 (1.44)	0.51	–
APGAR 5 min	9.00 (0.00)	8.89 (0.45)	8.94 (0.54)	8.60 (0.92)	0.12	–

Note: C, class; C-section, cesarean section.

parity, race, and ethnicity $ps > 0.07$. The classes did differ on household income ($p < 0.01$), with the “Severe, Persisting” class reporting a lower income ($mean = \$50–\$60,000$) than both the “Subclinical, Remitting” and “Low, Remitting” classes ($mean = \$100–120,000$ and $mean = \$120–140,000$, respectively); none of the other classes differed on income. The classes also did not differ on the number of individuals that they knew who had either a confirmed or suspected case of the coronavirus or in their adherence

to social distancing guidelines or restrictions ($ps > 0.20$). Voluntary quarantine due to fear of exposure was an exception ($p = 0.02$), with the “Severe, Persisting” group reporting a higher rate of self-quarantining (70%) as compared to the other classes (35–55%).

Social support

Consistent with expectation, the classes differed on several measures of social support (see Table 4). Across all metrics,

Class 1 “Severe, Persisting” reported the lowest levels of social support, relative to both Class 3 “Subclinical, Remitting” and Class 4 “Low, Remitting” for the number of relatives and friends that they felt close to, and relative to all other groups for the other social support metrics. For most measures, Class 4 “Low, Remitting” reported the highest social support, though in several cases their reports were not significantly higher than Class 3 “Subclinical, Remitting.” Interestingly, Class 3 “Subclinical, Remitting” reported the highest Positive Social Interaction scores, which perhaps points to a mechanism through which their symptoms are remitting over time.

Birth outcomes

Among the 247 women recruited during pregnancy, 185 had given birth to a singleton at the time of this report. The average offspring birthweight was 3.30 kg ($SD = 0.56$), length was 50.36 cm ($SD = 2.50$), and the average GA at birth was 39.02 weeks ($SD = 1.70$). Thirty-one percent of deliveries were via caesarian section and the average APGAR scores were 7.91 ($SD = 1.55$) at 1 minute and 8.77 ($SD = 0.73$) at 5 minutes. The subgroups did not differ on any of these birth outcomes ($ps > .12$; see Table 4). In supplemental analyses, we examined whether there were group differences in birth outcomes when child sex was controlled, or whether controlling for GA at delivery when examining birthweight altered results. Results remained unchanged when controlling for these variables.

Postpartum subgroups

Demographics

The postpartum classes also did not differ on the number of weeks between the onset of the pandemic and when the participant enrolled in the study, maternal age and child age at enrollment, parity, race, and ethnicity $ps > 0.12$. These classes also differed on household

income ($p = 0.002$), such that the “Low, Remitting” class had a higher average income ($mean = \$160$ – $180,000$) than the “Severe, Persisting” ($mean = \$80$ – $100,000$) and “Moderate, Remitting” ($mean = \$100$ – $120,000$) classes (though the “Low, Remitting” and “Moderate, Remitting” classes did not differ from one another). The classes also did not differ on the number of individuals that they knew who had either a confirmed or suspected case of the coronavirus or in their adherence to social distancing guidelines ($ps > 0.23$).

Social support

The postpartum classes differed from one another on all metrics, except for the average number of friends they feel close to ($p = 0.09$) (see Table 5). Across all metrics, Class 1 “Severe, Persisting” reported the lowest social support, Class 2 “Moderate, Remitting” reported intermediate levels of social support, and Class 3 “Low, Remitting” reported the highest social support, though these difference were not always statistically significant.

Comparisons to the pre-pandemic cohort

To provide additional context for the data collected during the COVID-19 pandemic, data from the pre-pandemic cohort are also presented. As can be seen in Table 6, the pre-pandemic cohort's point-estimates during pregnancy were 13–21% for mild/moderate depression and 1–2% for moderate/severe depression. Point-estimates in the postpartum period were 7–14% for mild/moderate depression and 0–3% for moderate/severe depression. Results from paired samples t -tests suggest that, consistent with previously published reports, maternal depressive symptoms in this pre-pandemic cohort typically increased across pregnancy ($p < 0.001$) and decreased in the postpartum period ($p < 0.05$). This is in contrast to the decrease in symptoms seen in the COVID-19 cohort (described above). In the postpartum period, the pre-pandemic

