Trajectories of pain during pregnancy predict symptoms of postpartum depression

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Abstract

Introduction: Postpartum depression imparts a significant and long-lasting burden on maternal and child health. Successful prevention or early detection of postpartum depression will rely on the identification of early risk factors. Pain during pregnancy (before childbirth) is a key potential predictor of postpartum depression risk. However, longitudinal studies characterizing pregnancy pain, its normal trajectory over time, and its prospective relations with symptoms of postpartum depression are lacking.

Methods: We used data from a longitudinal study of maternal emotion that included assessments of pain and depressive symptoms at 3 time points—during the second and third trimester of pregnancy and at 4 months postpartum. Structural equation modelling was used to estimate longitudinal patterns of change in maternal pain over time. Latent growth curve parameters were tested as predictors of symptoms of postpartum depression.

Results: Ninety-three healthy pregnant women enrolled in this study. Although the sample comprised women with relatively low-risk pregnancies, more than 90% of participants experienced pregnancy pain. Greater linear increases and less negative quadratic change in maternal pain over time were associated with greater levels of postpartum depression, even when controlling for prenatal depressive symptoms. Interpreting both parameters together, pain that increased in late pregnancy, when normative patterns had either levelled off or begun to decline, was associated with greater levels of postpartum depression.

Conclusion: A developmental trajectory of pain experience that did not subside after childbirth was associated with greater postpartum depressive symptoms, suggesting that atypical trajectories of pain may be a risk factor for postpartum depression.

Keywords: Pregnancy, Prenatal pain, Postpartum depression, Maternal health

1. Introduction

Approximately 1 in 9 mothers[41] will be diagnosed with postpartum depression, defined as a depressive episode during the peripartum or postpartum period, and an additional 1 in 3 women will show elevated symptoms of depression in the 24 months after childbirth.[35,45] The onset of symptoms for more than half of women who are diagnosed with postpartum depression will not be predicted by previous or prenatal depression.[3,40,52] Routine screens for depression alone across the perinatal period have been ineffective in improving diagnosis among women without a

history of previous mood disorders and fail to detect an estimated 20% to 30% cases of postpartum depression.[42,62,63] Unmanaged postpartum depression has significant adverse effects on maternal and child health,[5,28,50,56,58] and delays in identification and treatment are consequential.[55] Despite known risk factors (eg, previous depression, anxiety proneness, domestic abuse, and caesarean section[10,38,61,66]), postpartum depression remains underdiagnosed.[42,62] Therefore, there is a critical need for thorough understanding of early risk factors to improve clinical provision of both preventative and timely care for postpartum depression.[4,19,38,57]

Most women will experience pain during pregnancy; approximately 70% of all pregnancies involve low back, pelvic girdle, or abdominal pain.[11,12,27,37,47,48,53,64] On average, women report experiencing pregnancy pain that is moderately severe.[64] Cross-sectionally, pain during pregnancy is associated with factors that enhance depression risk (eg, sleep disturbance, interference and disability, and loss of work).[7,15,16,64] When assessed up to 11 years postpartum, women who reported having experienced pelvic girdle pain during pregnancy also reported greater rates of depression compared with women who did not experience pregnancy pain.[24] Furthermore, qualitative studies indicate that at least some women intuit that severe pain during pregnancy was the primary cause of their postpartum depression.[54]

Previous research supports consideration of pain experiences during the perinatal period as an important index of risk for

postpartum depression. For example, persistent pain during the first 3 months postpartum more than doubles mothers' odds of screening positive for postpartum depression.[26,60] Similarly, women with severe acute postpartum pain 8 weeks after childbirth were 3 times more likely to report postpartum depression compared with those with mild postpartum pain.[22] However, a major limitation in the existing literature is a nearly universal focus on maternal pain experienced during childbirth or in the early postpartum period. Furthermore, by relying almost exclusively on postpartum measures without prenatal controls, pregnancy and postpartum pain experiences are likely confounded. Yet other than in one recent study,[65] the possibility that pain experiences during pregnancy predict symptoms of maternal postpartum depression has gone largely unaddressed. This oversight is critical because experiences during pregnancy are often more robust predictors of symptoms of maternal postpartum depression than are postpartum factors.[3] Moreover, focusing only on postpartum pain ignores maternal experiences of pain across pregnancy and precludes an understanding of how the developmental course of pain experiences might offer insight into risk for symptoms of postpartum depression.

