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Conceptualization, measurement, and effects of pregnancy-specific stress: review of research using the original and revised Prenatal Distress Questionnaire

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Abstract Pregnancy-specific stress (PSS) arises from the numerous changes that women experience during pregnancy and from their concerns about childbirth and the health of their offspring. Prolonged or elevated maternal stress heightens risk for poor fetal, infant, and child outcomes. The Prenatal Distress Questionnaire (PDQ) and its expanded successor, the revised Prenatal Distress Questionnaire (NuPDQ), were developed to assess PSS, but their psychometric properties and findings are not well-documented. We reviewed research using the PDQ (n = 45) or NuPDQ (n = 37). Results establish that PSS as measured by these instruments is common in pregnancy; PSS is associated with sociodemographic and obstetric characteristics, perceptions of pregnancy, health behaviors, maternal health, and birth outcomes. The NuPDQ is an especially appropriate tool to assess PSS, with demonstrated reliability and convergent, concurrent, and predictive validity. The ability to assess PSS in a reliable and valid manner is critical to advance research and improve maternal and child health.

Keywords Pregnancy · Stress · Women's health · Birth outcomes · Reliability · Validity

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Introduction

Pregnancy can be a stressful experience for women due to its impact on their physical state, identity, and interpersonal relationships, and because pregnant women may be concerned about childbirth, their child's health, and impending parenthood (Guardino & Dunkel Schetter, 2014; Lobel, Hamilton, et al., 2008; Misra et al., 2001). The stress of pregnancy may be exacerbated by co-occurring strains in women's lives, such as those associated with work or family roles. A large body of research establishes that elevated stress during pregnancy can impair fetal development and increase risk of adverse birth outcomes including low birth weight, preterm delivery, or unplanned cesarean delivery [see reviews by Coussons-Read (2013), Lobel and Dunkel Schetter (2016)]. High prenatal stress also increases the likelihood of poor offspring outcomes in infancy, childhood, and adulthood (e.g., Dunkel Schetter & Glynn, 2010; Heaman et al., 2013; Stein et al., 2014). Prenatal stress produces these effects through neuroendocrine, immune, cardiovascular, metabolic, and behavioral pathways (Dunkel Schetter, 2011; Lobel & Dunkel Schetter, 2016). Given the potentially serious consequences of prenatal stress, the ability to assess this variable in a reliable and valid manner is critical to facilitate rigorous research and to inform interventions. Therefore, we evaluated a widely-used instrument that assesses this construct, the Prenatal Distress Questionnaire (PDQ; Yali & Lobel, 1999), and its successor, the revised Prenatal Distress Questionnaire (NuPDQ; Lobel, Cannella, et al., 2008). We describe the magnitude of stress that pregnant women experience as measured by these instruments, identify maternal characteristics and behaviors associated with prenatal stress, and summarize existing evidence examining the association of prenatal stress as measured by the

PDQ or NuPDQ with adverse maternal health and birth outcomes.

Conceptualizing and measuring prenatal stress

Some prior research has operationally defined prenatal stress as the number of major life events or daily hassles that occur during pregnancy (e.g., Jesse et al., 2003; Khashan et al., 2009). Such operational definitions are insufficient because they fail to consider perceptions of or responses to these occurrences that contribute to their impact on health (Hogue et al., 2001; Lobel, 1994). Other studies of prenatal stress have defined it by focusing on women's emotions, particularly anxiety (Littleton et al., 2007), without attention to what is eliciting these emotions. This definition may therefore be an indicator of individual tendencies rather than of stress. Furthermore, many prior studies—including those defining stress exclusively as occurrences or as emotions—have examined general or non-specific stress, without assessing stress that women experience because of pregnancy itself. Yet there is evidence that pregnant women experience stress specific to their physical symptoms, bodily changes, the health of the fetus, and their anticipation of childbirth and caring for a newborn (Alderdice et al., 2012; Lobel, 1998; Lynn et al., 2011). Failure to assess pregnancy-specific stress (PSS) may therefore result in inaccurate estimates of the magnitude of stress that pregnant women are experiencing and in turn, underestimate the extent to which prenatal stress affects outcomes.