TABLE 5 Social support differences across the postpartum latent class growth analysis classes

	Postpartum			<i>p</i>	
	Class 1	Class 2	Class 3		
	Severe, persisting	Moderate, remitting	Low, remitting		
	Mean (<i>SD</i>)	Mean (<i>SD</i>)	Mean (<i>SD</i>)		
Number of relatives	3.30 (2.34)	4.38 (2.66)	5.19 (2.88)	0.01	C1<C3
Number of friends	3.70 (2.68)	4.90 (5.19)	5.88 (4.11)	0.094	–
Tangible support	4.03 (1.01)	4.22 (0.88)	4.57 (0.78)	0.009	C2<C3
Affectional support	3.90 (1.18)	4.66 (0.50)	4.84 (0.52)	<0.001	C1<C2=C3
Positive social interaction	3.45 (1.17)	4.89 (0.86)	4.59 (0.68)	<0.001	C1<C2<C3
Emotional/informational support	3.36 (0.86)	4.19 (0.86)	4.61 (0.70)	<0.001	C1<C2<C3

Note: C, class.

TABLE 6 Maternal depressive symptom (CES-D) scores in the pre-pandemic comparison sample

	Before 03/23/2020	Before 02/28/2020	Before 1/30/2020
	Oregon stay at home order	First COVID-19 case in Oregon	WHO declared global health emergency
2nd trimester	<i>N</i> = 155	<i>N</i> = 144	<i>N</i> = 133
Mean	8.62	8.34	8.13
<i>SD</i>	7.12	7.1	6.87
>15	23 (15%)	20 (14%)	17 (13%)
>27	3 (2%)	3 (2%)	3 (2%)
3rd trimester	<i>N</i> = 111	<i>N</i> = 105	<i>N</i> = 94
Mean	11.06	10.8	11.28
<i>SD</i>	6.52	6.31	6.42
>15	23 (21%)	20 (19%)	20 (21%)
>27	1 (1%)	1 (1%)	1 (1%)
1 month postpartum	<i>N</i> = 75	<i>N</i> = 64	<i>N</i> = 55
Mean	8.12	8.19	8.35
<i>SD</i>	6.13	5.91	5.98
>15	6 (8%)	5 (8%)	4 (7%)
>27	1 (1%)	1 (2%)	1 (2%)
6 months postpartum	<i>N</i> = 43	<i>N</i> = 36	<i>N</i> = 25
Mean	7.53	8.22	7.48
<i>SD</i>	7.01	7.21	6.26
>15	5 (12%)	5 (14%)	3 (12%)
>27	1 (2%)	1 (3%)	0 (0%)

Note: CES-D, Center for Epidemiological Studies–Depression Scale; WHO, World Health Organization.

and COVID-19 cohorts both decreased in depressive symptoms, though (as was also true during pregnancy) the pre-pandemic cohort endorsed fewer symptoms. See Figure 2 for a visual depiction of these results. In this figure, the mean CES-D values for the pre-pandemic cohort (using 2/28/2020 as the cutoff) have been superimposed on the plot of the COVID-19 cohort's LCM results. This figure is meant to assist in comparisons across cohorts, though of note, no formal statistical comparisons were made between the cohorts on these means, given the differences in timing and frequency of sampling.

This pre-pandemic cohort did not differ significantly from the COVID-19 cohort on birth outcomes (as determined by *t*-tests and chi-squared tests, *ps* > 0.19). Infants born to mothers in the pre-pandemic cohort were on average 39.21 weeks gestation (*SD* = 2.01), weighed 3.36 kg (*SD* = 0.54), and were 50.77 cm long (*SD* = 2.80) at birth. Thirty three percent of children were born via cesarean section and their average APGAR scores were 7.88 (*SD* = 1.45) at 1 min and 8.81 (*SD* = 0.62) at 5 min after birth.

DISCUSSION

The goal of the current study was to characterize perinatal depressive symptom trajectories in the context of the

COVID-19 pandemic, whose social isolation measures have presented unique challenges for pregnant women and mothers with young children. This study aimed to characterize the average trajectory of depressive symptoms, and to examine whether there are subgroups of individuals who differ on their initial levels and/or the developmental course of these symptoms. Results suggest that there is significant heterogeneity in maternal perinatal depressive symptom trajectories over the perinatal period, and that reduced social support can help to discriminate individuals most at risk. Maternal depressive symptom trajectories were not associated with birth outcomes in this sample.

