HHS Public Access

Author manuscript

Matern Child Health J. Author manuscript; available in PMC 2024 March 19.

Published in final edited form as:

Matern Child Health J. 2023 March ; 27(3): 497–507. doi:10.1007/s10995-022-03577-1.

Adverse Maternal Experiences and Neonatal Abstinence Syndrome

Khaleel S. Hussaini[1,2], **George Yocher**[2]

[1]Division of Reproductive Health, Field Support Branch, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services, Atlanta, GA, USA

[2]Division of Public Health, Delaware Department of Health and Social Services, 1351 W. North Street, Dover, DE 19904, USA

Abstract

Objectives—To propose a measure for adverse maternal experiences (AMEs) and examine if AMEs are independently associated with delivery of a neonatal abstinence syndrome (NAS) diagnosed infant.

Methods—Using the Pregnancy Risk Assessment Monitoring System (PRAMS) stressful life events questions, we constructed a composite measure of AMEs. We conducted a retrospective analysis of linked Birth Certificate Data, Hospital Discharge Data and PRAMS data for 2012–2018 using the composite measure. Our analytic sample included 6358 singleton deliveries. We calculated prevalence of NAS and AMEs and prevalence odds ratio (POR) for delivery of an NAS-diagnosed infant adjusting for maternal sociodemographic characteristics, pre-pregnancy depression, prescription medicine 12 months prior to pregnancy, and smoking during pregnancy.

Results—The overall prevalence of NAS in Delaware during 2012–2018 was 2.2% (95% CI 1.8–2.6); 9.5% (95% CI 8.7–10.2) of women reported AMEs. After adjustment, women with AMEs had 1.1 times greater odds (aPOR 2.1; 95% CI 1.3–3.3) to deliver a NAS-diagnosed infant as compared with women without AMEs.

Conclusions—Although the cross-sectional nature of the study limits drawing any causal inferences, there are co-occurring factors that support plausibility of an association between AMEs and delivering NAS-diagnosed infants. Addressing AMEs, mental health and substance use screening and treatment as part of preconception and prenatal care may mitigate risks.

✉Khaleel S. Hussaini, lpk4@cdc.gov; Khaleel.Hussaini@delaware.gov.

Author Contributions KSH: Conceptualization, Methodology, Software, Formal analysis, Writing—Original Draft, GY: Conceptualization, Writing—Reviewing and Editing. Our study followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guideline.

Conflict of interest The authors have no conflicts of interest relevant to this article to disclose.

Ethical Approval The study involved no human participants, and the use of secondary data was reviewed, and the activity was determined to meet the requirements of public health surveillance by the Delaware Division of Public Health under applicable federal law.

Disclaimer The findings and conclusions in this study are those of the authors and do not necessarily represent the official position of the U.S. Department of Health and Human Services, the Centers for Disease Control and Prevention, the Health Resources and Services Administration, or the Delaware Department of Health Social Services, Division of Public Health.

Keywords

Adverse maternal experiences; Neonatal abstinence syndrome; Item response theory; Depression; Stressful life events; Linked datasets; PRAMS

Background

The symptoms of in utero exposure to opioids in neonates, known as neonatal abstinence syndrome (NAS), varies in signs, and severity among infants born to women with chronic opioid use (heroin, prescription pain medicines), medications (methadone or buprenorphine) for opioid use disorder, exposures to cocaine, selective serotonin reuptake inhibitors (SSRIs) and nicotine have been well-documented (Jansson & Velez, 2012; Jansson & Patrick, 2019; Jones et al., 2013; McQueen & Murphy-Oikonen, 2016; Patrick et al., 2012; Winkelman et al., 2018). However, few studies have examined the maternal characteristics of NAS-diagnosed infants beyond socio-demographics such as age, race, income, and education, and maternal substance use type and mental health (Arnaudo et al., 2017; Kozhimannil et al., 2017; McQueen & Murphy-Oikonen, 2016). Better understanding of the social context of women delivering NAS-diagnosed infants may inform strategies to help mitigate adversities experienced by women and infants.

Studies that describe the characteristics of women who deliver a NAS-diagnosed infant in the U.S indicate that a disproportionate number are non-Hispanic white, and the payer of delivery is Medicaid (Hayes & Brown, 2012; McQueen & Murphy-Oikonen, 2016; Patrick et al., 2012; Winkelman et al., 2018). Some studies such as that of Kozhimannil, et al. (2017) indicate that many have mental health issues and use polysubstances including alcohol, tobacco, and marijuana. Kozhimannil et al.'s study (2017) also indicated that most women were under 25 years old, white, and used tobacco in the past year, and approximately 25% had depression or anxiety in the past year. Pregnant women who use opioids are also more likely to meet diagnostic criteria for depression, anxiety, post-traumatic stress disorder (PTSD), and panic disorder (Smith et al., 2015). Similarly, Arnaudo et al. (2017) notes that co-occurrence of psychiatric disorders in pregnant women with opioid use disorder (OUD) is common.

Adverse Maternal Experiences (AMEs)

Evidence suggests that a woman's exposure to stressful life events during and before pregnancy is linked to multiple adverse outcomes such as low birth weight, preterm delivery, gestational diabetes, and maternal hypertension (Chen et al., 2020; Cheng et al., 2015). Stress can occur in a variety of domains; however, we conceptualize stress consistent with Aneshensel et al. (1991), who provide a compelling argument about sociological and sociomedical paradigms. Negative life events, such as trauma-related loss that occurs to a pregnant woman, or someone important to her, are more stressful than other life events; and financial stress, is an indicator of chronic life strains (Aneshensel et al., 1991).

Stress can both exacerbate mental health symptoms and be a challenge for individuals with mental health or substance use disorders. In substance misuse literature, substance use

disorders (SUDs) are interpreted as a maladaptive coping mechanism where individuals may "self-medicate," and SUDs may be associated with posttraumatic stress disorder (PTSD) that occurs in response to a variety of life stressors (Brady et al., 2004). In one study, three life stressors—money, work, and family—were significantly associated with increased risk for medication misuse and mediated by a sense of personal powerlessness (Black & Hendy, 2019). Another study examined how adverse life stressors predicted high opioid use mediated by low self-esteem (Hendy et al., 2018).

We propose a method to assess adverse maternal experiences (AMEs) from negative stressful life event questions in the Pregnancy Risk Assessment Monitoring System (PRAMS) survey data described below and assess if AMEs are independently associated with NAS.