Alderdice and colleagues (2012) evaluated existing research and concluded that while PSS (also labeled pregnancy-specific distress or pregnancy anxiety) tends to co-occur with general stress, the constructs are distinct, and PSS exhibits strong independent prediction of birth outcomes. There is some evidence that PSS may be a more powerful predictor of outcomes than general stress (Lobel, Cannella, et al., 2008). For example, Roesch et al. (2004) found that pregnancy anxiety predicted earlier birth, but general state anxiety, general perceived stress, and life events did not. DiPietro and colleagues (2002) found that fetal heart rate variability in late pregnancy and fetal movement in pregnancy were associated with higher scores on their measure of pregnancy-specific hassles but not with general stress. PSS may be a more deleterious type of stress because it triggers greater physiological arousal than general stress (DiPietro et al., 2002, 2004; Huizink et al., 2004) and women may lack experience coping with this type of stress, especially if they are pregnant for the first time (Lobel & Dunkel Schetter, 2016). Furthermore, PSS may be assessed more reliably compared to general stress. Most PSS measures include explicit references to pregnancy, birth, and parenting that can improve accuracy of recall and reporting.

The Prenatal Distress Questionnaire

Alderdice et al. (2012) evaluated 15 PSS instruments with varying item content and response scales, concluding that many have methodological or conceptual weaknesses or both, including poor internal consistency, lack of predictive validity, or use of conceptually inappropriate items. One of the instruments that Alderdice et al. cited as most promising is the Prenatal Distress Questionnaire (PDQ; Yali & Lobel, 1999), which has been widely-used to assess PSS. The PDQ is a 12-item instrument that was originally developed based on descriptive research and structured interviews with women during mid-pregnancy (approximately 20 weeks). This instrument is grounded in a conceptualization of prenatal stress that includes pregnancy-specific conditions and women's appraisals or responses to these. Sample items include "body changes bother me", "I worry about having an unhealthy baby", and "physical symptoms of pregnancy such as nausea, vomiting, swollen feet, or backaches irritate me". Responses are on a five-point Likert scale ranging from 0 (not at all) to 4 (extremely). An early study using the PDQ among medically high-risk women in mid-pregnancy established that the PDQ was sensitive to individual differences in PSS, with participants' scores ranging from 3 to 47 out of the 0–48 range possible (M = 14.9, SD = 7.2; Yali & Lobel, 1999). The average response in that study corresponded to feeling "a little" concerned or worried about pregnancy-related issues. Subsequent studies have administered the PDQ at different time points during the prenatal period (e.g., Dukal et al., 2015; Haselbeck et al., 2017; Koletzko et al., 2015), although the instrument was originally developed to assess stress specific to mid-pregnancy only.

The PDQ was subsequently expanded to enable its use across pregnancy in recognition that women tend to be distressed by different things in early pregnancy (e.g., nausea and vomiting) than they do as pregnancy progresses (e.g., childbirth). The expanded 17-item instrument was named the revised Prenatal Distress Questionnaire, or NuPDQ (pronounced "New-PDQ"). Initially, the NuPDQ had three forms for administration in early, mid-, and late pregnancy (as used in Lobel, Cannella, et al., 2008; Yali & Lobel, 2002). This version of the instrument included nine core items representing concerns of pregnant women likely to arise at any time point in pregnancy and additional items that were added in mid- (3 items), and late (5 items) pregnancy to assess issues that become more relevant as pregnancy progresses (e.g., concerns about caring for a newborn). The response scale for the NuPDQ was also reduced for ease and speed of administration. Respondents

indicate the extent to which they are feeling "bothered, upset, or worried" on a scale ranging from 0 (not at all) to 2 (very much). Because the different item composition of the instrument at early, mid-, and late pregnancy precluded comparisons across these timepoints, the NuPDQ was subsequently modified to include all 17 items regardless of when the instrument is administered in pregnancy. This version has since become the most widely-used.

The present study

As the PDQ and NuPDQ have become prominent, commonly-used instruments to assess PSS, there is a need for comprehensive review of what has been learned with these instruments and for an analysis of their reliability and validity. We analyzed studies using the PDQ or NuPDQ. We first describe the types of studies in which the instruments have been used. Then we summarize (1) levels of PSS from studies using these instruments, including cross-study comparisons; (2) stability or change in PSS across pregnancy; and (3) the extent to which PSS scores within individual studies are associated with women's sociodemographic characteristics (e.g., age, parity, education), obstetric conditions or health, and women's perceptions of pregnancy.

