Published in final edited form as:

J Reprod Infant Psychol. 2010 January 1; 28(3): 307–323. doi:10.1080/02646831003630039.

Role of pelvic sensory signaling during delivery in postpartum mental health

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Abstract

Background—Animal research demonstrates that pelvic sensory signaling at parturition initiates behavioral and emotional changes that are protective for mother and offspring. In contrast, research with humans has found no effect of cesarean delivery (*i.e.*, procedure that blocks pelvic signaling) on mother's mental health. The lack of effect may reflect little consideration for the use of epidurals, another intervention that blocks pelvic signaling. The following study examines whether blocking pelvic signaling during delivery predicts postpartum depression symptomatology.

Method—Longitudinal mental health data were collected prospectively from 142 primiparous women who had a cesarean delivery and/or received epidural anesthesia (Intervention) or delivered vaginally without anesthesia (No-Intervention). Measurements began in late pregnancy and continued through the first postpartum year.

Results—Intervention mothers reported more depressive symptoms at the end of the first postpartum year compared to those in the No-Intervention group. This effect was independent of socio-cultural factors known to predict levels of depressive symptoms.

Conclusion—These results suggest that pelvic sensory signaling may help to prepare women for the postpartum period. Considering there are many factors influencing the mental health of mothers, the present finding suggest that populations vulnerable to postpartum depression should consider a delivery without intervention, when medically permissible.

Keywords

Post-partum depressive symptoms; depression; Hierarchical linear modeling; Pelvic sensory signaling

Introduction

With the growing popularity of cesarean deliveries (Menacker, 2005; Ford, Grewal, Mikolajczyk, Meikle & Zhang, 2008), concern that the absence of a “natural” (vaginal) delivery would promote mental distress spurred many clinical studies that examined the relationship between cesarean delivery and postpartum depression. Generally, these clinical studies reported that cesarean delivery posed no risk, meaning women who gave birth via cesarean section or vaginally were at equal risk for developing postpartum depression (Carter, Frampton & Mulder, 2006). However, findings from animal research have

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demonstrated that the physical act of delivery triggers changes in the brain that allow mothers to provide optimal postpartum maternal care (Hayes & de Vries, 2007; Stern, 1985; Yeo & Keverne, 1986; Keverne, Levy, Poindron & Lindsay, 1983; Poindron, Soto & Romeyer, 1997). The discordance between the clinical and animal findings may reflect a difference in the aspect of delivery emphasized. While clinical studies focused on the presence or absence of the physical act of a vaginal delivery (Carter et al., 2006), animal research emphasized the physiological consequences of a vaginal delivery (*e.g.*, sensory signaling from pelvis, neural activation, and neurochemical and hormonal changes; Hayes & de Vries, 2007; Da Costa, De La Riva, Guevara-Guzman & Kendrick, 1999; Kendrick, Keverne, Hinton & Goode, 1991; Levy, Kendrick, Goode, Guevara-Guzman & Keverne, 1995). The present study draws implications from results of the animal studies to examine more closely the effects of different types of obstetric intervention on maternal well-being.

In animal studies using prairie voles and sheep, the cascade of physiological events at parturition is important for optimal maternal functioning. The stretching of the birth canal as the fetus descends activates innervating sensory fibers, sending signals through the spinal cord to the brain thereby causing the release of various neurochemicals (*e.g.*, Ferguson's reflex; Levy et al., 1995; Berkley, Robbins & Sato, 1988; Berkley, Hotta, Robbins & Sato, 1990; Robbins, Sato, Hotta & Berkley, 1990; Krehbiel, Poindron, Levy & Prud'Homme, 1987; Ferguson, 1941). These neurobiological changes facilitate the birth process and are involved in changes in emotionality and induction of maternal behaviors (Kendrick et al., 1991; Da Costa et al., 1999; Levy, Kendrick, Keverne, Piketty & Poindron, 1992). For female voles and sheep to care for their neonates, they must experience a vaginal delivery of their young, specifically sensory signaling from the birth canal (Hayes & de Vries, 2007; Keverne et al., 1983). In the absence of pelvic sensory signaling, as a result of a cesarean delivery or administration of neuroaxial anesthesia (*i.e.*, epidural), these characteristic behavioral and neurochemical changes at delivery do not occur and these females fail to care for their young (Hayes & de Vries, 2007; Keverne et al., 1983; Ferguson, 1941; Levy et al., 1992; Higuchi, Uchide, Honda & Negoro, 1987).