Methods

Data and Sample

We use linked PRAMS data, Hospital Discharge data (HDD) and Birth Certificates data (BCD) for 2012–2018 for Delaware. The Delaware PRAMS was established in 2006 is administered by the Centers for Disease Control and Prevention (CDC). PRAMS is a dual-mode survey that uses telephone and hard copy (via U.S. mail) and is a stratified random sample of women from the birth certificate records who had a recent live birth (Shulman et al., 2018). The HDD for inpatient admissions based on the uniform claims and billing dataset (UB-82 or successor form) from all Delaware licensed hospitals are collected under Delaware law (16 Del.C. Ch. 20, § 2001–2009) and include all non-federal facilities.

Unique identifiers (e.g., hospital identifiers, medical record numbers, first name, last name, date of birth, etc.) were used to identify all hospital births in Delaware-to-Delaware residents between 2012 and 2018. These identifiers were used to link HDD data that contains information on all newborns (e.g., discharges, length of stay, procedures, etc.) with the respective BCD. The HDD-BCD linkage for all hospital births yielded about a 99% match using a deterministic linkage method. Since PRAMS respondents are a subset of BCD, we re-linked PRAMS data to the linked HDD-BCD dataset for 2012–2018.

Our analytic sample had 6358 singleton deliveries during 2012–2018 from linked HDD-BCD-PRAMS data. The PRAMS data are weighted to account for the survey and sampling design generalizable to the population of women who deliver a live birth. We recreated a weight for combined years of PRAMS based on Korn et al. (1999) methodology.

Because we used secondary data involving no human subjects, the study was reviewed and exempt by the Delaware Privacy Board.

Measures

Our study outcome was whether an infant was diagnosed with NAS or not (yes/no). We ascertained NAS cases from the HDD using International Classification of Diseases—Ninth Revision Clinical Modification (ICD-9-CM) diagnosis of 779.5 and ICD-10-CM diagnosis of P96.1 excluding iatrogenic cases of NAS, very low birth weight, intraventricular

hemorrhage, periventricular leukomalacia, necrotizing enterocolitis, spontaneous intestinal perforation, or bronchopulmonary dysplasia similar to Patrick et al. (2012) and Patrick et al. (2015), and the current tier 2 definitions from the Council of State and Territorial Epidemiologists (CSTE, 2019).

For our primary exposure of interest, AMEs, we created a composite measure from dichotomous items (yes/no) available in the PRAMS survey (see Table 1). While Stanhope and Hogue (2020) used principal component analysis to analyze stressful life events from PRAMS data among women living in Atlanta, Georgia, principal component analysis to develop an index for AMEs may not be appropriate for dichotomous outcomes (van Schuur, 2003). We use item response theory (IRT) which is best suited for dichotomous/binary measures (Dregan et al., 2011; Edelen & Reeve, 2007; Ngyuen et al., 2014; Streiner et al., 2015) and conceptualize AMEs as a latent or an underlying trait. Our measure is comprised of the scores obtained from the IRT model detailed in the following paragraphs.

AMEs Composite Measure Development

A detailed overview of item response theory (IRT) is beyond the scope this paper, we provide a basic framework of IRT in developing and applying of our construct AMEs. IRT is a set of generalized linear models that describe the relationship between an individual's (i.e., women in our case) 'ability' or 'trait' and their response to items (i.e., negative stressors) or their observed survey responses on a scale by estimating the likelihood of different responses to items with different levels of the trait (Dregan et al., 2011; Edelen & Reeve, 2007; Ngyuen et al., 2014; Streiner et al., 2015). IRT has two specific parameters: item difficulty and ability. The probability of endorsing or answering yes, to a specific negative stressful item is difficulty. For example, a woman with 'mild' amount of emotional stress may more likely endorse the item "*I argued with my husband or partner more than usual*" rather than a difficult item such as "*my husband or partner pushed, hit, slapped, kicked, choked, or physically hurt me*." In measuring difficulty, we assess the proportion of women who failed or did not endorse the item. In measuring ability, we assess the proportion of women who are more likely to endorse difficult items. For any given item, the relationship between difficulty and ability is displayed through an item characteristic curve or category response curves (ICC/CRCs, see Fig. 1) also referred to as an item response function (Dregan et al., 2011; Edelen & Reeve, 2007; Ngyuen et al., 2014; Streiner et al., 2015). The ICC is an S-shaped probability curve that continuously increases (i.e., a monotonic). As an individual's trait level increases, the probability of endorsing an item also increases. The shape of the curve depends on the item's difficulty and discrimination. As such, a steep ICC indicates that the item can distinguish between women with low AMEs and those with high AMEs, (i.e., discriminates well). A flatter slope suggests that the item discriminates poorly. An individual's underlying trait level theta (θ) is measured along the x-axis and higher values of θ are associated with greater levels of the underlying trait. The y-axis indicates the probability of endorsing an item and is scaled from 0.0 to 1.0 and is represented as the proportion of people who have theta (θ) amount of the trait who endorse or answer the item i:

$$P_i(\theta) = \frac{e^{a_i(\theta - b_i)}}{1 + e^{a_i(\theta - b_i)}} \text{ or } P_i(\theta) = \frac{1}{e^{-a_i(\theta - b_i)}}$$

where {a}_{i} is the discrimination ability or parameter and {b}_{i} is the difficulty or severity parameter.

While there are one (1-PL), two (2-PL) and three-parameter logistic models (3-PL) available in IRT for dichotomous scored items such as yes/no or true/false or agree/disagree, the two commonly used IRT models in health outcomes are the 1-PL and 2-PL models (Dregan et al., 2011; Edelen & Reeve, 2007; Ngyuen et al., 2014; Streiner et al., 2015).

We used a 2-PL model and evaluated the relative fit of the 1-PL, 2-PL, and 3-PL models using Akaike Information Criteria (AIC), and Log-likelihood Ratio Chi-square (LR Chi-Square). We used ICC described earlier (Fig. 1), discrimination ability (a_i or slope) and difficulty level (b_i) parameters, and polychoric correlations to include/exclude items. Because parsimony is preferred, we also used both item information curves (IIC not shown) and the total information curve (TIC not shown) to arrive at an 11-item AME composite measure. The composite measure of AMEs included 11 of 15 indicators (see Table 1). We estimated factor scores for negative life events from the 2-PL model and categorized them as AMEs (yes/no) at the 90th percentile to ensure adequate variability and avoid ceiling effects, which equated to three or more negative stressful events.