The absence of prospective longitudinal work in efforts to identify risk factors for postpartum depression is a critical limitation of the extant literature. Longitudinal studies allow for the assessment of temporal patterns (ie, developmental trajectories) of pain progression and resolution. More general work demonstrates that the experience of pain is best represented in this dynamically sensitive way[18] and that the utility of single-point measures, particularly for predicting clinical outcomes,[2] is limited. Longitudinal assessments also allow for the mapping of normative and atypical trajectories, elucidating the "shape" of typical change and enhancing the ability to distinguish more from less worrisome patterns in a way that directly overlaps with contemporary notions of risk.[59] This may be most important for periods such as pregnancy, where a characteristic pattern of change would be expected, necessitating the distinction of normative from problematic development. Moreover, focusing work only on prenatal or postpartum measures, rather than across the perinatal period, offers little in the way of information regarding either pain resolution or new pain onset, both of which may play a role in levels of postpartum depression. For example, most perinatal pain is believed to resolve within the first 6 postpartum months.[21] However, the degree and speed of pain resolution has largely gone untested in the absence of a prospective longitudinal design that can map trajectories of pain across the perinatal period.

The absence of prospective investigations of outcomes related to perinatal pain is also significant given that pain experienced during pregnancy is likely to be underestimated in retrospective reports in studies of postpartum women.[43] Work that relies on medical records and clinician perceptions of the trajectory of pregnancy pain is similarly limited, likely significantly underestimating the experience of pain during pregnancy, as many women do not report their pregnancy pain to medical providers.[64]

Overall, noninterventional, prospective, longitudinal assessments of pregnancy pain and its consequences are severely lacking.[53] The absence of these data has resulted in a limited understanding of pain during the perinatal period and the overlooking of potentially critical upstream indicators or risk factors for postpartum morbidities such as postpartum depression. To address critical gaps in the literature described above, we used data from a prospective study of maternal emotion that included maternal reports of pain across the perinatal period to test developmental trajectories of maternal pain as a predictor for postpartum depression. We specifically tested the normative pattern of linear and nonlinear change in pain over this period and the extent to which pain trajectories predicted symptoms of postpartum depression. We anticipated a normative nonlinear trajectory of pain such that mothers would report experiencing increasing levels of pain from the second to third trimester of pregnancy but that levels of pain would largely resolve by 4 months postpartum. We also anticipated that greater increases in pregnancy pain and smaller declines in postpartum pain (reflected as positive linear and negative quadratic effects) would predict greater levels of depressive symptoms in postpartum mothers.

2. Method

2.1. Participants

This study included a sample of mothers who were part of a larger, longitudinal study of maternal emotion from pregnancy to postpartum from 2015 to 2017.[9] Procedures were approved by the Human Subjects Committee of the Institutional Review Board at Montana State University, in accordance with the Declaration of Helsinki. All participants provided written informed consent.

The sample was recruited from rural communities in the Mountain West. Participation included 3 laboratory visits: during the second trimester, third trimester, and 4 months postpartum. Participants were recruited through informational brochures distributed at local doctors' offices (26%), e-mail announcements through the local university (25%), word-of-mouth referrals (27%), flyers posted at local preschools and businesses (13%), referrals from the local Women, Infants, and Children office (7%), and announcements in local mothers' clubs (2%). To enroll in the study, women needed to be in their second or third trimester of pregnancy, not taking any stimulant medications, and free of any neurological impairments (ie, epilepsy). Both primigravida and multigravida mothers were allowed to enroll. The sample was determined to be relatively low-risk based on mothers' reports, at the postnatal visit, of the presence or absence of 28 different conditions (eg, flu, lead exposure, and diabetes), experiences (eg, induction and c-section), and medications taken at any time during their pregnancy.[44] As has been previously reported for this sample,[9] mothers reported low levels of pregnancy and delivery complications and medication use.