In previous clinical studies looking at the relationship between delivery and postpartum mental health, the focus was on the absence of a vaginal delivery. Little or no consideration was made of other obstetric interventions that block pelvic sensory signaling, such as the use of epidurals (Carter et al., 2006). However, epidurals are commonly used in both cesarean and vaginal deliveries (Center for Disease Control, 2006). Previous studies on the link between delivery and mental health either did not report the use of epidurals or did not compare those women who had an unassisted delivery (*i.e.*, vaginal delivery without the use of an epidural) with those who received an epidural and/or C-Section (Carter et al., 2006). Therefore, the reported lack of effect may reflect a comparison between two physiologically-identical groups. The importance of pelvic signaling for animals and the likely masked effects of cesarean delivery in past studies warrant a closer examination of the effects of obstetric intervention on postpartum mental health. The present translational study examined depression levels across late pregnancy through the first postpartum year of women who delivered with or without obstetric intervention that interferes with pelvic signaling. A number of key control variables known to be predictive of postpartum depression were included in the analyses. Specifically, higher income, more emotional support from kin and friends, and higher marital quality have all been shown to be related to fewer depressive symptoms; while depressive symptoms during late pregnancy predicts more depressive symptoms after delivery (Rich-Edwards, Kleinman, Abrams, Harlow, McLaughlin, Joffe & Gillman, 2006; Robertson, Grace, Wallington & Stewart, 2004). Thus, family income, social support, marital love and prenatal depressive symptom scores are all included as control variables in the models.

Methods

Participants

Data were collected from 142 opposite-sex couples as part of a longitudinal study of parents experiencing the transition to parenthood over one year. Approval for the study protocol was received from both the principal investigator's University as well as the hospital that collaborated with us in recruiting the sample. Couples were recruited from prenatal education classes in several western Massachusetts hospitals. Following inclusion criteria, the couples consisted of a primigravid mother and the biological father, were working-class (defined as educational achievement limited to an Associate's degree), and were both fully employed (≥ 35 hrs/week) prior to delivery. Both mothers and fathers intended to resume or continue full-time work within six months from the baby's birth. Twelve couples failed to complete the study, however the use of multilevel modeling allowed these couples to be retained in the analyses. Those mothers who failed to complete the study did not differ from those who remained on Time 1 depressive symptoms, family income, marital quality, emotional support or likelihood of an obstetric intervention (at $p > .10$).

Sample demographics

Mothers ranged in age between 18- and 40-years old ($M=27.41$, $SD = 4.81$). Couples were either married or cohabitating and had been together for 2.77 years on average ($SD = 2.63$). Of 142 couples, 95.1% of the mothers were European American, 1.4 % were Latino, 0.7% African American, and 2.8% did not specify their ethnic origins. The majority (52.8%) of the mothers had some college or vocational training, 14.8% had an Associate's degree, 21.7% a high school diploma or equivalent, and 0.7 % did not complete high school. Couples' combined income was \$54,924 ($SD = \$17,322$.) on average.

Procedure

Recruitment entailed a 5-minute presentation given directly to pregnant women by trained graduate students during prenatal education courses. At this time, the purpose and procedures of the study were described and women were given the opportunity to ask questions. Pregnant women were given a brief questionnaire that included items about their age, relationship-status, education and income level, occupation, and their intent to return to work after pregnancy. Families that met study criteria were contacted by study personnel and scheduled for interviews. All families received \$150 for participation. The study included four in-person interviews conducted by graduate level clinicians at the participants' homes and one mail interview. The first interview took place in the third trimester of pregnancy (Time 1), with the four subsequent interviews occurring over the first year post partum: one month after the baby's birth (Time 2), 1 month after the mother returned to work (Time 3), 6 months after the baby's birth (Time 4), and one year after the baby's birth (Time 5). Information collected included demographic information, assessment of romantic relationship and social support (Time 1), obstetric data (Time 2), and depressive symptoms (Time 1-5).