At the baseline assessment, 34% of participants in this study endorsed mild/moderate levels of depression (35% pregnant, 33% postpartum) and 10% endorsed moderate/severe depression (12% pregnancy, 8% postpartum). These estimates are consistent with those reported by cross-sectional studies examining perinatal depression during the COVID-19 pandemic (Cameron et al., 2020; Jeffers & Glass, 2020; Lebel et al., 2020) but appear to be elevated compared to previously published studies (Gavin et al., 2005) and compared to the pre-pandemic cohort described herein. The estimated period prevalence (defined here as occurring during pregnancy or during the first year postpartum) is 45% (45% in

pregnancy and 45% postpartum) for mild/moderate depression, and 17% for moderate/severe depression (18% pregnancy, 14% postpartum). Notably, these rates are two to three times those reported by Gavin et al., (2005) in their systematic review of the prevalence of perinatal depression, which highlights the significant burden of perinatal depression during the pandemic. This is of particular concern given that prior to the COVID-19 pandemic, the high prevalence of psychopathology among perinatal women (Ko et al., 2017) lead to recommendations by the US Preventive Services Task Force to screen all perinatal individuals for depression risk and refer for services as indicated (Curry et al., 2019; Freeman, 2019). The 11% discrepancy between our point-prevalence estimates and the period-prevalence estimates highlights the need for repeated assessment of depression during the perinatal period in order to accurately identify and treat women at risk.

Results from variable-centered trajectory models (LCMs) suggest that participants, on average, began with elevated, but subclinical levels of depressive symptoms that improved over time. Interestingly, this pattern was observed in both the pregnancy and postpartum cohorts enrolled in this COVID-19 study, which is in contrast to the pre-pandemic data presented here and to previously published reports which suggest that maternal depressive symptoms typically increase across gestation and decrease over the first year of the child's life (Baron et al., 2017). The cause for this diverging trend is not clear, but may be related to changes in the natural history of the pandemic (e.g., fluctuations in infection rates, changes in social distancing guidelines, changes in access to healthcare or other resources), emerging knowledge about the impact of the coronavirus on fetal and child development, as well as information related to the development of vaccines and therapeutics. Alternatively, it may be that as pregnancy progresses and the age of viability approaches, women's concern about the consequences of infection for their developing child may decrease, which likely would decrease distress. Future research should investigate these and other possible mechanisms of symptom change.

Results from our person-centered trajectory models (LCGAs) suggest that there is significant heterogeneity in these symptom trajectories, as evidenced by a 4-class solution in the pregnancy period and a 3-class solution in the postpartum period. The classes produced in the two periods were similar, with both periods having a group that corresponds to "High, Persisting," a group endorsing "Low, Remitting" symptoms, and 1–2 moderate trajectory groups who differ in trajectory ("Moderate, Persisting" and "Subclinical, Remitting" in the pregnancy period, and "Moderate, Remitting" in the postpartum period). These results are consistent with those of studies conducted pre-pandemic, which report that there is significant heterogeneity in perinatal depressive symptom trajectories (Glasheen et al., 2013; Santos et al., 2017).

Interestingly, these subgroups did not vary based on most demographic factors (i.e., party, race, ethnicity, maternal age and education, GA/child age at enrollment, timing of enrollment relative to the pandemic), though notably some did differ on their average household income. They also did not differ on the number of individuals who they knew who had a suspected or confirmed case of COVID-19, or on their adherence to social distancing guideline. Instead, what emerged as the important factor was social support. Social isolation has been hypothesized to represent an important pathway through which the pandemic may lead to escalating mental health symptomatology through dysregulation of brain circuitry underlying reward and stress processing (Hagerty & Williams, 2020) and may be a particularly potent risk factor among perinatal women. Prior research indicates the importance of social support for the mental health of perinatal women (Collins et al., 1993; Gjerdingen et al., 1991; Logsdon & McBride, 1994; Westdahl et al., 2007).