2.2. Procedure

The full procedures for the parent study have been previously reported[9] and are available through the Open Science Framework (https://osf.io/ajx38/?view_only=fc2e408751a94046b5db 4f4430d88b38). As such, we focus on those procedures and measures directly related to the aims of this study: maternal self-reported depression and pain during the second and third trimesters of pregnancy and at 4 months postpartum. Two weeks before each visit, mothers were mailed a packet of questionnaires to complete and bring with them to the laboratory. Questionnaires for the postpartum assessment were identical to the prenatal assessments but also assessed complications experienced across pregnancy and during childbirth. To minimize missing data, demographic information was collected at each assessment.

2.3. Measures

2.3.1. Maternal symptoms of depression

Maternal depressive symptoms were assessed at all 3 visits using the Edinburgh Postnatal Depression Scale (EPDS[13]). The EPDS is

a 10-item measure that asked mothers to rate, on a 4-point Likert scale (0 = *absence of the symptoms* to 3 = *most frequent experience of the symptoms*), the degree to which they experienced a variety of symptoms over the past 7 days. Scores of 12 or greater on the EPDS are consistent with the likely presence of depression. The EPDS showed acceptable internal consistency at each visit (second trimester α = 0.82, third trimester α = 0.88, and postpartum α = 0.82). The EPDS has demonstrated validity during pregnancy and the postpartum period.[39] Given the focus of this study on symptoms of postpartum depression, we used the 4 month assessment of maternal depressive symptoms as our outcome variable. This choice is consistent with work showing that symptoms of postpartum depression are generally present by 3 to 5 months postbirth.[49] Given additional evidence that symptoms most frequently onset during the prenatal period,[32,34] we also included the most recent prenatal assessment (third trimester) as a covariate.

2.3.2. Maternal-reported pain

Participants reported on their levels of pain at all 3 visits as part of the RAND 36-item Health Survey. The RAND included one item that asked mothers to rate, on a 6-point scale (1 = none, 2 = very mild, 3 = mild, 4 = moderate, 5 = severe, and 6 = very severe), how much bodily pain they had experienced during the previous 4 weeks. Pain assessments using the RAND-36 both mirror other assessments of pain[23] and demonstrate construct validity through associations with quality of life and health outcomes.[23,31]

2.4. Analytic plan

Analyses were conducted in Mplus 7 version 1.4 (Los Angeles, CA[51]) using a latent growth curve model.[36] A structural equation model (SEM) was created to estimate longitudinal patterns of change in maternal pain. The SEM identified an intercept, linear slope, and quadratic slope as latent variables with loadings for each of the assessments. Intercepts for the manifest variables (ie, loadings for the manifest variables onto the latent intercept) were fixed to zero to make the latent intercept interpretable as the first assessment occasion. Unequal spacing between assessments was accounted for in the loadings of the manifest variables on the latent linear and quadratic slope factors. Errors of manifest variables were also constrained to zero. In each model, latent growth curve parameters (ie, intercept, linear slope, and quadratic slope) were then tested as predictors of maternal symptoms of postpartum depression. Third trimester depressive symptoms were included as a covariate. The data file and syntax used for analyses are available through the Open Science Framework.

2.5. Missing data

Pain ratings were missing from 14 participants during the second trimester visit (12 not yet enrolled in the study and 2 did not return questionnaires). Pain ratings and symptoms of depression were missing from 11 participants during the third trimester visit (6 withdrew, 4 did not return questionnaires, and 1 skipped this phase of the study) and 19 participants at the postpartum visit (7 withdrew, 3 were not yet 4 months postpartum when the study ended, and 9 did not return questionnaires).

An analysis of missing data patterns from measures of pain and depressive symptoms suggested that the data were missing completely at random (Little MCAR $\chi^2(14)$ = 4.42, P = 0.99).