In addition, we summarize evidence reflecting the reliability and validity of the instruments. Internal consistency is the most appropriate type of reliability for the PDQ and NuPDQ as opposed, for example, to interrater reliability, because there is not an additional rater, or to test–retest reliability, because repeated assessments of PSS have substantive rather than methodological interpretation. Internal consistency is quantified by Cronbach's alpha, for which a coefficient of 0.70 or greater is considered satisfactory (Terwee et al., 2007). We also examined several types of validity that are pertinent to evaluate the Nu/PDQ: convergent validity, concurrent validity, and predictive validity (Mokkink et al., 2010). *Convergent* validity is the degree to which similar constructs or indicators of distress such as state anxiety or depressed mood are correlated with Nu/PDQ scores (Souza et al., 2017). *Concurrent* validity can be demonstrated by examining associations with variables expected to correlate with distress during pregnancy (Souza et al., 2017). We evaluated four categories of such variables: (1) traits or individual characteristics that have been shown in past research with various populations to correlate with greater (e.g., trait anxiety) or lower (e.g., optimism) distress; (2) perceptions (e.g., ambivalence) or conditions (e.g., relationship quality) likely to influence pregnant women's distress; (3) ways of coping that have been shown in other populations to correlate with distress positively (e.g., avoidance) or inversely (e.g., positive appraisal); and (4) health behaviors that are postulated to be practiced more (e.g., substance use) or less (e.g., physical activity) frequently when pregnant women experience stress. Finally, we examined the *predictive validity* of the Nu/PDQ (Souza et al., 2017), that is, the ability of scores on these instruments to predict birth outcomes and maternal or offspring mental and physical health following birth.

Methods

Search strategy

The first author and a trained research assistant conducted a forward reference search using Google Scholar, PsycINFO, PubMed, Scopus, and Web of Science to locate articles that cited PDQ and NuPDQ publications. The reference lists of all identified articles were also reviewed. Articles were included if they were peer-reviewed and written in English. Dissertations were excluded. The initial search was conducted in January 2017, with a final update of the search in July 2018. Two articles that were under publication review in July 2018 but have since been published were also included. The study search and selection process for the PDQ and the NuPDQ are displayed in Fig. 1. A total of 45 articles using the PDQ and 37 articles using the NuPDQ were coded.

Data extraction

Data were extracted using a template which included the following categories: year of publication; country/city; study design (e.g., cross-sectional, longitudinal, randomized controlled trial); sample characteristics including sample size, health (e.g., healthy/low-risk, high-risk), gestational age, ethnicity/race, income, education, age, relationship status, parity, and gestational age(s) at time of assessment; and mean and standard deviation of the total PDQ/NuPDQ score or of items at each measurement time point. In addition, general characteristics of the PDQ/NuPDQ were extracted, including version used, language, and method of translation. If reported, internal consistency, and indicators of convergent, concurrent, and predictive validity as defined above were extracted. Data extraction was performed independently by three trained research assistants. Excellent inter-rater reliability was achieved, with 93% agreement across a sample of 25 articles. Differences were discussed with the first author until consensus was reached.