Covariates

We include demographic covariates from BCD that were assessed in previous studies and are known to be associated with NAS: maternal age (< 25 and 25 years or more), maternal education (< 12 years of school; high school graduate; more than 12 years of school), race and ethnicity (non-Hispanic white, non-Hispanic Black, Hispanic, and Other races (non-Hispanic) i.e., includes non-Hispanic Asians, American Indian or Alaska Native, Native Hawaiian or Pacific Islander, and two or more races), and insurance status (i.e., Medicaid vs. non-Medicaid). Using directed acyclic graphs (Greenland et al., 1999), we also include a priori factors associated with NAS. We use self-reported diagnosis of depression as a covariate to serve as a proxy for mental health and its association with substance use disorders (Faherty et al., 2018). We also used prescription medication use as a covariate as an estimated 14% to 22% women filled at least one opioid prescription during pregnancy based on commercial (Bateman et al., 2014) and Medicaid (Desai et al., 2014) insurance claims for pharmacy dispensing. Further, Ko et al., found 6.6% of respondents reported prescription opioid use during pregnancy from PRAMS data, and of those 21.2% reported opioid misuse and 27.1% indicated wanting or needing to reduce or stop opioid use (Ko et al., 2020). To assess if AMEs are independently associated with a NAS delivery, we used self-reported pre-pregnancy diagnosis of depression (yes/no) *before you got pregnant with your new baby, did a doctor, nurse, or other health care worker tell you that you had depression*" and; self-reported use of prescription medicine (yes/no) "*at any time during the 12 months before you got pregnant…was regularly taking prescription medicines other*

than birth control from PRAMS, and smoking during pregnancy (yes/no) from BCD as covariates.

Statistical Analysis

We present summary statistics to describe the sample characteristics and used the Rao-Scott χ^2 test to determine significant differences between women with and without AMEs and neonate NAS status. We present the overall prevalence estimates with 95% confidence intervals (CIs), crude prevalence odds ratio (cPOR) and adjusted prevalence odds ratio (aPOR). Odds ratios approximate relative risks when the prevalence of the outcome is low (i.e., < 10%; see Davies et al., 1998). We use − 2 Log Likelihood Ratio statistic for evaluating the overall model fit for logistic regression models and used the concordance statistic (c-statistic), a measure of model discrimination, which is an indexless unit that evaluates predictive accuracy (i.e., equivalent to area under the curve). All tests were two-sided with alpha at 0.05 level of significance. All analyses were carried out using SAS v9.4 (SAS Institute, Inc., Cary, NC) with complex survey module and ICCs for AMEs were produced using the latent trait models (LTM) package in R, version 3.4.3 (R Foundation for Statistical Reporting, Vienna, Austria).

Results

For the 6358 deliveries in Delaware during 2012–2018, Table 1 shows the prevalence of each adverse maternal experience and items that were dropped after IRT analysis. Items 1, 3, 8, and 14 were not included in the final composite measure of AMEs. Table 2 shows there were 627 deliveries with AMEs with an estimated prevalence of 9.5% (95% CI 8.7–10.2). NAS was identified in 169 infants (see Table 3) for an estimated prevalence of 2.2% (95% CI 1.8–2.6) of deliveries.

Prevalence of AMEs was higher in: younger women as compared with older women (13.9%; 95% CI 12.1–15.8 vs. 7.9%; 95% CI 7.1–8.7); women with only a high school diploma (14.5%; 95% CI 12.6–16.3), compared with women with less than 12 years of schooling (10.6%; 95% CI 8.6–12.7) or more than 12 years of schooling (6.8%; 95% CI 6.0–7.7); non-Hispanic Black (12.8%; 95% CI 11.0–14.7), followed by women of other races (10.3%; 95% CI 6.2–14.3), non-Hispanic white women (8.8%; 95% CI 7.8–9.8), and women with Hispanic ethnicity (7.5%; 95% CI 5.7–9.3); women whose delivery was paid by Medicaid (16.7%; 95% CI 15.2–18.2) compared with non-Medicaid (3.0; 95% CI 2.4–3.6); women regularly taking prescription medicine before pregnancy (12.7%; 95% CI 10.9–14.4) compared with women not taking prescription medicine regularly (8.5%; 95% CI 7.6–9.3); and women who smoked during pregnancy (25.6%; 95% CI 22.1–29.2) compared with women who did not smoke (7.7%; 95% CI 6.9–8.4).

Prevalence of NAS was higher in infants born to women with AMEs (8.7%; 95% CI 6.4–11.0) as compared to women without AMEs (1.5%; 95% CI 1.2–1.9). Prevalence of NAS was slightly higher among infants born to older women (over 25 years) (2.4%; 95% CI 2.0–2.9) as compared with younger women (1.6%; 95% CI 1.0–2.2); and higher in: women with less than 12 years of schooling (4.3% 95% CI 3.0–5.6); women with only a high school diploma (3.9%; 95% CI 2.9–4.9); and non-Hispanic white women (3.2%; 95% CI 2.6–3.8),

followed by non-Hispanic Black women (1.2%; 95% CI 0.6–1.8), and women of other races (1.1%; 95% CI 0.1–2.2) and Hispanic ethnicity (0.9%; 95% CI 0.3–1.6). NAS prevalence was also higher in infants born to women whose deliveries were paid by Medicaid (4.1% 95% CI 3.4–4.9) compared with non-Medicaid (0.5; 95% CI 0.2–0.7); women with pre-pregnancy depression (6.8% 95% CI 4.9–8.6) compared with no pre-pregnancy depression (1.6%; 1.2–1.9); women regularly taking prescription medicine before pregnancy (6.1%; 95% CI 4.8–7.4) compared with women who did not take prescription medication regularly (1.0%;95% CI 0.7–1.3); and women who smoked during pregnancy (15.6%; 95% CI 12.6–18.5) compared with who did not smoke (0.7%; 0.5–1.0).

Women with AMEs had 5.1 times greater odds (cPOR 6.1; 95% CI 4.2–8.8) of delivering a NAS-diagnosed infant as compared with women without AMEs (see Table 3). After adjusting for sociodemographic characteristics, and a priori factors of pre-pregnancy depression, regular use of prescription medicine before pregnancy, and smoking during pregnancy, women with AMEs had 1.1 times greater odds (aPOR 2.1; 95% CI 1.3–3.3) of delivering a NAS-diagnosed infant as compared with women without AMEs (see Table 4). We found that the full model III had a better fit -2LL (1275.355) and a higher c-statistic (0.921) as compared with models I and II, which had fewer covariates.