This study did not provide evidence that differences in maternal depressive symptom trajectories are associated with child birthweight or GA at birth. There were also no observed differences in birth outcomes between the pre-pandemic cohort and the pregnancy cohort recruited during the COVID-19 pandemic. Though some studies have found an association between depression during pregnancy and birth outcomes or exposure to major stressful events during pregnancy and birth outcomes, many have not (e.g., Accortt et al., 2015; Lim et al., 2019). Future research should investigate this issue further, by considering other birth outcomes as well as other dimensions of child development. Moreover, it will likely be important to consider potential key moderators, such as infant sex, infant temperament, birth order, and variability in the biological mechanism through which maternal psychological distress is hypothesized to impact birth outcomes.

This study had a number of strengths, including densely sampled depression data from a large sample of pregnant and postpartum women as the pandemic was unfolding. This is in contrast to previous studies of maternal psychological response to stressful events which typically have assessed psychological adjustment at a single time point, often after the event has ended. Though previous reports have shown that depression is elevated in the context of the COVID-19 pandemic (Yan et al., 2020) and that social support is related to depressive symptoms cross-sectionally (Ayaz et al., 2020; Lebel et al., 2020), this is the first to consider trajectories of depressive symptoms as they relate to social support. Also, although some studies have examined heterogeneity in perinatal depression trajectories in the past, few have used this many data points, particularly during pregnancy. Third, we considered several possible types and sources of social support, including tangible support, affectionate support, positive social interaction, and

emotional/informational support, as well as the number of family members and friends that the respondent felt close to. This is in contrast to other studies in this area that have largely focused on a single dimension of support (e.g., partner support) or general social support, and offers a far richer picture of the social support experienced by these pregnant and new mothers. Another strength of this study is that both person-centered and variable-centered statistical approaches were used to examine these densely sampled data. Based on the variable-centered analyses alone (which report the average trajectory), it would be reasonable to conclude that most women are not experiencing clinically significant levels of depressive symptoms and these symptoms are decreasing over time. The person-centered analyses highlight an important caveat, that a large portion of this sample – 31–49% of participants – are experiencing clinically significant levels of depression that are not remitting. Given the consequences of even subclinical levels of depression on maternal functioning and child development (Diego et al., 2005; Field, 2011; Goodman & Gotlib, 1999; Lebel et al., 2016), this is important information. The rich characterization of a number of COVID-related objective stressors and subjective responses is another strength of this study, as was its inclusion of data from a pre-pandemic comparison group that was recruited from the same hospital system using similar methods.

Limitations of this study include data acquired through a single hospital system in a city that is somewhat unique with regard to its increasing, but relative low infection rates, as compared to other parts of the country. Future research should investigate whether these results replicate in other populations, including in populations that include a greater number of individuals from racially and ethnically diverse backgrounds. A second limitation is that the current study only examined one dimension of psychological functioning, depressive symptoms. Consideration of other symptom domains, such as anxiety or sleep, which commonly co-occur with depression in the perinatal period (Field et al., 2007; Heron et al., 2004), but that may have unique trajectories and consequences for child outcomes represents an important future direction for this work. Though a strength of this study is that it considered several types of social support, including more concrete indices such as the number of family members and friends that the respondent felt close to, it is important to note that the respondent's perception of social support is likely confounded with their depressive symptoms. The current study examined whether maternal depressive symptoms during pregnancy were associated with child GA and weight at birth in this first report of this ongoing study. While these have been shown to be meaningful metrics that have long-term implications for child development (Hack et al., 1995; Petrou et al., 2001), future research should investigate other child outcomes as they relate

to maternal perinatal depression. Although most (77%) of our information about birth outcomes came directly from medical records, we relied on self-report of this information for some participants.

SUMMARY AND CONCLUSIONS

Consistent with cross-sectional reports, this study found that rates of perinatal depression and mean depressive symptoms were elevated in the context of the COVID-19 pandemic, relative to published reports and relative to a pre-pandemic comparison group. This increase is particularly apparent when examining longitudinal, repeated measures of depression, which reveal a period-prevalence of 45% (a value more than twice what is reported outside of the context of a pandemic). On average, participants endorse subclinical levels of depression that decrease over time. However, this study found evidence for heterogeneity in depressive symptom trajectories over the perinatal period. Consistent with expectation, this heterogeneity was related to differences in maternal social support; however, it was not related to child birth outcomes.