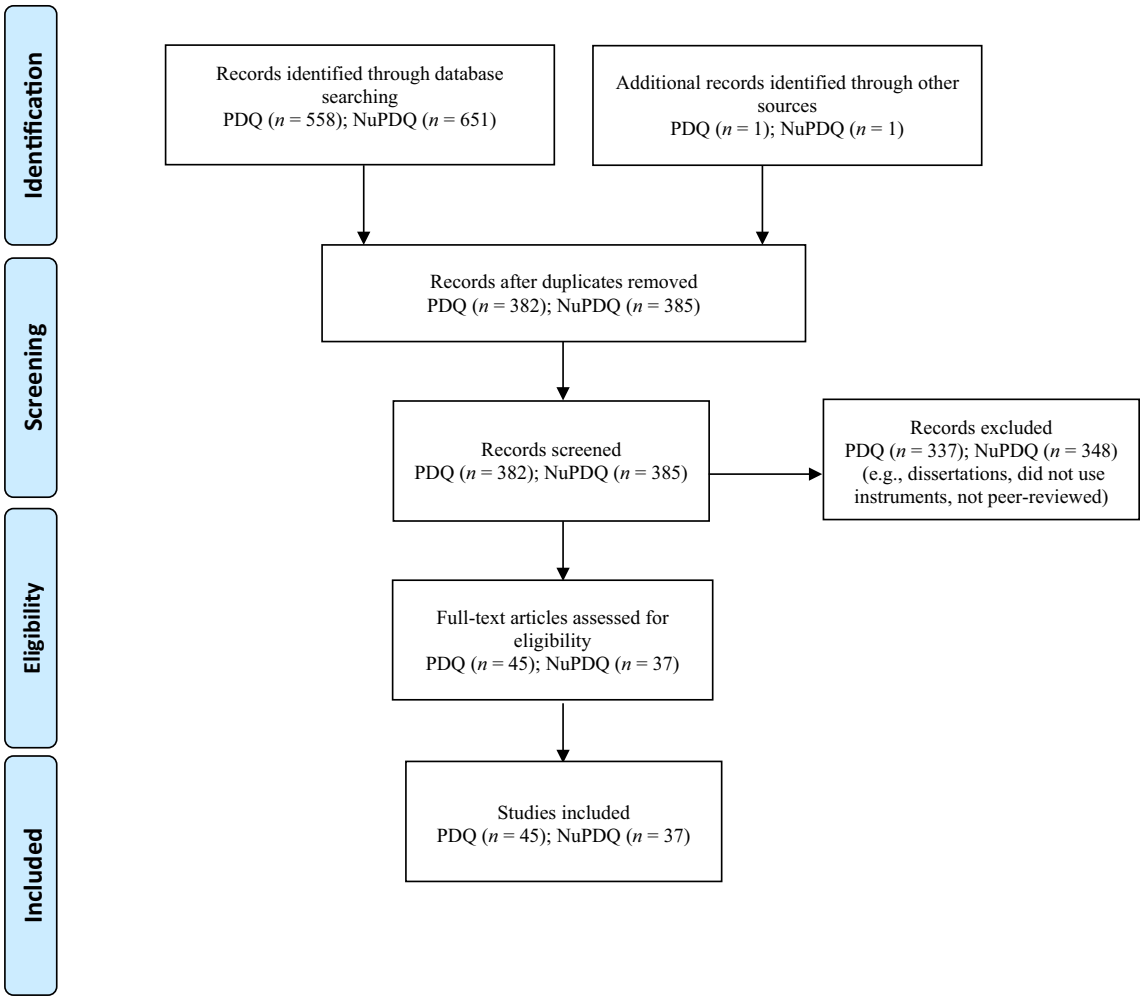

Fig. 1 PRISMA flow diagram showing the study selection process

Results

A summary of the information reported by each study appears in Table 1.

Study characteristics

The PDQ has been translated into German, Spanish, Chinese, and Farsi and administered to women in the United States, United Kingdom, Iran, Switzerland, Spain, Hong Kong, Germany, and other German-speaking countries in Central Europe (Bittner et al., 2014; Caparros-Gonzalez et al., 2017; Chan, 2014; Faramarzi et al., 2015). Sample sizes range from 16 to 1010. The PDQ has been administered as a self-report measure in all but one study (Send et al., 2017).

The NuPDQ has been translated into Spanish, Turkish, and Korean (Barcelona de Mendoza et al., 2015; Kim & Chung, 2017; Yuksel et al., 2013). Studies using the NuPDQ have been conducted in a number of locales, predominantly in the United States, but also in studies conducted in Australia, New Zealand, Korea, and Turkey. Sample sizes range from 56 to 1047. The NuPDQ has been administered as a self-report instrument (n = 25) and in interview format (n = 12). A majority of studies administered the full 17-item version of the NuPDQ. A small number of studies used the earlier version, which, as explained above, had three forms for administration in early, mid-, and late pregnancy (e.g., Coussons-Read et al., 2012; Hamilton & Lobel, 2008; Woods-Giscombé et al., 2010).

Almost half of published studies (n = 17) using the NuPDQ administered it at multiple timepoints in pregnancy, including three studies that administered the instrument in all three trimesters (Christian et al., 2012; Gillespie et al., 2018; Mitchell et al., 2017).

Both the PDQ and NuPDQ have been administered to women of various obstetric risk, parity, race/ethnicity,