Measures

Obstetric Interventions—During the second interview, mothers were asked a wide range of questions about the physical and emotional experience of giving birth, which included items about medical procedures. Mothers were asked whether they had a cesarean delivery; if labor had been induced; or if they had received an epidural during labor. Using these items, we created two variables: childbirth with (Intervention) and without (No Intervention) signal blocking obstetric intervention. For these analyses, it was assumed that

participants were given general anesthesia if they reported having a cesarean delivery but did not receive an epidural (Figure 1).

Depressive Symptoms (Center for Epidemiologic Studies Depression Scale, CES-D; Radloff, 1977)—Mothers' and fathers' depressive symptoms were assessed at all five time points using a 20-item self-report scale created by the Center for Epidemiological Studies at the National Institutes of Health. Respondents were asked to rate their feelings and behaviors (*e.g., I felt lonely; I could not get going*) on a 4 point scale where 0 = *rarely/none of the time* and 3 = *most of the time*. The first time point was used as a control variable and the following four time points provide a continuous trajectory of depressive symptom level between one month and one year postpartum. Although not constituting a clinical diagnosis of depression, scores at or above 16 on the CES-D are considered indicative of clinically significant depression. The measure is highly reliable in this sample. Mothers' Cronbach's alphas ranged between 0.87 and 0.91 for all five time points and fathers' alphas ranged between 0.86 and 0.91.

Relationship Questionnaire (RQ; Braiker & Kelley, 1979)—Mothers' perceptions of marital quality were operationalized by using the love subscale from the RQ as a control variable to determine whether mothers' late pregnancy assessment of their romantic relationships influenced the effect of obstetric intervention on mothers' depressive symptom level. The love scale consists of 10 items designed to gauge an individual's perception of shared love in their romantic relationship (*e.g., To what extent do you have a sense of belonging to your partner*). Items are rated on a 1-9 scale where lower values reflect less and higher values reflect more perceived mutual love in the relationship. The scale is sufficiently reliable in this sample. Women had an alpha of 0.61 and men 0.73 in late pregnancy.

Social Network Inventory (Daugherty, Salloway & Nuzzarello, 1988)—Emotional support was measured using the Social Network Inventory. At Time 1, women were asked to list up to 10 individuals with whom they socialized. Among the individuals listed, they were asked to indicate which ones they talk to about problems in the following areas: (1) social/relational, (2) financial, (3) family, (4) relationship with partner, (5) health, and (6) sex. They also were asked to indicate which of these individuals they consult on personal problems and which from the list would monitor them if they were having problems. Counts (0 or 1) for each item were summed and then averaged across individuals listed to form a total mean score for emotional support.

Analytic Strategy

Multilevel modeling techniques were used to plot temporal trajectories of mothers' and fathers' depressive symptom levels across a 12-month period, and to predict variance in their depressive symptom trajectories depending on whether obstetric intervention was used at delivery. The HLM6 program of Raudenbush and colleagues (2004) was used to estimate the parameters of these growth models. HLM has several distinct advantages that address challenges inherent in the analysis of dependent data as in the case of couples (Lyons & Sayer, 2005) and repeated measurements over time (Raudenbush, Brennan & Barnett, 1993). For these analyses, the couple is the unit of analysis, with males' and females' depressive symptom level nested within a couple. Use of a dyadic longitudinal multilevel model takes into account the shared variance in repeated measures over individuals over time and between male and female partners within a couple. Information about the association between the depressive symptom scores of the couple and among repeated measures is used to compute a more precise standard error in testing regression coefficients. In addition, the model provides correlations between male and female partners' level and change in depressive symptoms.