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REFERENCES

- Accortt, E. E., Cheadle, A. C., & Schetter, C. D. (2015). Prenatal depression and adverse birth outcomes: An updated systematic review. *Maternal and Child Health Journal, 19*(6), 1306–1337. <https://doi.org/10.1007/s10995-014-1637-2>
- Allison, P. D. (2003). Missing data techniques for structural equation modeling. *Journal of Abnormal Psychology, 112*(4), 545–557. <https://doi.org/10.1037/0021-843X.112.4.545>
- Asparouhov, T., & Muthén, B. (2012). Using Mplus TECH11 and TECH14 to test the number of latent classes. *Mplus Web Notes, 14*, 22.
- Ayaz, R., Hocaoglu, M., Günay, T., Yardımcı, O. D., Turgut, A., & Karateke, A. (2020). Anxiety and depression symptoms in the same pregnant women before and during the COVID-19 pandemic. *Journal of Perinatal Medicine, 48*(9), 965–970. <https://doi.org/10.1515/jpm-2020-0380>
- Baron, E., Bass, J., Murray, S. M., Schneider, M., & Lund, C. (2017). A systematic review of growth curve mixture modelling literature investigating trajectories of perinatal depressive symptoms and associated risk factors. *Journal of Affective Disorders, 223*, 194–208. <https://doi.org/10.1016/j.jad.2017.07.046>
- Bennett, H. A., Einarson, A., Taddio, A., Koren, G., & Einarson, T. R. (2004). Prevalence of depression during pregnancy: Systematic review. *Obstetrics & Gynecology, 103*(4), 698–709. <https://doi.org/10.1097/01.AOG.0000116689.75396.5f>
- Berkowitz, G. S., Wolff, M. S., Janevic, T. M., Holzman, I. R., Yehuda, R., & Landrigan, P. J. (2003). The World Trade Center disaster