Missing data were handled using a full information maximum likelihood procedure, which uses all available data to create nonbiased parameter estimates. The full information maximum likelihood procedure thus allows one to take advantage of the full sample from which at least some data are available. The full information maximum likelihood procedure is appropriate when data, even with large amounts of missingness and small sample sizes, are believed to be missing at random.[25]

3. Results

3.1. Sample characteristics

Ninety-three healthy pregnant women enrolled in this study (M_{age} = 30.49, SD = 4.22, range: 21–41 years old). Rolling recruitment procedures allowed mothers to enter the study during their second or third trimester of pregnancy, resulting in 81 participants at the second trimester visit (M = 21.15 weeks; SD = 3.79), 85 at the third trimester visit (11 new, 1 skipped this phase because the baby was born early, and 6 withdrew; M = 35.92 weeks; SD = 1.47), and 75 at the postpartum visit (7 withdrew and 3 were not yet 4 months postpartum when the study ended because the principal investigator switched institutions; M = 4.27 months, SD = 0.62).

Of those mothers who reported race and ethnicity, 89% were White, 8% Asian, 1% American Indian, 1% African American, and 1% mixed race. Most mothers were also non-Hispanic (96%). The median and mode level of education was a college degree (36%), and family incomes ranged from less than $15,000 to more than $91,000. Rates of pregnancy and labor and delivery complications were low (M = 3.35, SD = 2.22). The most commonly reported pregnancy complication was a fever or chills (n = 7), and the most common delivery-related risk factor was labor induction (n = 21). No participants reported a depression diagnosis. Participants used very few medications during pregnancy (M = 1.02, SD = 1.13), most frequently reporting treatments for heartburn or nausea. On average, infants were full term (M = 39.64, SD = 1.75 weeks; range 34–44 weeks). Only 6 infants were born before 37 weeks' gestation.

3.2. Preliminary analyses

Preliminary analyses were conducted before imputation as a means of characterizing the raw data. Variable means and SDs (**Table 1**) suggested substantial individual differences in both maternal reports of pain and maternal symptoms of depression. Mothers experienced nearly the full range of pain indexed by the questionnaire, with the sample, on average, reporting mild pain levels. Less than 10% of mothers reported experiencing no pain at the 2 assessments that occurred during pregnancy (7.5% in the second trimester and 4.5% in the third trimester). By contrast, 17.2% of mothers in their second trimester and 21.6% in their third trimester reported experiencing moderate to severe pain within the previous weeks. At the time of the postpartum assessment, three-quarters of mothers (77.4%) reported experiencing pain. No mothers reported experiencing zero symptoms across all 3 assessments. Fifteen mothers (16%) during the prenatal period and 5 mothers' (5%) postpartum met or exceeded the EPDS cutoff for likely depression (total score >12[13]).

Correlations (**Table 1**) suggested that symptoms of depression were moderately stable over time. Self-reported pain was positively correlated with maternal depressive symptoms at concurrent and adjacent assessments.

Table 1

Descriptive statistics and correlations for study variables.

	M (SD)	1	2	3	4
1. Second trimester pain	2.57 (0.94)				
2. Third trimester pain	2.86 (0.91)	0.35**			
3. Postpartum pain	2.15 (1.06)	0.20	0.39**		
4. Third trimester depression	5.46 (4.74)	0.34**	0.34**	0.10	
5. Postpartum depression	5.30 (4.26)	0.00	0.29*	0.27*	0.32*

$*P < 0.05$, $**P < 0.01$.

3.3. Maternal trajectories of pain as predictors of postpartum symptoms

The SEM was a fully saturated model, consistent with the estimates of fit returned per 3 commonly used indices (RMSEA: 0.00 [0.00—0.00], CFI: 1.00, and TLI: 1.00[6]). All manifest variables loaded significantly onto growth curve parameters (**Fig. 1**).