Latent trajectory modeling yielded two linked models. The level-1 model had three coefficients that estimated participants' depressive symptom level over the course of the year following childbirth, while the level-2 model included predictors to explain variance in these parameters. A likelihood ratio test was used to identify the best fitting model. This strategy compared two models to test the null hypothesis that there is no difference in fit between the two models. It uses a chi-square test statistic that is calculated as deviance (full model) – deviance (reduced model) where the full model is the one with the greater number of parameters. The degrees of freedom (df) for the test were calculated as df (full) – df (reduced). P-values less than .05 allowed us to reject the null hypothesis.

The Level-1 HLM Model

The trajectories of fathers and mother's level and change in depressive symptoms were modeled at Level 1. This level 1 model included mothers' and fathers' depressive symptom parameters centered at 12 months. This model was represented by the following equation: $Y_{ij} = \beta_{0j}(\text{mother intercept})_{ij} + \beta_{1j}(\text{mother linear})_{ij} + \beta_{2j}(\text{mother quadratic})_{ij} + \beta_{3j}(\text{father intercept})_{ij} + \beta_{4j}(\text{father linear})_{ij} + \beta_{5j}(\text{father quadratic})_{ij} + e_{ij}$. Y_{ij} is the depressive symptom level score i , with $i = 1 \dots 4$ time points for couple j , with $j = 1 \dots 142$ couples. For mothers, β_{0j} was the model intercept. The intercept reflected the predicted mothers' depressive symptom level when the origin of time is 0. Time was rescaled so that the intercept reflects depressive symptom levels at 12 months. Rescaling the data with time centered at 12 months allows for a more meaningful understanding of postpartum depressive symptom trajectories over the course of the year. β_{1j} was the linear rate of change in mothers' depressive symptom level at time zero, which indicated how fast the curve changed at the time point where the analysis was centered. β_{2j} was the rate of change in mothers' depressive symptoms over the 12 months postpartum (also called the quadratic effect or curvature of the growth trajectory). Finally, e was the error, which was assumed to have a mean of zero and a constant variance σ^2 . β_{3j} , β_{4j} , and β_{5j} represented the same parameters for the fathers' depressive symptom trajectories. This model also clarified the importance of using a statistical technique that accounted for the shared variance between the partners' scores. This dependency in the data was estimated as covariance in the Tau matrix. These are interclass covariances, converted to correlations between the partners' levels of depressive symptoms, rates of change in depressive symptoms, and the curvatures of their depressive symptom trajectories across the four postpartum measurement points.

The Level-2 HLM Models

For these models, both control and predictor variables were added at level 2. This model was represented by the following equations:

$$\begin{aligned}\beta_{0j} &= \gamma_{10} + \gamma_{11} + \gamma_{12} + \gamma_{13} + \gamma_{14} + \gamma_{15} + \gamma_{16} + u_{7j} \\ \beta_{1j} &= \gamma_{20} + u_{2j} \\ \beta_{2j} &= \gamma_{30} + \gamma_{31} + \gamma_{32} + \gamma_{33} + \gamma_{34} + \gamma_{35} + \gamma_{36} + u_{3j} \\ \beta_{3j} &= \gamma_{40} + u_{4j} \\ \beta_{4j} &= \gamma_{50} + \gamma_{51} + \gamma_{52} + \gamma_{53} + \gamma_{54} + \gamma_{55} + \gamma_{56} + u_{5j} \\ \beta_{5j} &= \gamma_{60} + u_{6j}\end{aligned}$$

In the level-2 models, every γ beyond the intercept was equal to a predictor or a control variable plus a random effect, which represented the residual variance around the mean. The linked level-1 and level-2 growth models represented statistical tests of the relationship between each intervention and mothers' depressive symptom level at 12 months postpartum, the instantaneous rate of change in depressive symptom level at 12 months postpartum, as

well as the association of each intervention to the curvature of the depressive symptom trajectory across the 11-month period.

Our second model predicting both mothers' change in depressive symptoms over the first year and level of depressive symptoms at 12 months included four control variables: (1) mother's late pregnancy depressive symptoms level, (2) family income, (3) mother's assessment of marital relationship quality, and (4) mother's perceived social support. Our third model tested whether mothers' obstetric intervention status predicted change in depressive symptoms at 12 months and change in depressive symptoms controlling for key variables.