- and intrauterine growth restriction. *JAMA*, 290(5), 595–596. <https://doi.org/10.1001/jama.290.5.595-b>
- Bollen, K. A., & Curran, P. J. (2006). *Latent curve models: A structural equation perspective*, Vol. (467). John Wiley & Sons.
- Browne, M. W., & Cudeck, R. (1993). Alternative ways of assessing model fit. In K. A. Bollen, & J. S. Long (Eds.), *Testing structural equation models* (pp. 136–162). Sage Focus Editions.
- Buthmann, J., Finik, J., Ventura, G., Zhang, W., Shereen, A., & Nomura, Y. (2019). The children of Superstorm Sandy: maternal prenatal depression blunts offspring electrodermal activity. *Biological Psychology*, 146, 107716. <https://doi.org/10.1016/j.biopsycho.2019.107716>
- Cameron, E. E., Joyce, K. M., Delaquais, C. P., Reynolds, K., Protudjer, J. L., & Roos, L. E. (2020). Maternal psychological distress & mental health service use during the COVID-19 pandemic. *Journal of Affective Disorders*, 276, 765–774.
- Caparros-Gonzalez, R. A., & Alderdice, F. (2020). The COVID-19 pandemic and perinatal mental health. *Journal of Reproductive and Infant Psychology*, 38(3), 223–225. <https://doi.org/10.1080/02646838.2020.1786910>
- Castro e Couto, T., Cardoso, M. N., Brancaglioni, M. Y. M., Faria, G. C., Garcia, F. D., Nicolato, R., Marques de Miranda, D., & Corrêa, H. (2016). Antenatal depression: Prevalence and risk factor patterns across the gestational period. *Journal of Affective Disorders*, 192, 70–75. <https://doi.org/10.1016/j.jad.2015.12.017>
- Collins, N. L., Dunkel-Schetter, C., Lobel, M., & Scrimshaw, S. C. (1993). Social support in pregnancy: Psychosocial correlates of birth outcomes and postpartum depression. *Journal of Personality and Social Psychology*, 65(6), 1243. <https://doi.org/10.1037/0022-3514.65.6.1243>
- Currie, J., & Rossin-Slater, M. (2013). Weathering the storm: Hurricanes and birth outcomes. *Journal of Health Economics*, 32(3), 487–503. <https://doi.org/10.1016/j.jhealeco.2013.01.004>
- Curry, S. J., Krist, A. H., Owens, D. K., Barry, M. J., Caughey, A. B., Davidson, K. W., Doubeni, C. A., Epling, J. W., Grossman, D. C., Kemper, A. R., Kubik, M., Landefeld, C. S., Mangione, C. M., Silverstein, M., Simon, M. A., Tseng, C.-W., & Wong, J. B. (2019). Interventions to prevent perinatal depression: US Preventive Services Task Force recommendation statement. *JAMA*, 321(6), 580–587. <https://doi.org/10.1001/jama.2019.0007>
- Dancause, K. N., Laplante, D. P., Oremus, C., Fraser, S., Brunet, A., & King, S. (2011). Disaster-related prenatal maternal stress influences birth outcomes: Project Ice Storm. *Early Human Development*, 87(12), 813–820. <https://doi.org/10.1016/j.earlhumdev.2011.06.007>
- Diego, M. A., Field, T., & Hernandez-Reif, M. (2005). Prepartum, postpartum and chronic depression effects on neonatal behavior. *Infant Behavior and Development*, 28(2), 155–164. <https://doi.org/10.1016/j.infbeh.2005.02.002>
- Entringer, S., Buss, C., & Wadhwa, P. D. (2015). Prenatal stress, development, health and disease risk: A psychobiological perspective—2015 Curt Richter Award Paper. *Psychoneuroendocrinology*, 62, 366–375. <https://doi.org/10.1016/j.psyneuen.2015.08.019>
- Field, T. (2011). Prenatal depression effects on early development: a review. *Infant Behavior and Development*, 34(1), 1–14. <https://doi.org/10.1016/j.infbeh.2010.09.008>
- Field, T., Diego, M., Hernandez-Reif, M., Figueiredo, B., Schanberg, S., & Kuhn, C. (2007). Sleep disturbances in depressed pregnant women and their newborns. *Infant Behavior and Development*, 30(1), 127–133. <https://doi.org/10.1016/j.infbeh.2006.08.002>
- Freeman, M. P. (2019). Perinatal depression: Recommendations for prevention and the challenges of implementation. *JAMA*, 321(6), 550–552. <https://doi.org/10.1001/jama.2018.21247>
- Gavin, N. I., Gaynes, B. N., Lohr, K. N., Meltzer-Brody, S., Gartlehner, G., & Swinson, T. (2005). Perinatal depression. *Obstetrics & Gynecology*, 106(5, Part 1), 1071–1083. <https://doi.org/10.1097/01.AOG.0000183597.31630.db>