Table 1 Information provided by studies reviewed

Authors (year)	M ± SD: total or items	Reliability: Cronbach's alpha	Validity		
			Convergent validity	Concurrent validity	Predictive validity
PDQ, n = 45					
Alderdice and Lynn (2011)	✔	✔	X	X	X
Alderdice et al. (2013)	X	X	X	X	X
Asghari et al. (2016)	✔	X	X	X	X
Bittner et al. (2014)	X	X	X	X	X
Bolten et al. (2011)	✔	X	X	X	X
Borders et al. (2017)	X	X	X	X	X
Caparros-Gonzalez et al. (2017)	✔	✔	X	X	✔
Caparros-Gonzalez et al. (2019)	✔	✔	✔	✔	X
Chan (2014)	X	X	X	X	X
Dias and Lobel (1997)	✔	✔	X	✔	X
Draffin et al. (2017)	X	X	X	X	X
Dukal et al. (2015)	X	X	X	X	X
Faramarzi et al. (2015)	✔	X	X	X	X
Faramarzi and Pasha (2018)	X	✔	✔	X	X
Gennaro et al. (2008)	✔	✔	✔	X	X
Haghparast et al. (2016)	✔	X	X	X	X
Hasanjanzadeh and Faramarzi (2017)	✔	X	X	X	X
Haselbeck et al. (2017)	X	X	✔	X	X
Heery et al. (2014)	X	X	X	X	X
Heery et al. (2016)	X	X	X	X	X
Koletzko et al. (2015)	✔	✔	✔	✔	X
Levine et al. (2017)	✔	X	X	X	✔
Lobel et al. (2000)	✔	✔	✔	✔	X
Lynn et al. (2011)	✔	X	X	X	X
Lynn et al. (2013)	✔	✔	X	X	X
Matvienko-Sikar and Dockray (2017)	✔	✔	X	X	X
McCormack et al. (2011)	✔	X	X	X	X
Monk et al. (2016)	✔	X	X	X	X
Moog et al. (2017)	✔	X	X	X	X
Omidvar et al. (2018)	✔	✔	✔	✔	X
Pluess et al. (2010)	✔	✔	✔	✔	X
Richter et al. (2012)	✔	X	X	X	X
Rieger et al. (2004)	X	X	X	X	X
Romero-Gonzalez et al. (2018)	✔	X	X	X	✔
Ross et al. (2017)	X	✔	X	✔	X
Ruhstaller et al. (2017)	X	X	X	X	X
Schoch-Ruppen et al. (2018)	X	✔	X	✔	X
Schredl et al. (2016)	✔	X	X	✔	X
Send et al. (2017)	X	X	X	X	X
Simon et al. (2016)	✔	✔	X	X	X
Singh et al. (2017)	✔	X	X	✔	X
Talley et al. (2006)	✔	X	X	X	X
White et al. (2008)	X	X	X	X	X
Williams and Oravecz (2016)	X	X	X	X	X
Yali and Lobel (1999)	✔	✔	✔	✔	X

Table 1 continued

Authors (year)	M ± SD: total or items	Reliability: Cronbach's alpha	Validity		
			Convergent validity	Concurrent validity	Predictive validity
NuPDQ, *n* = 37					
Auerbach et al. (2014)	✔	✔	X	✔	X
Auerbach et al. (2017)	X	✔	X	✔	X
Barcelona de Mendoza et al. (2015)	X	✔	X	X	X
Barcelona de Mendoza et al. (2016)	X	✔	X	X	X
Blair et al. (2015)	✔	X	X	✔	X
Cannella et al. (2013)	✔	✔	X	✔	X
Christian et al. (2012)	✔	X	X	X	X
Christian et al. (2013)	X	X	✔	✔	X
Cole-Lewis et al. (2014)	✔	✔	X	X	✔
Coussons-Read et al. (2012)	✔	X	✔	✔	X
Earnshaw et al. (2013)	✔	✔	✔	✔	X
Giarratano et al. (2015)	✔	X	X	X	X
Gillespie et al. (2018)	✔	X	✔	X	X
Hamilton and Lobel (2008)	✔	✔	✔	✔	X
Harville et al. (2015)	X	X	X	X	X
Heberlein et al. (2015)	✔	✔	X	X	X
Hux et al. (2017)	✔	X	X	X	X
Ibrahim et al. (2019)	✔	✔	✔	✔	✔
Ickovics et al. (2007)	✔	X	X	X	X
Kennedy et al. (2011)	X	✔	X	X	X
Kim and Chung (2017)	X	✔	✔	X	X
Lobel, Cannella, et al. (2008) and Lobel, Hamilton, et al. (2008)	✔	✔	✔	✔	✔
Magriples et al. (2008)	✔	✔	X	X	X
Magriples et al. (2013)	✔	X	X	X	X
Magriples et al. (2015)	X	✔	X	X	✔
Mitchell and Christian (2017)	X	X	✔	X	X
Mitchell et al. (2017)	X	X	X	X	X
Okun et al. (2013)	X	X	X	X	X
Rosenthal et al. (2018)	X	✔	✔	✔	✔
Rosenthal and Lobel (2018)	✔	✔	X	X	X
Saunders et al. (2006)	X	X	X	X	✔
Staneva et al. (2016)	✔	✔	✔	✔	X
Staneva et al. (2017)	✔	✔	✔	✔	X
Walsh et al. (2016)	X	X	X	X	X
Woods-Giscombé et al. (2010)	✔	✔	✔	✔	X
Yali and Lobel (2002)	X	✔	X	X	X
Yuksel et al. (2013)	✔	✔	X	✔	X

✔ = provided by study; X = not provided

education, income, relationship status, and age (although rarely to adolescents). Some studies have used the NuPDQ to examine PSS in a specific context, such as women exposed to a natural disaster (Harville et al., 2015), living in a military setting (Kennedy et al., 2011), and/or receiving group prenatal care (Ickovics et al., 2007; Kennedy et al., 2011; Magriples et al., 2015).