Results

Descriptive analyses were examined for all predictor and outcome variables. Means and standard deviations are provided in Table 1. Mean scores on mothers' depressive symptoms with and without obstetric interventions are provided in Table 2. An ANOVA was conducted to determine if women who received obstetric interventions had higher levels of depressive symptoms prior to the birth than mothers receiving no intervention. Results showed there were no differences in depressive symptoms at the third trimester for mothers in the two groups.

Model 1: Trajectories of Depressive Symptoms after Delivery

Before testing the hypothesis that obstetric interventions that block pelvic signaling during parturition alter postpartum depressive symptoms level, an unconditional HLM model was fit with no predictors at level 2 to determine whether there was enough variance unaccounted for by the level 1 model to warrant an analysis of predictor variables (Tables 3 and 4). This unconditional model included the partners' CES-D depressive symptoms scores centered at 12 months postpartum. There was significant individual variation in level of depressive symptoms, rates of change in depressive symptoms, and in the acceleration and deceleration of the depressive symptom trajectory for the mothers. This significant variation meant that mothers showed substantial individual differences in the development of depressive symptoms during the year following childbirth. On average, mothers' level of depressive symptoms, as reflected in the intercept, was 12.32 (cut-off level associated with depressive disorder diagnosis = 16). The rate of change and trajectory acceleration and deceleration were not significant for the fathers. At 12 months, correlations between fathers' and mothers' were 0.237 for depressive symptoms, 0.384 for their rate of change, and 0.562 for their acceleration or deceleration of depressive symptom levels across the postpartum year. These correlations in depressive symptoms between partners confirmed the appropriateness of a dyadic model.

Model 2: Analyses with Control Variables

Some variance in postpartum depressive symptom scores was accounted for by total family income and emotional support (See Tables 3 and 4). Total family income predicted mothers' depressive symptoms level at 12 months ($\gamma = -0.00008$, $SE = .00004$, $p < .05$). Emotional support predicted mothers' depressive symptom level at 12 months ($\gamma = -11.108$, $SE = 4.946$, $p < .05$), the instantaneous rate of change in mothers' depressive symptoms at 12 months ($\gamma = 26.283$, $SE = 12.605$, $p < .05$), and the shape of the trajectory of mothers' depressive symptoms across the first postpartum year ($\gamma = 34.750$, $SE = 15.138$, $p < .05$). Late pregnancy depressive symptoms and perceived love in the marital relationship did not account for variance in postpartum depressive symptoms.

Model 3: Is Obstetric Intervention Related to Depressive Symptoms?

This model evaluated the effect of signal-blocking intervention on depressive symptom severity over the year following childbirth while controlling for the mother's late pregnancy depressive symptom level, family income, mother's assessment of marital love, and mother's perceived social support (See Tables 3 & 4). This model demonstrated that mothers who had no intervention had lower levels of depressive symptoms 12-months postpartum ($\gamma = -3.840$, $SE = 1.508$, $p < .05$), while those who had obstetric intervention had higher levels ($\gamma = 3.541$, $SE = 1.54$, $p < .05$; Figure 2). Mothers who gave birth vaginally and did not receive epidurals (No Intervention) showed a steeper decline in depressive symptoms than those who received intervention (Intervention; $\gamma = -3.84$, $SE = 1.508$, $p < .05$). Obstetric intervention did not affect the instantaneous rate of change in mothers' depressive symptoms at 12 months or the shape of the trajectory across the year. That is, obstetric intervention was not correlated with a change in the rate at which depressive symptoms were increasing or decreasing for mothers at the 12-month time point (at which these analyses were centered). Intervention also did not predict a significantly different pattern of acceleration or deceleration over the entire postpartum year.