- Gaynes, B. N., Gavin, N., Meltzer-Brody, S., Lohr, K. N., Swinson, T., Gartlehner, G., & Miller, W. C. (2005). Perinatal depression: Prevalence, screening accuracy, and screening outcomes. Evidence report/technology Assessment No. 119. AHRQ Publication 05-E006-1. Rockville, MD: Agency for Healthcare Research and Quality. <http://www.ahrq.gov/clinic/epcsums/peridepsum.pdf>
- Gjerdingen, D. K., Froberg, D. G., & Fontaine, P. (1991). The effects of social support on women's health during pregnancy, labor and delivery, and the postpartum period. *Family Medicine*, 23(5), 370–375.
- Glasheen, C., Richardson, G. A., Kim, K. H., Larkby, C. A., Swartz, H. A., & Day, N. L. (2013). Exposure to maternal pre- and postnatal depression and anxiety symptoms: Risk for major depression, anxiety disorders, and conduct disorder in adolescent offspring. *Development and Psychopathology*, 25(4pt1), 1045–1063. <https://doi.org/10.1017/S0954579413000369>
- Glover, V. (2015). Prenatal stress and its effects on the fetus and the child: Possible underlying biological mechanisms. In M. C. Antonelli (Ed.), *Perinatal programming of neurodevelopment* (pp. 269–283). Springer.
- Goodman, S. H., & Gotlib, I. H. (1999). Risk for psychopathology in the children of depressed mothers: A developmental model for understanding mechanisms of transmission. *Psychological Review*, 106(3), 458. <https://doi.org/10.1037/0033-295X.106.3.458>
- Grote, N. K., Bridge, J. A., Gavin, A. R., Melville, J. L., Iyengar, S., & Katon, W. J. (2010). A meta-analysis of depression during pregnancy and the risk of preterm birth, low birth weight, and intrauterine growth restriction. *Archives of General Psychiatry*, 67(10), 1012–1024. <https://doi.org/10.1001/archgenpsychiatry.2010.111>
- Hack, M., Klein, N. K., & Taylor, H. G. (1995). Long-term developmental outcomes of low birth weight infants. *The Future of Children*, 5(1), 176–196. <https://doi.org/10.2307/1602514>
- Hagerty, S. L., & Williams, L. M. (2020). The impact of COVID-19 on mental health: The interactive roles of brain biotypes and human connection. *Brain, Behavior, & Immunity - Health*, 5, 100078. <https://doi.org/10.1016/j.bbih.2020.100078>
- Hahn-Holbrook, J., Cornwell-Hinrichs, T., & Anaya, I. (2018). Economic and health predictors of national postpartum depression prevalence: A systematic review, meta-analysis, and meta-regression of 291 studies from 56 countries. *Frontiers in Psychiatry*, 8, 248. <https://doi.org/10.3389/fpsy.2017.00248>
- Harville, E., Xiong, X., & Buekens, P. (2010). Disasters and perinatal health: A systematic review. *Obstetrical & Gynecological Survey*, 65(11), 713. <https://doi.org/10.1097/OGX.0b013e31820eddbe>
- Heron, J., O'Connor, T. G., Evans, J., Golding, J., Glover, V., & Team, A. S. (2004). The course of anxiety and depression through pregnancy and the postpartum in a community sample. *Journal of Affective Disorders*, 80(1), 65–73. <https://doi.org/10.1016/j.jad.2003.08.004>
- Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, 6(1), 1–55. <https://doi.org/10.1080/10705519909540118>
- Jeffers, N. K., & Glass, N. (2020). Integrative review of pregnancy and birth outcomes after exposure to a hurricane. *Journal of Obstetric, Gynecologic & Neonatal Nursing*, 49(4), 348–360. <https://doi.org/10.1016/j.jogn.2020.04.006>
- Jung, T., & Wickrama, K. (2008). An introduction to latent class growth analysis and growth mixture modeling. *Social and Personality Psychology Compass*, 2(1), 302–317. <https://doi.org/10.1111/j.1751-9004.2007.00054.x>
- Khalil, A., Kalafat, E., Benlioglu, C., O'Brien, P., Morris, E., Draycott, T., Thangaratinam, S., Le Doare, K., Heath, P., Ladhani, S., von Dadelszen, P., & Magee, L. A. (2020). SARS-CoV-2 infection in pregnancy: A systematic review and meta-analysis of clinical features and pregnancy outcomes. *EClinicalMedicine*, 25, 100446. <https://doi.org/10.1016/j.eclinm.2020.100446>
- Ko, J. Y., Rockhill, K. M., Tong, V. T., Morrow, B., & Farr, S. L. (2017). Trends in postpartum depressive symptoms—27 states,