Discussion

Our study aimed to understand the social context of women who delivered NAS-diagnosed infants in Delaware by using linked HDD, BCD, and PRAMS survey data that contains rich social context indicators not usually found in other sources of data on pregnancy outcomes. Using negative stressful life events before and during pregnancy, we developed a composite measure for AMEs to understand its association with an infant health indicator such as NAS. Prevalence of AMEs varied by age, education, race and ethnicity, socio-economic status (i.e., Medicaid), among women with and without depression, pre-pregnancy prescription drug use, and cigarette use. We found that women with AMEs before or during pregnancy have higher odds than women without AMEs to deliver a NAS-diagnosed infant in Delaware. The finding is consistent even after we account for sociodemographic factors and a priori factors such as depression, regular use of prescription medicine before pregnancy, and cigarette use before the birth event.

AMEs may be a precursor to depression, smoking, and opioid use disorder alone or in combination. Some women may smoke or misuse opioids as a maladaptive coping mechanism to cope with life stressors such as finances, work, family problems or intimate partner violence (Black & Hendy, 2019; Brady et al., 2004). Smoking (nicotine) before or during pregnancy often coexists with substance misuse and use disorders (Jones, et al., 2013; Weinberger et al., 2017), and nicotine alone may lead to NAS. The amplifying effect of nicotine underscores the critical importance of addressing nicotine addiction in medication-assisted treatment while also addressing substance use.

Women experiencing AMEs may also have contended with adverse childhood experiences (ACEs). For instance, Haahr-Pederson et al. (2020) found that women who reported ACEs have mental health, social, and emotional difficulties in adulthood. A prospective study

by Selous et al. (2020) that tracked children and adults for up to 50 years found that ACEs were associated with increased rates of adult mood problems. Racine et al.'s study (2018) suggests that "psychosocial risks in pregnancy…contribute to the transmission of vulnerability from maternal ACEs to child development outcomes in infancy via maternal behavior" (p. 1). Some studies found that women with OUD have a high rate of mental health comorbidities (Arnaudo et al., 2017; Kozhimannil et al., 2017) and interventions for NAS may need to go beyond counseling and behavioral therapy that commonly accompany medication-assisted therapy treatment for OUD, to address underlying trauma and mental health needs.

Perinatal behavioral health programs that include mental health supports, assist women to navigate community service systems, provide outpatient therapy program for women and children may need to address AMEs. Tracking the trajectories of ACEs to AMEs through longitudinal studies like that of Haahr-Pedersen et al. (2020), Racine et al. (2018) and Selous et al. (2020), or surveys of past life events would help fill the gap in knowledge of maladaptive coping mechanisms. Identification of and intervention early in life could lead to the adoption of appropriate coping skills and help reduce adverse events or their sequelae, and subsequent poor health outcomes.

Limitations

Despite the strength of utilizing linked administrative data and PRAMS survey data, the general cross-sectional nature limits our ability to draw causal inferences. NAS cases were identified using HDD, and these data may be prone to coding errors (Patrick et al., 2012). Further, and not all neonates chronically exposed to opioids develop NAS postdelivery (McQueen & Murphy-Oikonen, 2016), provider misdiagnosis (Doherty et al., 2021), state surveillance laws (Chiang et al., 2019) or symptom presentations (Jansson & Patrick, 2019). Our dataset did not have measures for maternal ACEs and did not contain specific details about other substance use, measures for substance misuse, frequency, or type and dose of prescription medications that could be potential confounders. Our dataset was also limited as it did not have information to distinguish opioid and non-opioid medications. PRAMS is a probability-based sample from BCD and the NAS prevalence was low (n = 169 or 2.2% in our study), which limited our ability to conduct any sub-group analyses and examine specific life stressors like the study of Chen et al. (2020) or Hendy et al. (2018). Combining more years of data or using data from other states may allow discernment of specific types of stressors (health, money, work, family) that are associated with NAS.

Conclusion

Using multiple sources of linked data, we developed a measure of negative life events that can be used to understand birth outcomes such as NAS. Coping with life stressors may take various forms, and for some women it may involve maladaptive behaviors such as cigarette use (nicotine) or drug misuse (opioids). Our study shows that AMEs may play an independent role in women delivering NAS-diagnosed infants even after accounting for regularly taking prescription medication during the 12 months before pregnancy, pre-pregnancy depression, and smoking during pregnancy. AMEs may be a useful measure

to understand the social context of women before and during pregnancy and subsequent perinatal outcomes outcome such as NAS.

Funding

PRAMS is made possible with assistance from CDC grant 5U01DP006239. The data linkage activity is supported by the Health Resources and Services Administration (HRSA) of the U.S. Department of Health and Human Services (HHS) Grant H18MC000 under the State Systems Development Initiative (SSDI).

References

Aneshensel C, Rutter C, & Lachenbruch P (1991). Social structure, stress, and mental health: Competing conceptual and analytic models. American Sociological Review, 56(2), 166–178. 10.2307/2095777

Arnaudo CL, Andraka-Christou B, & Allgood K (2017). Psychiatric co-morbidities in pregnant women with opioid use disorders: Prevalence, impact, and implications for treatment. Current Addiction Reports, 4(1), 1–13. 10.1007/s40429-017-0132-4 [PubMed: 28357191]

Bateman BT, Hernandez-Diaz S, Rathmell JP, Seeger JD, Doherty M, Fischer MA, & Huybrechts KF (2014). Patterns of opioid utilization in pregnancy in a large cohort of commercial insurance beneficiaries in the United States. Anesthesiology, 120(5), 1216–1224. 10.1097/ALN.0000000000000172 [PubMed: 24525628]

Black P, & Hendy H (2019). Perceived powerlessness as a mediator between life stressors and deviant behaviors. Deviant Behavior, 40(9), 1080–1089. 10.1080/01639625.2018.1461744

Brady K, Back S, & Coffey S (2004). Substance abuse and post-traumatic stress disorder. Current Directions in Psychological Science, 13(5), 206–209. 10.1111/j.0963-7214.2004.00309.x

Chen L, Shi L, Chao M, Tong X, & Wang F (2020). Stressful life events, hypertensive disorders, and high blood sugar during pregnancy. Stress and Health, 36(2), 160–165. 10.1002/smi.2911 [PubMed: 31714017]

Cheng E, Park H, Wisk L, Mandell K, Wakeel F, Litzelman K, & Witt W (2015). Examining the link between women's exposure to stressful life events prior to conception and infant and toddler health: The role of birth weight. Journal of Epidemiology and Community Health, 70(3), 245–24552. 10.1136/jech-2015-205848 [PubMed: 26500337]