Discussion

Most of the mothers in the present study reported subclinical levels of depression (CES-D score < 16), meaning their scores were lower than the clinically significant cutoff associated with a diagnosis of postpartum depression. However, subclinical depression, even during the postpartum period, can be as debilitating as clinical depression in regards to psychosocial functioning and general health (Lewinsohn, Solomon, Seeley & Zeiss, 2000; Judd, Schettler & Akiskal, 2002; Olsson, Broadhead, Weissman, Leon, Farber, Hoven, Kathol, 1996; Weinberg, Tronick, Beeghly, Olson, Kernan, Riley, 2001). In the present study, all mothers reported the same level of depressive symptoms during late pregnancy and the early postpartum period. The depressive symptom scores for mothers who experienced obstetric intervention remained constant throughout the postpartum year. In contrast, the depressive symptom scores of mothers who delivered without intervention began to decrease during the latter half of the year. This effect was independent of socio-cultural predictors known to influence postpartum mental health (*i.e.*, income and social support).

The quality and quantity of early maternal care a child receives is heavily influenced by maternal mental health (Lovejoy, Graczyk, O'Hare & Neuman, 2000; Campbell, Cohn & Meyers, 1995; Fields, 1995). Depression after delivery is associated with adverse parenting styles (*e.g.*, intrusive or withdrawn) and in extreme cases, child abuse (Lovejoy et al., 2000; Windham, Rosenberg, Fuddy, McFarlane, Sia & Duggan, 2004). In the present study, the data suggest that postpartum mental health is influenced by physiological changes at parturition. Fewer depressive symptoms were associated with women who experienced pelvic signaling at the time of delivery. Clinical research suggests that changes in physiology may be linked to maternal responsiveness in humans. Parturition is characterized by a hormonal profile that is altered by obstetric intervention. Women who deliver vaginally have higher plasma levels of cortisol (Namba, Smith, Fox & Challis, 1980), β -endorphin (Goebelsmann, Abboud, Hoffman & Hung, 1984), oxytocin (Vasicka, Kumaresan, Han & Kumaresan, 1978), and norepinephrine and epinephrine (Irestedt, Lagercrantz, Hjemdahl, Hagnevik & Belfrage, 1982) at the time of delivery than women who deliver via cesarean with an epidural. Moreover, physiological differences between deliveries with and without obstetric intervention persist during the postpartum period (Nissen, Uvnas-Moberg, Svensson, Stock, Widstrom & Winberg, 1996; Zanardo, Nicolussi, Carlo, Marzari, Faggian, Favaro & Plebani, 2001). The physiological profile of the mother also is linked to differences in maternal sensitivity. Neural activation in response to infant cries differs in women who deliver vaginally or via cesarean section. Mothers who delivered vaginally

show a pattern of neural activation in areas regulating maternal sensitivity that respond more to their own infant's cries than those of unrelated infants. This effect was not seen in their cesarean counterparts (Swain, Tasgin, Mayes, Feldman, Todd Constable & Leckman, 2008). Likewise, women who deliver vaginally have higher cortisol levels (Okamoto, Takagi, Makino, Sata, Iwata, Nishino, Mitsuda, Sugita, Otsuki & Tanizawa, 1989), which correlate with greater attraction to and recognition of their own infant's smell (Fleming, Steiner & Corter, 1997).

Contrary to the animal findings, the effect of pelvic signaling in the present study was not evident immediately after delivery. In the clinical literature, the period of time in which mental distress related to parity has been reported generally ranged from 1 month, as stated in the DSM-IV, to the first postpartum year (see Stowe & Nemeroff, 1995). In the present study, the significant difference in depressive symptomatology 12 months postpartum may have resulted from the subclinical depression scores reported by the mothers. Quite possibly, other factors (*e.g.*, managing responsibilities associated with new infant followed by the return to work) may have maximized depressive symptom levels (*i.e.*, ceiling effect) for the mothers so that differences were not apparent until later in the year, once the mothers adjusted to the new demands. In support of this hypothesis, depressive symptom scores between the Intervention and No Intervention groups began to differ around 6 months postpartum after the mothers returned to work (data not shown).