Consistent with the graph of means in **Figure 1**, intercept (β = 2.73, 95% confidence interval [CI] [2.25–3.21], $P < 0.01$), linear slope (β = 0.39, 95% CI [0.16–0.63], $P < 0.01$), and quadratic slope (β = −0.12, 95% CI [−0.81 to −0.31], $P < 0.01$) values were all significant. Significant intercept values suggested that pain levels were already nonzero, on average, by the time of the second trimester assessment. Because they describe the same manifest variables, it is appropriate to interpret the linear and quadratic effects together.[17,29] A positive linear combined with a negative quadratic slope is consistent with a pattern of pain that increases early in the assessment period and then levels off over time before decreasing in the postpartum period. The residual variance in maternal postpartum depression was also significant, suggesting that neither pain nor prenatal levels of depression fully accounted for the observed variability of postpartum depressive symptoms in our sample (β = 0.80, 95% CI [−0.60 to 1.01], $P < 0.01$).

Central to study hypotheses, both linear and quadratic changes in pain significantly predicted levels of postpartum depression (**Fig. 2**). Specifically, greater linear increases in maternal pain over time predicted higher levels of postpartum depressive symptoms. Similarly, less negative quadratic changes in maternal pain symptoms over time were associated with more symptoms of postpartum depression. These associations reflect changes from the original intercept and slope values; as such, they suggest that greater linear increases (Δβ = 0.39 + 1.00 = 1.39) and less negative quadratic changes (Δβ = −0.12 + 0.77 = 0.65) were associated with greater levels of postpartum depression. Again, the linear and quadratic parameters should be interpreted together while being mindful of the reversal in direction of the beta for quadratic change. This suggests that a pattern of change that includes pain that increases late in the assessment period, when normative patterns have either leveled off or begun to decline, is associated with greater levels of postpartum depression.

4. Discussion

Postpartum depression has significant effects on maternal and infant health, and there is a critical need for early detection of risk to enhance current screening practices. We examined trajectories of maternal pain across the perinatal period as predictors of postpartum depression. We found that trajectories of pain from the second trimester of pregnancy through 4 months postpartum significantly predicted maternal symptoms of postpartum depression. Specifically, we found that normative trajectories of pain involved increases in maternal-reported pain across pregnancy, followed by postpartum declines. However, greater increases in pain, particularly those that followed a positive, rather than a negative quadratic pattern, were associated with greater postpartum symptoms. This indicates that increases in pain late in pregnancy or postpartum predicted elevated postpartum depression symptoms. Notably, trajectories of pain predicted postpartum symptoms of maternal depression even when prenatal depression symptoms were controlled.

The prevalence of pain during pregnancy was higher in our sample, with more than 90% of women reporting pain, relative to previous reports (approximately 70%[11,12,27,37,48,53,64]). Key differences from previous studies include the use of a prospective design, which is likely more sensitive to detecting lower-level pain than retrospective designs that rely on recall after childbirth, and a broad assessment of nonspecific pain severity, rather than focusing on a primary source, to more holistically depict the maternal experience. Pregnancy pain severity was somewhat lower than previous estimates, again supporting the assumption that the prospective design may increase sensitivity to detect even mild pain. Importantly, this is the first study to prospectively map maternal pain trajectories and examine this change over time as potentially predictive of postpartum depression. Indeed, few studies have examined pain trajectories in any context, despite the utility of such an approach for dynamic constructs such as pain. Moreover, our work characterizes these dynamic changes and their longitudinal implications. Although these results should be replicated, if findings continue to suggest that more than 90% of women experience pain during pregnancy, parsing normative from risk-related trajectories will be critical for identifying those most at risk for negative outcomes.

Although previous work has demonstrated that labor and postpartum pain are associated with postpartum depression, this is the first study to demonstrate that *patterns* of change in pain beginning during pregnancy can predict levels of symptoms of postpartum depression. In this way, our work offers prospective, empirical support for the idea that trajectories of pain across the perinatal period comprise a putative risk factor for postpartum depression. This possibility has been implied[24] and intuited,[54] but not directly tested in previous research.