Chiang KV, Okoroh EM, Kasehagen LJ, Garcia-Saavedra LF, & Ko JY (2019). Standardization of state definitions for neonatal abstinence syndrome surveillance and the opioid crisis. American Journal of Public Health, 109(9), 1193–1197. 10.2105/AJPH.2019.305170 [PubMed: 31318590]

Council for State and Territorial Epidemiologists. (2019). Standardized Surveillance for Diseases or Conditions. Retrieved from https://cdn.ymaws.com/www.cste.org/resource/resmgr/ps/2019ps/19-MCH-01_NAS_updated_5.7.19.pdf

Davies HT, Crombie IK, & Tavakoli M (1998). When can odds ratios mislead? BMJ (clinical Research Ed.), 316(7136), 989–991. 10.1136/bmj.316.7136.989

Desai RJ, Hernandez-Diaz S, Bateman BT, & Huybrechts KF (2014). Increase in prescription opioid use during pregnancy among Medicaid-enrolled women. Obstetrics and Gynecology, 123(5), 997–1002. 10.1097/AOG.0000000000000208 [PubMed: 24785852]

Doherty KM, Scott TA, Morad A, Crook T, McNeer E, Lovell KS, Gay JC, & Patrick SW (2021). Evaluating definitions for neonatal abstinence syndrome. Pediatrics, 147(1), e2020007393. 10.1542/peds.2020-007393 [PubMed: 33268396]

Dregan A, Grieve A, van Staa T, & Gulliford M (2011). Potential application of item-response theory to interpretation of medical codes in electronic patient records. BMC Medical Research Methodology, 11(1), 168. 10.1186/1471-2288-11-168 [PubMed: 22176509]

Edelen M, & Reeve B (2007). Applying item response theory (IRT) modeling to questionnaire development, evaluation, and refinement. Quality of Life Research, 16(1), 5–18. 10.1007/s11136-007-9198-0 [PubMed: 17375372]

Faherty LJ, Matone M, Passarella M, & Lorch S (2018). Mental health of mothers of infants with neonatal abstinence syndrome and prenatal opioid exposure. Maternal and Child Health Journal, 22(6), 841–848. 10.1007/s10995-018-2457-6 [PubMed: 29417369]

Greenland S, Pearl J, & Robins J (1999). Causal diagrams for epidemiologic research. Epidemiology, 10, 37–48. [PubMed: 9888278]

Haahr-Pedersen I, Perera C, Hyland P, Vallières F, Murphy D, Hansen M, & Cloitre M (2020). Females have more complex patterns of childhood adversity: Implications for mental, social, and emotional outcomes in adulthood. European Journal of Psychotraumatology, 11(1), 1708618. 10.1080/20008198.2019.1708618 [PubMed: 32002142]

Hayes MJ, & Brown MS (2012). Epidemic of prescription opiate abuse and neonatal abstinence. JAMA, 307(18), 1974–1975. 10.1001/jama.2012.4526 [PubMed: 22546607]

Hendy H, Black P, Can S, Fleischut A, & Aksen D (2018). Opioid abuse as maladaptive coping to life stressors in U.S adults. Journal of Drug Issues, 48(4), 560–571. 10.1177/0022042618783454

Jansson LM, & Patrick SW (2019). Neonatal abstinence syndrome. Pediatric Clinics of North America, 66(2), 353–367. 10.1016/j.pcl.2018.12.006 [PubMed: 30819342]

Jones HE, Heil SH, Tuten M, Chisolm MS, Foster JM, O'Grady KE, & Kaltenbach K (2013). Cigarette smoking in opioid-dependent pregnant women: Neonatal and maternal outcomes. Drug and Alcohol Dependence, 131(3), 271–277. 10.1016/j.drugalcdep.2012.11.019 [PubMed: 23279924]

Ko JY, D'Angelo DV, Haight SC, Morrow B, Cox S, Salvesen von Essen B, Strahan AE, Harrison L, Tevendale HD, Warner L, Kroelinger CD, & Barfield WD (2020). Vital Signs: prescription opioid pain reliever use during pregnancy - 34 U.S. jurisdictions, 2019. *MMWR* Morbidity and Mortality Weekly Report, 69(28), 897–903. 10.15585/mmwr.mm6928a1 [PubMed: 32673301]

Korn E, & Graubard B (1999). Analysis of health surveys. Wiley.

Kozhimannil KB, Graves AJ, Jarlenski M, Kennedy-Hendricks A, Gollust S, & Barry CL (2017). Non-medical opioid use and sources of opioids among pregnant and non-pregnant reproductive-aged women. Drug and Alcohol Dependence, 174, 201–208. 10.1016/j.drugalcdep.2017.01.003 [PubMed: 28285727]

McQueen K, & Murphy-Oikonen J (2016). Neonatal abstinence syndrome. New England Journal of Medicine, 375(25), 2468–2479. [PubMed: 28002715]

Nguyen TH, Han HR, Kim MT, & Chan KS (2014). An introduction to item response theory for patient-reported outcome measurement. The Patient, 7(1), 23–35. 10.1007/s40271-013-0041-0 [PubMed: 24403095]

Patrick S, Schumacher R, Benneyworth B, Krans E, Mcallister J, & Davis M (2012). Neonatal Abstinence Syndrome and associated health care expenditures: United States, 2000–2009. JAMA, 307(18), 1934–1940. [PubMed: 22546608]

Racine N, Plamondon A, Madigan S, McDonald S, & Tough S (2018). Maternal adverse childhood experiences and infant development. Pediatrics, 141(4), e20172495. 10.1542/peds.2017-2495 [PubMed: 29559588]

Selous C, Kelly-Irving M, Maughan B, Eyre O, Rice F, & Collishaw S (2020). Adverse childhood experiences and adult mood problems: Evidence from a five-decade prospective birth cohort. Psychological Medicine, 50(14), 1–8. 10.1017/S003329171900271X [PubMed: 31663847]

Shulman HB, D'Angelo DV, Harrison L, Smith RA, & Warner L (2018). The Pregnancy Risk Assessment Monitoring System (PRAMS): Overview of design and methodology. American Journal of Public Health, 108(10), 1305–1313. 10.2105/AJPH.2018.304563 [PubMed: 30138070]

Smith MV, Costello D, & Yonkers KA (2015). Clinical correlates of prescription opioid analgesic use in pregnancy. Maternal and Child Health Journal, 19(3), 548–556. 10.1007/s10995-014-1536-6 [PubMed: 24951127]

Stanhope KK, & Hogue CJ (2020). Stressful life events among new mothers in Georgia: Variation by race, ethnicity and nativity. Maternal and Child Health Journal, 24(4), 447–455. 10.1007/s10995-020-02886-7 [PubMed: 31993934]

van Schuur WH (2003). Mokken scale analysis: Between the Guttman scale and parametric item response theory. Political Analysis, 11(2), 139–163.