Although known socio-cultural predictors of postpartum mental health (*i.e.*, income, relationship quality, and social support) did not explain our findings, there are other possible causes for the differences in depressive symptom scores. For example, the differences among the treatment groups might be attributed to other health and psychological issues. Possibly, women who delivered via cesarean section had higher levels of depressive symptoms because of poorer physical health. Preexisting medical conditions (*e.g.*, obesity and diabetes) and medical complications during labor (*e.g.*, pre-eclampsia) are common reasons for both planned and unplanned cesarean delivery (Ehrenberg, Durnwald, Catalano & Mercer, 2004; Saadat, Nejad, Habibi & Sheikhvatan, 2007). Likewise, women who had more depressive symptoms postpartum may have been more likely to request an epidural due to higher prepartum anxiety, depressive symptoms and/or stress (Chung, Lau, Yip, Chiu & Lee, 2001; Andersson, Sundstrom-Poromaa, Wulff, Astrom & Bixo, 2004). However, prepartum level of depressive symptoms is an unlikely cause because the mothers' prepartum depressive symptom scores (Time 1) did not differ.

Conclusions

With the growing popularity of cesarean deliveries (Menacker, 2005) and the widespread administration of epidurals (Center for Disease Control, 2006), the routine use of these obstetric interventions during delivery may contribute to the high prevalence of depressive symptoms found in women after delivery. Experimental manipulations in animal research found that pelvic signaling at the time of delivery is important in preparing animals for their postpartum role (Hayes & de Vries, 2007; Stern, 1985; Yeo & Keverne, 1986; Keverne et al., 1983). Likewise, pelvic signaling appears to have a similar effect in women. In the present study, women who received obstetric intervention that blocked pelvic signaling at the time of delivery reported experiencing more postpartum depressive symptoms. With a better understanding of how delivery (as a mechanism of risk) predicts depressive symptomatology, medical practitioners and expectant mothers can design birth plans that maximize the mothers' postpartum well-being, especially those considered at-risk for postpartum mental distress.

The present study is one of the first to take a translational approach to address the role of delivery in the postpartum mental health of women. By adopting a translational perspective based on the findings from animal research, the present study challenges the widely held belief that certain common obstetric interventions, such as cesarean delivery and epidural anesthesia, are innocuous. Although these interventions have been shown to save lives, our findings are contributing to a growing body of research that questions the more widespread use of interventions in non-emergency situations (e.g., glucocorticoid treatment during pregnancy; Davis, Waffarn, Uy, Glynn & Sandman, 2009).

Acknowledgments

We would like to thank all mothers who participated in this study, the research assistants for their technical support, and Baystate Medical Center for their continued commitment to research. This research was supported by the National Institute of Mental Health (R01-MH5677 to Maureen Perry-Jenkins).

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Figure 1. Schematic depicting the number of women who had cesarean (n=29; horizontal lines) or vaginal (n=113; vertical lines) delivery and, within each category, how many received an epidural (overlapping dots). In the present study, obstetric intervention consisted of cesarean deliveries (horizontal lines) and epidurals (elliptical).

Figure 2.

Postpartum depressive symptom scores of women who did (Intervention) and did not receive obstetric intervention (No Intervention) during delivery. Corresponding means and standard deviations for maternal CES-D scores at each time point for each intervention group are shown in Table 2. On average, women in both groups were below the CES-D score of 16, which is considered to be predictive of depressive disorder diagnoses. No statistically significant group differences were found in depression levels at Time 1 (ANOVA, $p>0.05$). In late pregnancy, 43% of the women had CES-D scores of 16 or higher.

Table 1
Descriptive statistics for prenatal control variables empirically linked to depression after delivery and depressive symptom scores

	<u>M</u>	<u>SD</u>	<u>N</u>
Total Family Income	54,924.11	17,322.16	142
Mothers' Perceived Love in Marital Relationship	8.10	0.58	142
Mothers' Perceived Social Support	0.65	0.15	142
Mothers' Depressive Symptoms			
Time 1	16.09	9.20	142
Time 2	12.30	8.25	142
Time 3	12.38	9.55	133
Time 4	12.55	9.31	128
Time 5	12.21	9.72	130