Furthermore, our model controlled for symptoms of depression during pregnancy, isolating increases in postpartum depressive symptoms as an outcome and eliminating the possibility that our results simply reflect persistent, co-occurring pain and depressive symptoms. Alongside evidence that pregnancy factors may be more robust predictors of maternal postpartum depression than postpartum factors,[3] additional research in this area is warranted and will likely be critical for advancing existing prevention and early intervention efforts. Specifically, our work lays a foundation for the identification of trajectories of increasing maternal pain that do not resolve early in the postpartum period as a specific risk factor for postpartum depression. Routine prenatal care includes assessments of trajectories and deviations from expected developmental patterns and therefore may easily incorporate assessment of pain trajectories. Identifying this risk factor in routine clinical assessments across the perinatal period through cooperative efforts between clinical providers is in line with previous suggestions for overlapping care and may allow healthcare providers to filter at-risk patients towards early postpartum depression intervention and support.[14,19]
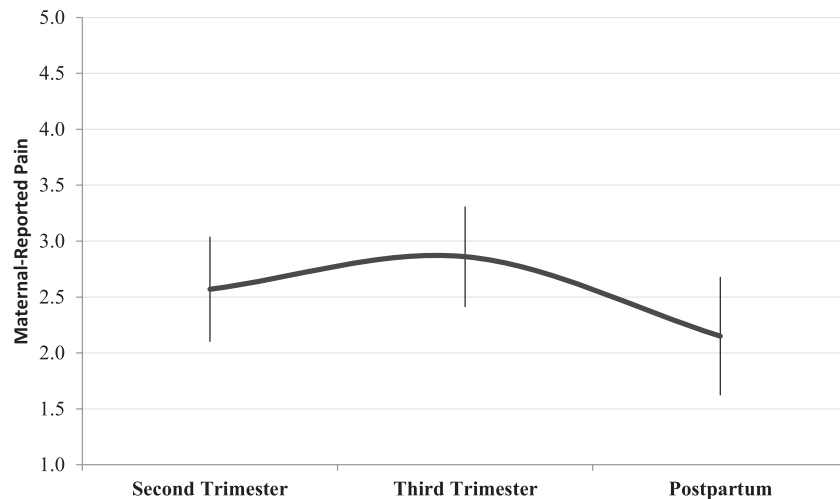
Figure 1. Means reflecting the normative pattern of maternal pain from the second trimester of pregnancy through 4 months postpartum. Bars reflect standard deviations around the mean.

