Social Science Research 64 (2017) 214–225

Contents lists available at ScienceDirect

Social Science Research

journal homepage: www.elsevier.com/locate/ssresearch

Using item response theory to optimize measurement of chronic stress in pregnancy

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ARTICLE INFO

Article history:
Received 9 September 2015
Received in revised form 2 November 2016
Accepted 17 December 2016
Available online 22 December 2016

Keywords:
Chronic stress
Pregnancy
Item response theory
Self-reported stress
Biomarkers

ABSTRACT

Objective: Utilize Rasch analysis to develop an optimized self-reported measure of stress in pregnancy and examine the association with patient demographics and biologic measures of stress.

Study design: Measured self-reported stress in pregnant women using 12 existing scales. Collected blood for biologic measures of stress (Epstein Barr Virus [EBV], C-Reactive Protein [CRP], Corticotropin Reactive Hormone [pCRH], and Adenocorticotropin Hormone [ACTH]). Used multidimensional scaling and Rasch analysis to produce an item reduced self-report measure.

Results: Enrolled 112 women. Survey items reduced to two factors: perceived stressors and buffers of stress. Women with a domestic partner had lower perceived stress ($p = 0.003$). Caucasian women reported higher buffers of stress ($p = 0.045$), as did women with private insurance ($p < 0.001$), a planned pregnancy ($p < 0.01$), and a domestic partner ($p < 0.001$). Women with higher buffers of stress had lower levels of pCRH (adjusted $p = 0.01$).

Conclusion: Item reduced, optimized measures of stress were associated with significant differences in patient demographics and biologic measures of stress.

1. Introduction

Pregnancy is a time of dynamic social-emotional and biological change that has profound implications for the long-term health of both mother and baby. Chronic psychosocial stress experienced by mothers may play an important role in pregnancy and birth outcomes, and of particular interest to social science, may drive racial disparities in these outcomes (Borders et al.,

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http://dx.doi.org/10.1016/j.ssresearch.2016.12.003
0049-089X/

2007; Copper et al., 1996; Dole et al., 2003a; Hedegaard et al., 1996; Hogue & Bremner, 2005; Lobel et al., 1992; Nordentoft et al., 1996; Rini et al., 1999a). Preterm birth (delivery < 37 weeks gestation) accounts for 85% of adverse perinatal outcomes, and in 2013 preterm birth occurred at a rate of 13.4% among Black women and 11.3% among Hispanic women, compared to 10.1% among white women (Martin et al., 2015). Having the ability to accurately measure the ways in which maternal psychosocial stress influences physiological pathways that predict adverse birth outcomes may be key to reducing such disparities, both in allowing clinicians to screen and identify at-risk patients, as well as in developing preventative treatment protocols to improve birth outcomes. Interventions such as CenteringPregnancy, a model of group prenatal care developed particularly for low-income and low-literacy women of color, have been associated with a 33% reduction in the rate of preterm birth, and significantly higher birth weight among ethnically diverse cohorts and adolescents (Joseph et al., 2009; Grady & Bloom, 2004; Williams et al., 2009; Ickovics et al., 2003; Robertson et al., 2009; Tandon et al., 2012). Yet it remains to be established precisely *how* such models of care improve birth outcomes (Baldwin, 2006; Grady and Bloom, 2004; Ickovics et al., 2003, 2011; Robertson et al., 2009; Shakespear et al., 2010).

Currently, there is inconsistency in the literature connecting self-reported maternal stress with physiological stress pathways that lead to adverse birth outcomes (Bryce et al., 1991; Hoffman and Hatch, 1996; Lu & Bhen, 2004; Oakley et al., 1990; Orr and Miller, 1995). One explanation for this inconsistency lies in the challenge to define "stress" as a meaningful socio-biologic construct. Psychosocial stress has been defined in predominantly objective terms as one's standing within a given socioeconomic and political context, as a predominantly subjective experience best captured via self-report, and in a great variety of time scales from years, to months, to days, to moments, or even across lifetimes and generations (Aneshensel, 1992; Cohen et al., 1995; Monroe, 2008; Pearlin and Bierman, 2013; Thoits, 2013; Turner, 2006). There is also a question about how to validate measures of stress, and whether self-report must be corroborated by outcomes measures of health and well-being (Cohen et al., 1995). This lack of consensus about the best definitions and validity of the stress construct has consequently produced a great diversity of survey tools for measuring stress, especially in the form of self-report (Chen et al., 2011; Kramer et al., 2009). Chen et al. published a comprehensive review of stress instruments used in studies investigating psychosocial stress and adverse pregnancy outcomes and found that 85 different instruments had been used to measure stress during pregnancy. The instruments included scales of stressful life events, anxiety, depression, stressful work, physical abuse, perceptions of neighborhood, discrimination, and low levels of social support (Chen et al., 2011). Many of the measures may not adequately characterize chronic stress, which seems to be of more physiologic importance during pregnancy than acute stress. Chronic stress can lead to systemic dysregulation of hormonal and inflammatory pathways that play important roles in the normal parturition cascade, contributing to cervical ripening, membrane rupturing, and uterine smooth muscle contraction, which may ultimately trigger preterm birth (Challis et al., 2009).