Table 2
Descriptive statistics of depressive symptom scores by birth type

	<u>M</u>	<u>SD</u>	<u>N</u>
<i>No Obstetric Intervention</i>			
Time 1 (LP)	15.59	7.08	44
Time 2	11.89	7.25	44
Time 3	10.37	8.38	42
Time 4	11.59	9.05	39
Time 5	9.14	7.41	38
<i>With Obstetric Intervention</i>			
Time 1 (LP)	16.32	10.03	98
Time 2	12.48	8.69	98
Time 3	13.31	9.95	91
Time 4	12.97	9.44	89
Time 5	13.48	10.3	92

Time 1: late pregnancy. Times 2-5 spread from 1 to 12 months postpartum.

Table 3
Parameter estimates of level 2 parturition interventions predicting depressive symptoms during the postpartum (Data centered at 12 months)

Fixed Effects	Model 1: Unconditional Model		Model 2: Model with Controls		Model 3: Pelvic Stimulation	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
Depressive Symptom Level						
Women	12.320*	0.762	12.354*	0.716	13.485*	0.830
No Intervention					-3.839*	1.508
<i>Time 1 Depressive Symptom Level</i>						
<i>Family Income</i>			0.141	0.076	0.133	0.074
<i>Love in Marital Relationship</i>			<-0.001*	-2.021	<-0.001*	<0.001
<i>Emotional Support</i>			-1.843	1.249	-1.929	1.217
Men			-11.108*	4.946	-11.417*	4.819
Instantaneous Rate of Change						
Women	8.515*	0.554	8.506*	0.554	8.510*	0.554
No Intervention	-1.094	1.866	-1.067	1.543	0.486	2.202
<i>Time 1 Depressive Symptom Level</i>					-3.997	3.856
<i>Family Income</i>			0.103	0.191	0.089	0.193
<i>Love in Marital Relationship</i>			<-0.001	<0.001	<-0.001	<0.001
<i>Emotional Support</i>			-0.033	3.417	0.011	3.450
Men			26.282*	12.605	25.298*	12.747
Curvature across trajectory						
Women	-0.641	1.542	-1.067	1.543	-1.034	1.539
No Intervention	-0.777	2.247	-0.962	2.175	-0.4638	2.651
<i>Time 1 Depressive Symptom Level</i>					-1.462	4.666
<i>Family Income</i>			0.001	0.227	-0.007	0.229
<i>Love in Marital Relationship</i>			<-0.001	<0.001	<-0.001	<0.001
<i>Emotional Support</i>			-1.063	4.119	-0.913	4.160
Men			34.750*	15.138	33.630	15.291
	-0.732	1.869	-0.685	1.875	-0.649	1.869

Fixed Effects	Model 1: Unconditional Model		Model 2: Model with Controls		Model 3: Pelvic Stimulation	
	Coefficient	SE	Coefficient	SE	Coefficient	SE
Number of Parameters	28		40		43	
Deviance	6741.275		6709.526		6702.811	
(Compared to Unconditional Model)						
χ^2 (12) = 31.749, $p < 0.005$ χ^2 (15) = 38.464, $p < 0.005$						

*
p < .05

Table 4
Variance components for HLM models of obstetric interventions and control variables predicting depressive symptom levels after delivery

	Model 1: Unconditional			Model 2: Controls			Model 3: Pelvic Stimulation		
	Variance Component	df	χ^2	Variance Component	df	χ^2	Variance Component	df	χ^2
Women Intercept	60.48592	125	522.93957*	51.17059	121	471.78968	47.81731	120	442.57495*
Women Rate of Change	134.52201	125	175.76515*	104.946	121	169.09933	110.82934	120	169.46454*
Women Curvature	208.27149	125	196.10879*	171.05046	121	185.97539	178.72298	120	186.59177*
Men Intercept	23.20086	125	291.63297*	23.11155	125	291.12386	23.16107	125	291.64981*
Men Rate of Change	17.69015	125	134.39104	17.04875	125	134.15062	16.4949	125	134.38078
Men Curvature	40.91113	125	128.59443	42.09606	125	128.38666	40.80516	125	128.62819

*
p<.005.