This work is not without limitations. In this study, pain assessment was limited to a single item. Although previous work demonstrates that such single items of pain have high construct validity and predictive value,[33] pain is a multidimensional construct, and future research on patterns of key dimensions of pain may provide a more complex picture of common trajectories of pregnancy pain as well as its relationship to postpartum depression. Although this study is one of the first to prospectively map pain trajectories during pregnancy and postpartum, results are limited by the minimum number of assessments required for this analysis. We also do not have information about mothers' medical histories or symptoms beyond the 4-month assessment. Future studies that include more frequent and earlier assessments are expected to provide a more complete picture of the development and variability of pregnancy pain over time. Such studies may also clarify the seemingly reciprocal relationship between pain and depression observed in cross-sectional postpartum measures,[22] particularly during critical or sensitive periods of maternal development. Our inclusion criteria may obscure potential differences in pain trajectories based on gravidity. Another limitation of the current work is that it was conducted in a relatively low-risk sample. That is, although mothers reported nearly the full possible range of both depressive symptoms and pain, this sample was not selected for either pain or depression symptoms. Future studies are needed to determine generalizability of these results to high-risk samples, including representation of high-risk pregnancies and women with significant comorbidities (eg, chronic pain and opioid use disorder), as well as women deemed higher risk for postpartum depression based on other criteria. This approach of identifying pain trajectories and associated risk profiles may serve as a foundation for research leading to the development of
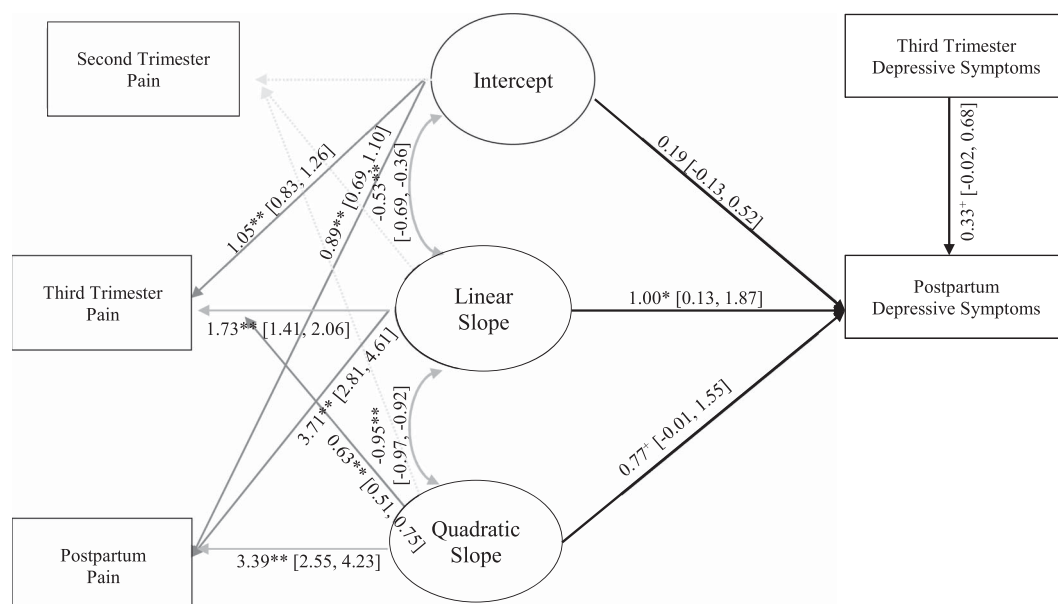

Figure 2. Latent growth model of pain predicting postpartum symptoms of depression. **$P < 0.01$, $^+P < 0.10$. Boxes reflect manifest variables; circles reflect latent variables. Loadings of second trimester pain onto manifest variables were fixed. All loadings are shown on a standardized scale. Intercept was correlated with quadratic slope ($r = 0.36$, $P < 0.01$).

preventative and treatment interventions. Experimental treatment studies may further elucidate the causal impact of maternal pain trajectories on postpartum depression—and whether pain trajectory profiles may be informative in providing more personalized treatment options. Finally, these results may be culturally constrained. Although American women experience greater rates of pregnancy-related low back and pelvic girdle pain[30] and have significantly higher rates of maternal mortality and morbidity compared with women in other wealthy countries,[1] few previous studies on pregnancy pain have been conducted in the United States. Given the variability in resources available to women during pregnancy and postpartum, research within nation and understanding of pregnancy pain experiences within sociocultural context may be additionally important for informing policies intended to enhance public health.

In summary, previous research demonstrates that not only is pregnancy pain a common—often unreported and understudied—experience that affects most women but also its consequences can extend to long-term changes in physical and mental health. In this study, we established a normative trajectory of maternal experience of pain that increases late in pregnancy and resolves by 4 months postpartum. We also identified an aberrant trajectory of pain over time that was associated with elevated symptoms of postpartum depression. Given the utility of assessing maternal experiences of pain, a consideration of adopting a multilevel strategy for assessing women's physical and mental postpartum health that includes developmental trajectories of pain is warranted. In fact, such a strategy has the potential to add substantial predictive value to assessments of risk for postpartum depression—above that of prenatal depression screens alone. Our results suggest the addition of pain trajectories may help identify women at greater risk for postpartum depression who would otherwise be missed with current screening recommendations. Given demonstrated efficacy of early psychological interventions (eg, Cognitive Behavioral Therapy and Acceptance and Commitment Therapy) on pain [20,46] and depression,[8,14] pain across the perinatal period may be a prime target for early interventions and personalized support and care for pregnant women.

Disclosures

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