Weinberger AH, Platt J, Esan H, Galea S, Erlich D, & Goodwin RD (2017). Cigarette Smoking is associated with increased risk of substance use disorder relapse: A nationally representative, prospective longitudinal investigation. Journal of Clinical Psychiatry, 78(2), e152–e160. 10.4088/JCP.15m10062 [PubMed: 28234432]

Winkelman T, Villapiano N, Kozhimannil K, Davis M, & Patrick S (2018). Incidence and costs of neonatal abstinence syndrome among infants with Medicaid: 2004–2014. Pediatrics, 141(4), e20173520. [PubMed: 29572288]

Significance Statement

Although the sequelae of in utero exposure to opioids in neonates, known as neonatal abstinence syndrome (NAS), has been well-documented, indicators for measuring adverse maternal experiences (AMEs) of these women before and during their pregnancy are needed. We developed a measure for AMEs using item-response theory (IRT) that may be a used to understand the social context of women before and during pregnancy and subsequent perinatal outcomes such as NAS. Our measure for AMEs defined as three or more negative stressful events, was associated with NAS even after adjusting for depression, and prescription medication use, suggesting that it may be important to address emotional well-being such as AMEs during preconception and prenatal periods.

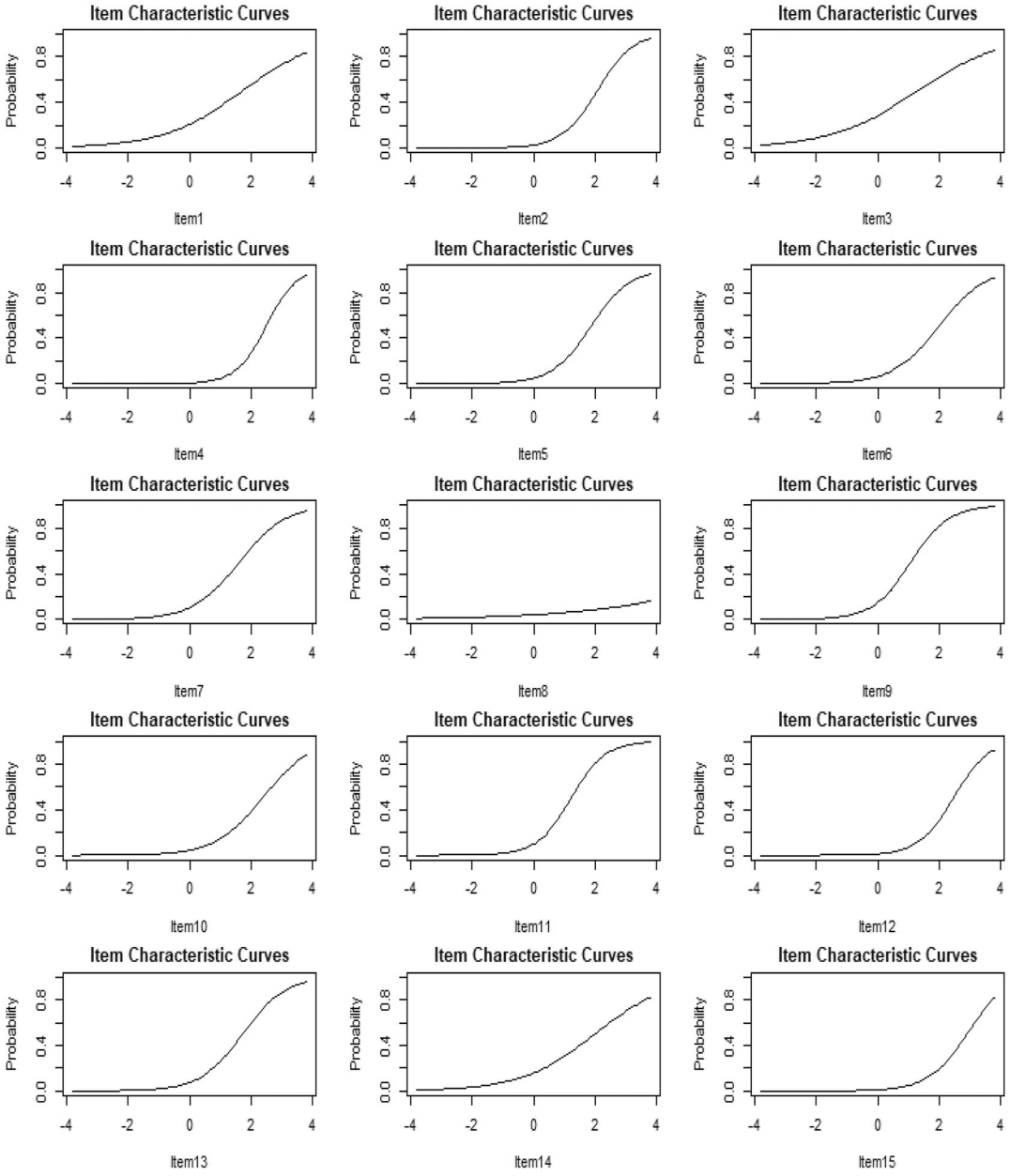

Fig. 1.