- 2004, 2008, and 2012. *MMWR. Morbidity and Mortality Weekly Report*, 66(6), 153. <https://doi.org/10.15585/mmwr.mm6606a1>
- Lebel, C., MacKinnon, A., Bagshawe, M., Tomfohr-Madsen, L., & Giesbrecht, G. (2020). Elevated depression and anxiety symptoms among pregnant individuals during the COVID-19 pandemic. *Journal of Affective Disorders*, 277, 5–13. <https://doi.org/10.1016/j.jad.2020.07.126>
- Lebel, C., Walton, M., Letourneau, N., Giesbrecht, G. F., Kaplan, B. J., & Dewey, D. (2016). Prepartum and postpartum maternal depressive symptoms are related to children's brain structure in preschool. *Biological Psychiatry*, 80(11), 859–868. <https://doi.org/10.1016/j.biopsych.2015.12.004>
- Lim, H. A., Chua, T.-E., Malhotra, R., Allen, J. C., Teo, I., Chern, B. S. M., Tan, K. H., & Chen, H. (2019). Identifying trajectories of antenatal depression in women and their associations with gestational age and neonatal anthropometry: a prospective cohort study. *General Hospital Psychiatry*, 61, 26–33. <https://doi.org/10.1016/j.genhosppsych.2019.09.001>
- Lipkind, H. S., Curry, A. E., Huynh, M., Thorpe, L. E., & Matte, T. (2010). Birth outcomes among offspring of women exposed to the September 11, 2001, terrorist attacks. *Obstetrics & Gynecology*, 116(4), 917–925. <https://doi.org/10.1097/AOG.0b013e3181f2f6a2>
- Logsdon, M. C., & McBride, A. B. (1994). Social support and postpartum depression. *Research in Nursing & Health*, 17(6), 449–457. <https://doi.org/10.1002/nur.4770170608>
- Monk, C., Lugo-Candelas, C., & Trumppf, C. (2019). Prenatal developmental origins of future psychopathology: Mechanisms and pathways. *Annual Review of Clinical Psychology*, 15, 317–344. <https://doi.org/10.1146/annurev-clinpsy-050718-095539>
- Muthén, L. K., & Muthén, B. O. (1998–2017). *Mplus User's guide*, (Eighth ed.). Muthén & Muthén.
- Nomura, Y., Davey, K., Pehme, P. M., Finik, J., Glover, V., Zhang, W., Huang, Y., Buthmann, J., Dana, K., Yoshida, S., Tsuchiya, K. J., Li, X. B., & Ham, J. (2019). Influence of in utero exposure to maternal depression and natural disaster-related stress on infant temperament at 6 months: The children of Superstorm Sandy. *Infant Mental Health Journal*, 40(2), 204–216. <https://doi.org/10.1002/imhj.21766>
- Oliveira, V., & Quintana-Domeque, C. (2016). Natural disasters and early human development: hurricane Catarina and birth outcomes in Brazil.
- Petrou, S., Sach, T., & Davidson, L. (2001). The long-term costs of preterm birth and low birth weight: Results of a systematic review. *Child: Care, Health and Development*, 27(2), 97–115. <https://doi.org/10.1046/j.1365-2214.2001.00203.x>
- Radloff, L. S. (1977). The CES-D scale a self-report depression scale for research in the general population. *Applied Psychological Measurement*, 1(3), 385–401. <https://doi.org/10.1177/014662167700100306>
- Richardson, H. N., Zorrilla, E. P., Mandyam, C. D., & Rivier, C. L. (2006). Exposure to repetitive versus varied stress during prenatal development generates two distinct anxiogenic and neuroendocrine profiles in adulthood. *Endocrinology*, 147(5), 2506–2517.
- Saigal, S., & Doyle, L. W. (2008). An overview of mortality and sequelae of preterm birth from infancy to adulthood. *The Lancet*, 371(9608), 261–269.
- Santos, H., Tan, X., & Salomon, R. (2017). Heterogeneity in perinatal depression: how far have we come? A systematic review. *Archives of Women's Mental Health*, 20(1), 11–23. <https://doi.org/10.1007/s00737-016-0691-8>
- Schneider, M. L., & Coe, C. L. (1993). Repeated social stress during pregnancy impairs neuromotor development of the primate infant. *Journal of Developmental and Behavioral Pediatrics*, 14(2), 81–87. <https://doi.org/10.1097/00004703-199304000-00002>
- Sherbourne, C. D., & Stewart, A. L. (1991). The MOS social support survey. *Social Science & Medicine*, 32(6), 705–714. [https://doi.org/10.1016/0277-9536\(91\)90150-B](https://doi.org/10.1016/0277-9536(91)90150-B)
- Thomason, M. E., Graham, A., & VanTieghem, M. R. (2020). The COPE-IS: Coronavirus Perinatal Experiences - Impact Survey.
- Werner, E. A., Aloisio, C. E., Butler, A. D., D'Antonio, K. M., Kenny, J. M., Mitchell, A., Ona, S., & Monk, C. (2020). Addressing mental health in patients and providers during the COVID-19 pandemic. *Seminars in Perinatology*, 44(7), 151279. <https://doi.org/10.1016/j.semperi.2020.151279>
- Westdahl, C., Milan, S., Magriples, U., Kershaw, T. S., Rising, S. S., & Ickovics, J. R. (2007). Social support and social conflict as predictors of prenatal depression. *Obstetrics and Gynecology*, 110(1), 134. <https://doi.org/10.1097/01.AOG.0000265352.61822.1b>
- Xie, R.-H., He, G., Koszycki, D., Walker, M., & Wen, S. W. (2009). Prenatal social support, postnatal social support, and postpartum depression. *Annals of Epidemiology*, 19(9), 637–643. <https://doi.org/10.1016/j.annepidem.2009.03.008>
- Yan, H., Ding, Y., & Guo, W. (2020). Mental health of pregnant and postpartum women during the coronavirus disease 2019 pandemic: A systematic review and meta-analysis. *Frontiers in Psychology*, 11, 3324.

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