Levels and correlates of stress

The Grand Mean calculated from the 25 studies that report a mean total PDQ score is 16.21 (out of 48 possible points), *SD* = 6.22, corresponding to an item response between "a little" and "moderately" on average. Few studies report a mean item score. Exceptions include Pluess and colleagues (2010), who reported an item mean of 1.23, and Koletzko et al. (2015), who reported an item mean of 2.23 on the 5-point Likert scale (0 = "not at all worried", 1 = "a little", 2 = "moderately", 3 = "very much", 4 = "extremely worried"). Monk et al. (2016) used a 5-point response scale ranging from 1 = "not at all true" to 5 = "very true" and reported an item mean of 4.00 in their predominantly Hispanic/Latina, healthy, low-risk sample.

Means for the total NuPDQ score are more frequently reported than item means, although a considerable number of studies (n = 15) report neither. The Grand Mean of the total NuPDQ calculated across studies is 11.92 (out of 34 possible points), *SD* = 6.52, corresponding to an item response close to the equivalent of "somewhat" on the 3-point response scale (0 = "not at all", 1 = "somewhat", and 2 = "very much"). Similarly, item mean scores range from 0.38 (Hux et al., 2017) to 0.83 (Coussons-Read et al., 2012). Hence, most women in these studies endorsed items with responses of "not at all" or "somewhat". Rosenthal and Lobel (2018) used the 9-item early version of the NuPDQ and the full 17-item version, respectively, in two studies of racially and ethnically diverse women. Mean item responses on both of these versions were approximately 1.9 on a 4-point response scale from 1 = "not at all" to 4 "very much".

Comparisons of studies conducted in different countries suggest some differences by geographic region. Studies administering the PDQ or NuPDQ to women in Iran (e.g., Asghari et al., 2016; Faramarzi et al., 2015) or the United States (e.g., Simon et al., 2016; Talley et al., 2006) report the highest levels of PSS. Studies conducted with pregnant women in Germany (Bolten et al., 2011; Richter et al., 2012) or Spain (Caparros-Gonzalez et al., 2017; Romero-Gonzalez et al., 2018) using the PDQ and studies using the NuPDQ conducted in Australia, New Zealand (Staneva et al., 2016, 2017), and Turkey (Yuksel et al., 2013) have reported lower levels of PSS. There is a mixed pattern of findings from studies conducted in the United Kingdom with some reporting high levels of PSS (Matvienko-Sikar & Dockray, 2017; McCormack et al., 2011) and others reporting low levels (Levine et al., 2017; Lynn et al., 2011, 2013). Each of these studies administered the PDQ.

In studies administering the PDQ, PSS has been shown to be higher in studies of women with specific medical conditions including hyperemesis gravidarum, spontaneous abortion history, and pre-eclampsia (Asghari et al., 2016; Haghparast et al., 2016; McCormack et al., 2011). Obstetric conditions associated with higher PSS as measured by the NuPDQ include excessive pelvic pain (Staneva et al., 2016), recent hospital admission (Staneva et al., 2016), serious infection (Staneva et al., 2016), and higher systolic blood pressure (Magriples et al., 2013). Women with a prior history of medically-indicated termination (Staneva et al., 2016) or previous diagnosis of anxiety or depression (Staneva et al., 2016) also exhibit higher PSS as measured by the NuPDQ.

Comparisons across studies also implicate participant characteristics that are associated with PSS. Studies of African–American/Black women (Simon et al., 2016) and pregnant women experiencing interpersonal violence currently or within the past year (Talley et al., 2006) have reported high mean PDQ scores, ranging from 20.4 to 26.25. Studies of unpartnered women and of women with lower socioeconomic status (SES) also report higher PSS as measured by the NuPDQ (Christian et al., 2013; Earnshaw et al., 2013; Giarratano et al., 2015; Magriples et al., 2013). Several American samples with high mean NuPDQ scores (M's= 11.64–15.7) were comprised of women of color. For example, Ickovics et al. (2007) administered the NuPDQ in a study of predominantly African–American/Black women comparing those who received group or individual prenatal care. Women in both conditions had considerably higher NuPDQ scores (group prenatal care: M = 15.2, *SD* = 7.1; individual care: M = 13.7, *SD* = 7.3) compared to European or White women in other studies.