Item characteristic curves from item response analysis for 15 individual adverse maternal experiences[†] assessed for creating a composite measure, Delaware, 2012–2018. Adverse maternal experiences composite measure developed from Pregnancy Risk Assessment Monitoring Survey (PRAMS) data—Items 1 to 14 are prefaced with…*This question is about things that may have happened during the 12 months before your new baby was born. For each item, check No if it did not happen to you or Yes if it did. (It may help to look at the calendar when you answer these questions).* Items: *1. A close family member was very sick and had to go into the hospital[‡]; 2. I got separated or divorced from my husband or partner; 3. I moved to a new address[‡]; 4. I was homeless or had to sleep outside, in a car, or in a shelter; 5. My husband or partner lost his job; 6. I lost my job even though I wanted to go*

on working; 7. My husband, partner, or I had a cut in work hours or pay; 8. I was apart from my husband or partner due to military deployment or extended work-related travel‡; 9. I argued with my husband or partner more than usual; 10. My husband or partner said he didn't want me to be pregnant; 11. I had problems paying the rent, mortgage, or other bills; 12. My husband, partner, or I went to jail; 13. Someone very close to me had a problem with drinking or drugs; 14. Someone very close to me died‡; 15. During the 12 months before you got pregnant with your new baby, did your husband or partner push, hit, slap, kick, choke, or physically hurt you in any other way?‡The ICC is a S-shaped probability curve that continuously increases (i.e., a monotonic). As an individual's trait level increases, the probability of endorsing an item also increases. The shape of the curve depends on the item's difficulty and discrimination. As such, a steep ICC indicates that the item can distinguish between women with low AMEs and those with high AMEs, (i.e., discriminates) well, a flatter slope suggests that the item discriminates poorly. Items were dropped from the composite measure after examining the item characteristic curves (ICCs) discrimination ability (a_i or slope) and difficulty level (b_i) parameters, and polychoric correlations to include/exclude items. Because parsimony is preferred, we also used both item information curves (IIC not shown) and the total information curve (TIC not shown) to arrive at 11-item AME composite measure and assessing model fit from Item Response Analysis

Table 1

Adverse maternal experiences (AMEs) within 12 months preceding a live birth, 2012–2018

Individual adverse maternal experiences (AMEs) items	n[a]	Prevalence	(95% CI)[b]
1. A close family member was very sick and had to go into the hospital[c]	1462	23.2	(22.0–24.3)
2. I got separated or divorced from my husband or partner	454	6.9	(6.3–7.6)
3. I moved to a new address‡	1884	30.1	(28.9–31.3)
4. I was homeless or had to sleep outside, in a car, or in a shelter	188	2.7	(2.3–3.1)
5. My husband or partner lost his job	644	10.1	(9.3–10.9)
6. I lost my job even though I wanted to go on working	683	10.7	(9.9–11.5)
7. My husband, partner, or I had a cut in work hours or pay	1006	15.9	(14.9–16.9)
8. I was apart from my husband or partner due to military deployment or extended work-related travel‡	285	4.6	(4.0–5.1)
9. I argued with my husband or partner more than usual	1443	23.0	(21.9–24.2)
10. My husband or partner said he didn't want me to be pregnant	490	**7.7**	(6.9–8.4)
11. I had problems paying the rent, mortgage, or other bills	1183	18.3	(17.3–19.3)
12. My husband, partner, or I went to jail	257	4.0	(3.5–4.5)
13. Someone very close to me had a problem with drinking or drugs	828	12.9	(12–13.8)
14. Someone very close to me died‡	1167	18.1	(17.1–19.2)
15. During the 12 months before you got pregnant with your new baby, did your husband or partner push, hit, slap, kick, choke, or physically hurt you in any other way?	175	2.7	(2.3–3.2)

Items are self-reported via questionnaire 1 to 14 are prefaced with…*This question is about things that may have happened during the 12 months before your new baby was born. For each item, check No if it did not happen to you or Yes if it did. (It may help to look at the calendar when you answer these questions)*

[a] n is unweighted number of singleton deliveries who endorsed "yes" of 6358 singleton deliveries

[b] Weighted percent and 95% confidence intervals (CI)

[c] Items were not included in the composite AME measure after examining the item characteristic curves (ICCs) and assessing model fit from item response analysis

Table 2

Prevalence of adverse maternal experiences among women with a live singleton delivery, by maternal characteristics, 2012–2018

Maternal characteristics	Adverse maternal experiences (AMEs)[a]				
	Yes% N[b] = 627	(95% CI)	No% n[b] = 5731	(95% CI)	*p*-value
Overall	9.5	(8.7–10.2)	90.5	(89.8–91.3)	n/a
Age (in years)					
Less than 25	13.9	(12.1–15.8)	86.1	(84.2–87.9)	< 0.0001
25 and older	7.9	(7.1–8.7)	92.1	(91.3–92.9)	
Education					
< 12 years of schooling	10.6	(8.6–12.7)	89.4	(87.3–91.4)	< 0.0001
High school graduate	14.5	(12.6–16.3)	85.5	(83.7–87.4)	
> 12 years of schooling	6.8	(6.0–7.7)	93.2	(92.3–94.0)	
Race and ethnicity					
White (non-Hispanic)	8.8	(7.8–9.8)	91.2	(90.2–92.2)	< 0.0001
Black (non-Hispanic)	12.8	(11.0–14.7)	87.2	(85.3–89.0)	
Hispanic	7.5	(5.7–9.3)	92.5	(90.7–94.3)	
Other races (non-Hispanic)	10.3	(6.2–14.3)	89.7	(85.7–93.8)	
Medicaid payer of delivery					
Yes	16.7	(15.2–18.2)	83.3	(81.8–84.8)	< 0.0001
No	3.0	(2.4–3.6)	97.0	(96.4–97.6)	
Pre-pregnancy depression					
Yes	24.8	(21.5–28.1)	75.2	(71.9–78.5)	< 0.0001
No	7.4	(6.7–8.2)	92.6	(91.8–93.3)	
Prescription drug use (12-month before being pregnant)					
Yes	12.7	(10.9–14.4)	87.3	(85.6–89.1)	< 0.0001
No	8.5	(7.6–9.3)	91.5	(90.7–92.4)	
Cigarette use during pregnancy					
Yes	25.6	(22.1–29.2)	74.4	(70.8–77.9)	< 0.0001
No	7.7	(6.9–8.4)	92.3	(91.6–93.1)	

Weighted percent (%) and 95% confidence intervals (CI). Rao-Scott χ^2 test for significant differences in maternal characteristics for women with and without AMEs

[a] Dichotomized composite measure (yes/no) of AMEs based on item response analysis. Items include: *I got separated or divorced from my husband or partner; I was homeless or had to sleep outside, in a car, or in a shelter; My husband or partner lost his job; I lost my job even though I wanted to go on working; My husband, partner, or I had a cut in work hours or pay; I argued with my husband or partner more than usual; My husband or partner said he didn't want me to be pregnant; I had problems paying the rent, mortgage, or other bills; My husband, partner, or I went to jail; Someone very close to me had a problem with drinking or drugs; Husband or partner push, hit, slap, kick, choke, or physically hurt you in any other way?*

[b] n is unweighted number of singleton deliveries

Table 3

Prevalence and crude odds of delivering an infant with Neonatal Abstinence Syndrome, by maternal characteristics, 2012–2018