Efforts have been made to draw together various types and scales of stress into a unified framework (refs). Modern psychometric methodologies such as Rasch analysis and other Item Response Theory (IRT) models have been used to reduce the number of individual items that comprise a measure and to identify the items that are most informative and necessary to produce a valid and reliable measure. Unlike traditional classical test theory that weighs all items equally; Rasch/IRT analysis calibrates items and individuals' responses onto the same latent trait or continuum. This approach allows most informative items to be selected for use in an "optimized" scale (Anastasi and Urbina, 1997; Suen, 1990; Thissen and Orlando, 2001). While Rasch/IRT analysis has been used to optimize patient-reported outcomes in other disciplines, it has not been applied to the self-reported measurement of stress in pregnant women (Butt, 2008; Chen et al., 2009; Lai et al., 2009; Lai et al., 2005; Teresi et al., 2009; Thissen and Orlando, 2001). Applying the Rasch technique to pregnancy-specific assessements of stress has direct clinical relevance, as there is currently no standard practice for stress screening during routine obstetric care, and the development of an optimized tool could provide a simple yet effective strategy to conduct such screening.

Further, such an optimized scale can help predict which physiological pathways of stress play a key role in adverse birth outcomes. The pathways from maternal psychosocial stress to adverse birth outcomes are still unclear in the literature (Entringer et al., 2010, 2015; Kramer et al., 2009; Wadhwa et al., 2011), though the pathways of greatest interest include the maternal Hypothalamic-Pituitary-Adrenal axis (HPA axis) (Entringer et al., 2009; Mancuso et al., 2004; Sandman et al., 2006; Smith and Nicholson, 2007), maternal inflammation (Challis et al., 2009; Christian, 2012), and the placenta (McLean et al., 1995; Smith and Nicholson, 2007; Smith et al., 2009). The maternal HPA axis, which mediates the maternal physiologic stress response, initiates a cascade of Corticoptrophin-Releasing Hormone (CRH) from the hypothalamus, Adrenocorticotrophic Hormone (ACTH) from the anterior pituitary, and cortisol from the adrenals. Cortisol increases maternal inflammation, indexed by C-Reactive Protein (CRP) from the liver and Epstein Barr Virus antibodies (EBV) which serve as a marker of innate immune function. The placenta also releases CRH (abbreviated as pCRH to differentiate from maternal CRH) into maternal and fetal circulation during pregnancy. Maternal cortisol and pCRH interact during pregnancy, though their relationship is not well-described (Sandman et al., 2006). While maternal CRH is not detectable in peripheral circulation, pCRH is measurable in maternal blood during pregnancy, and elevated pCRH in late pregnancy has been found to predict increased risk of early delivery and preterm birth (Smith and Nicholson, 2007; Smith et al., 2009). Given what is known about the role of these ligands with respect to maternal stress and pregnancy risk, we expect that an optimized measure of stress will be able to predict levels of ACTH, pCRH, and CRP and EBV in maternal blood. Further, as maternal stress is believed to play a role in racial disparities in pregnancy and birth outcomes (Kramer and Hogue, 2009; Lu and Chen, 2004; Lu and Halfon, 2003; Osypuk and Acevedo-Garcia, 2008), an optimized measure of stress can identify group differences in self-reported stress that may be relevant for risk of adverse birth events (Borders et al., 2010; Coussons-Read et al., 2012; Lockwood, 1999; Wadhwa et al., 2001; Wadhwa et al., 1998).