Few studies administering the PDQ report whether characteristics of their participants are associated with PSS. One exception is a study conducted by Schoch-Ruppen et al. (2018), who reported that PDQ scores were significantly higher among study participants who were young, nulliparous, lacked a college education, were unmarried, or had an unplanned pregnancy compared to their counterparts. Of these maternal characteristics, young age was the strongest correlate of PSS ($r = -0.272$, $p < 0.001$). Similarly, within individual studies administering the NuPDQ, maternal characteristics found to be associated with greater PSS include younger age (Auerbach et al., 2014, 2017; Rosenthal et al., 2018; Rosenthal & Lobel, 2018); African–American/Black and/or Hispanic/Latina race and ethnicity (compared to White/European; Rosenthal & Lobel, 2018); primiparity (Hamilton & Lobel, 2008; Rosenthal et al., 2018; Woods-Giscombé et al., 2010); unplanned pregnancy (Staneva et al., 2016); and indicators of lower SES including lower household income (Auerbach et al., 2014, 2017), food insecurity (Rosenthal et al., 2018), and less education (Rosenthal & Lobel, 2018; Staneva et al., 2016).

Stability and change in stress

Fourteen studies administered the PDQ at multiple time points in pregnancy, although the specific timing of administration differs across studies and is not always reported, complicating synthesis of these findings. Most studies employing repeated measures report one of two patterns: either stability in PSS or declines over the course of pregnancy. For example, two studies that administered the PDQ multiple times throughout the third trimester observed a decrease in scores (Gennaro et al., 2008; Levine et al., 2017). McCormack et al. (2011) reported that PSS as measured by the PDQ decreased from early pregnancy (7 to 16 weeks gestation) to the third trimester for women without hyperemesis gravidarum; however, women with hyperemesis gravidarum exhibited more persistent and greater distress. Two additional studies have described a "U" shaped pattern: Romero-Gonzalez et al. (2018) found that PSS decreased from the first to the second trimester but rebounded during late pregnancy; Caparros-Gonzalez et al. (2017) reported the same pattern, but for depressed study participants only.

Eight longitudinal studies utilizing the NuPDQ have examined changes in PSS across pregnancy. These studies found that PSS as measured by the NuPDQ decreased from the second to the third trimester [Cole-Lewis et al., 2014; Coussons-Read et al., 2012; Gillespie et al., 2018 (for multiparous women only); Hamilton & Lobel, 2008; Ibrahim et al., 2019; Lobel, Cannella, et al., 2008; Staneva et al., 2017; Woods-Giscombé et al., 2010]. For example, Staneva et al. (2017) studied 285 White women from Australia and New Zealand. NuPDQ scores in this study were generally low and decreased from 9.04 (SD = 4.88) in the second trimester to 5.52 (SD = 4.85) in the third trimester. A majority of these women were married or cohabiting, multiparous, had a college or postgraduate degree, and had planned their pregnancy.

Internal consistency

Sixteen studies report internal consistency for the PDQ. Cronbach's alpha coefficients range from 0.71 (Caparros-Gonzalez et al., 2017) to 0.93 (Faramarzi & Pasha, 2018), with most coefficients around 0.80.

Twenty-two studies report internal consistency for the NuPDQ, with alphas for the full 17-item version ranging from 0.79 (Staneva et al., 2016, 2017) to 0.88 (Auerbach et al., 2014; Cannella et al., 2013; Magriples et al., 2008; Rosenthal & Lobel, 2018). By comparison, Lobel, Cannella, et al. (2008) reported an alpha of 0.59 using the early, 9-item version of the NuPDQ, bolstering the superior reliability of the longer version of this instrument.

Factor analyses were conducted in three studies that administered the PDQ to Irish (Alderdice & Lynn, 2011; Alderdice et al., 2013) or Spanish (Caparros-Gonzalez et al., 2019) women. In the first of these studies, Alderdice and Lynn conducted exploratory factor analysis with oblique rotation, resulting in three correlated factors (r's 0.30 to 0.60) that corresponded to concerns about birth and the baby, about physical symptoms and body image, and about emotions and relationships. In a subsequent study, Alderdice et al. conducted confirmatory factor analysis, comparing a unidimensional measurement model to a two-factor and three-factor model. Of these, the three-factor model offered the best fit to data, replicating the factor structure reported previously by Alderdice and Lynn. Correlations among the factors were not reported.

Caparros-Gonzalez et al. (2019) administered a Spanish translation of the PDQ to pregnant women in southern Spain. These authors conducted exploratory factor analysis using half of their sample, followed by confirmatory factor analysis with the remaining half. Their analyses replicated the three-factor structure identified in the two Irish samples, with minor differences in model specifications. The three factors were highly intercorrelated (r's = 0.35 to 0.71). Caparros-Gonzaelez et al. compared the three-factor structure to a unidimensional factor structure of the PDQ and found these models to have equivalent fit.