Maternal characteristics	Neonatal Abstinence Syndrome (NAS)[b]					Odds ratio
	Yes% (n[c] = 169)	(95% CI)	No% (n[c] = 6189)	(95% CI)	*p*-value	cPOR (95% CI)
Overall prevalence	2.2	(1.8–2.6)	97.8	(97.4–98.2)	n/a	n/a
Adverse maternal experiences (AMEs)[a]						
Yes	8.7	(6.4–11.0)	91.3	(89.0–93.6)	< 0.0001	6.1 (4.2–8.8)
No	1.5	(1.2–1.9)	98.5	(98.1–98.8)		Ref
Age (in years)						
Less than 25	1.6	(1.0–2.2)	98.4	(97.8–99.0)	0.046	0.6 (0.4–1.0)
25 and older	2.4	(2.0–2.9)	97.6	(97.1–98.0)		Ref
Education						
< 12 years of schooling	4.3	(3.0–5.6)	95.7	(94.4–97.0)	< 0.0001	5.4 (3.3–8.7)
High school graduate	3.9	(2.9–4.9)	96.1	(95.1–97.1)		4.9 (3.1–7.6)
> 12 years of schooling	0.8	(0.5–1.1)	99.2	(98.9–99.5)		Ref
Race and ethnicity						
White (non-Hispanic)	3.2	(2.6–3.8)	96.8	(96.2–97.4)	< 0.0001	2.9 (1.1–7.5)
Black (non-Hispanic)	1.2	(0.6–1.8)	98.8	(98.2–99.4)		1.1 (0.4–3.1)
Hispanic	0.9	(0.3–1.6)	99.1	(98.4–99.7)		0.8 (0.3–2.6)
Other race (non-Hispanic)	1.1	(0.1–2.2)	98.9	(97.8–99.9)		Ref
Medicaid payer of delivery						
Yes	4.1	(3.4–4.9)	95.9	(95.1–96.6)	< 0.0001	9.2 (5.1–16.6)
No	0.5	(0.2–0.7)	99.5	(99.3–99.8)		Ref
Pre-pregnancy depression						
Yes	6.8	(4.9–8.6)	93.2	(91.4–95.1)	< 0.0001	4.6 (3.1–6.6)
No	1.6	(1.2–1.9)	98.4	(98.1–98.8)		Ref
Prescription drug use (12-month before being pregnant)						
Yes	6.1	(4.8–7.4)	93.9	(92.6–95.2)	< 0.0001	6.2 (4.3–8.9)
No	1.0	(0.7–1.3)	99.0	(98.7–99.3)		Ref
Cigarette use during pregnancy						

Matern Child Health J. Author manuscript; available in PMC 2024 March 19.

Maternal characteristics	Neonatal Abstinence Syndrome (NAS)[b]					Odds ratio
	Yes% (n[c] = 169)	(95% CI)	No% (n[c] = 6189)	(95% CI)	*p*-value	cPOR (95% CI)
Yes	15.6	(12.6–18.5)	84.4	(81.5–87.4)	< 0.0001	25.3 (17.1–37.6)
No	0.7	(0.5–1.0)	99.3	(99.0–99.5)		Ref

Weighted percent (%) and crude prevalence odds ratio (cPOR) with 95% confidence intervals (CI) estimated using logistic bivariate regression. Rao-Scott χ^2 test for significant differences in maternal characteristics for NAS-diagnosed and non-NAS infants

[a]Dichotomized composite measure (yes/no) of AMEs based on item response analysis. Items include: *I got separated or divorced from my husband or partner; I was homeless or had to sleep outside, in a car, or in a shelter; My husband or partner lost his job; I lost my job even though I wanted to go on working*;

My husband, partner, or I had a cut in work hours or pay; I argued with my husband or partner more than usual; My husband or partner said he didn't want me to be pregnant; I had problems paying the rent, mortgage, or other bills;

My husband, partner, or I went to jail; Someone very close to me had a problem with drinking or drugs; Husband or partner push, hit, slap, kick, choke, or physically hurt you in any other way?

[b]Neonatal Abstinence Syndrome (NAS): International Classification of Diseases—Ninth Revision Clinical Modification (ICD-9-CM) diagnosis of 779.5 and ICD-10-CM diagnosis of P96.1

[c]n is unweighted number of singleton deliveries

Matern Child Health J. Author manuscript; available in PMC 2024 March 19.

Table 4

Adjusted prevalence odds ratios for delivering an infant with Neonatal Abstinence Syndrome, by presence of Adverse maternal experiences, 2012–2018

Adverse maternal experiences[d]	Neonatal Abstinence Syndrome (NAS)[e]		
	Adjusted Prevalence Odds Ratio (aPOR)		
	Model I (95% CI)[a]	Model II (95% CI)[b]	Model III (95% CI)[c]
Yes	3.5 (2.3–5.4)	2.6 (1.6–4)	2.1 (1.3–3.3)
No	Ref	Ref	Ref
Model fit (*-2LL*)	1621.563	1432.148	1275.355
C-statistic	0.851	0.889	0.921

Adjusted prevalence odds ratio (aPOR) with 95% confidence intervals (CI). Model fit statistics − 2 Log Likelihood Ratio (− 2LL); Concordance (c-statistic) is an indexless unit that evaluates predictive accuracy (i.e., equivalent to area under the curve) and a measure of discrimination

[a]Model I adjusts for demographic covariates: maternal age, education, race and ethnicity, and Medicaid status

[b]Model II adjusts a priori factors of pre-pregnancy depression, prescription drug use (12-month before being pregnant), and cigarette use during pregnancy

[c]Model III is a full model and adjusts for demographic covariates in Model I and a priori factors in Model II

[d]Dichotomized composite measure (yes/no) of adverse maternal experiences (AMEs) based on item response analysis. Items include: *I got separated or divorced from my husband or partner; I was homeless or had to sleep outside, in a car, or in a shelter; My husband or partner lost his job; I lost my job even though I wanted to go on working; My husband, partner, or I had a cut in work hours or pay; I argued with my husband or partner more than usual; My husband or partner said he didn't want me to be pregnant; I had problems paying the rent, mortgage, or other bills; My husband, partner, or I went to jail; Someone very close to me had a problem with drinking or drugs; Husband or partner push, hit, slap, kick, choke, or physically hurt you in any other way?*

[e]Neonatal Abstinence Syndrome (NAS): International Classification of Diseases—Ninth Revision Clinical Modification (ICD-9-CM) diagnosis of 779.5 and ICD-10-CM diagnosis of P96.1