Convergent validity

Numerous studies report associations with other types of emotional distress that would be expected to correlate with PSS and hence offer evidence of the convergent validity of the PDQ or NuPDQ.

For studies administering the PDQ, correlations are r = 0.55 and 0.29 with scores on the State form of the State-Trait Anxiety Inventory (STAI) (Lobel et al., 2000; Omidvar et al., 2018); r's range from 0.32 to 0.56 with scores on the Perceived Stress Scale (Caparros-Gonzalez et al., 2019; Gennaro et al., 2008; Koletzko et al., 2015; Lobel et al., 2000; Pluess et al., 2010); r's range from 0.27 to 0.50 with SCL-90-R subscales (Caparros-Gonzalez et al., 2019); r = 0.20 with scores on the Beck Depression Inventory-II (Omidvar et al., 2018); and r's = 0.33 to 0.44 with scores derived from prenatal administration of the Edinburgh Postnatal Depression Scale (EPDS; Koletzko et al., 2015; Pluess et al., 2010). Additionally, Yali and Lobel (1999) reported a strong correlation (r = 0.53) of the PDQ with an aggregate score derived from the Perceived

Stress Scale and STAI; Monk et al. (2016) reported that correlations of the PDQ with the Perceived Stress Scale, Hamilton Depression Rating Scale, and Hamilton Anxiety Rating Scale were all greater than $r = 0.26$ (individual correlations with each scale were not reported).

The NuPDQ is correlated with scores on similar instruments, including the Perceived Stress Scale (Christian et al., 2013; Lobel, Cannella, et al., 2008; Mitchell & Christian, 2017; r's= 0.45 to 0.54), the Center for Epidemiological Studies Depression Scale (CES-D) (Christian et al., 2013; Earnshaw et al., 2013; Gillespie et al., 2018; Mitchell & Christian, 2017; r's = 0.28 to 0.54); the state anxiety subscale of the State-Trait Personality Inventory (STPI; Hamilton & Lobel, 2008; Ibrahim et al., 2019; Lobel, Cannella, et al., 2008; Woods-Giscombé et al., 2010; r's = 0.36 to 0.57); and the EPDS administered during pregnancy (Staneva et al., 2016, 2017; r's = 0.36 to 0.49). Significant correlations with maternal cortisol levels in early and mid-pregnancy have also been reported (Gillespie et al., 2018; $r = 0.20$).

Concurrent validity

Several traits or stable individual characteristics have been postulated to elevate or protect against PSS. Accordingly, scores on the PDQ have been shown to correlate in expected directions with trait anxiety (r's = 0.31 and 0.40; Pluess et al., 2010), self-actualization ($r = -0.19$; Omidvar et al., 2018), and satisfaction with life ($r = -0.26$; Koletzko et al., 2015), and more strongly, with optimism ($r = -0.36$; Lobel et al., 2000), self-esteem ($r = -0.37$; Dias & Lobel, 1997), and coping self-efficacy ($r = -0.45$; Koletzko et al., 2015). PSS as measured by the NuPDQ is also inversely correlated with favorable individual traits including optimism (Auerbach et al., 2014; Cannella et al., 2013; Hamilton & Lobel, 2008; r's = -0.29 to -0.45), self-esteem (Auerbach et al., 2014; $r = -0.45$), and sense of coherence (Staneva et al., 2016, 2017; r's = -0.50 to -0.54).

A second indicator of concurrent validity is evidence that PSS is correlated with negative perceptions or stressful life conditions. Koletzko et al. (2015) reported that ambivalence about one's pregnancy was a strong correlate of PDQ scores, $r = 0.44$. PDQ scores are also correlated with dissatisfaction in one's marriage or primary relationship (Omidvar et al., 2018; Ross et al., 2017; r's = 0.12 and 0.29, respectively), with nightmare frequency ($r = 0.30$; Schredl et al., 2016), use of words expressing negative emotions (e.g., hate, hurt; $r = 0.23$) or anxiety (e.g., nervous, tense; $r = 0.19$; Schoch-Ruppen et al., 2018), and with the number of negative life changes reported by study participants at two timepoints during pregnancy (Pluess et al., 2010; r's = 0.32 and 0.37).

Similarly, NuPDQ scores have been shown to correlate with perceived discrimination (Earnshaw et al., 2013; Rosenthal et al., 2018; Rosenthal & Lobel, 2018; r's= 0.26 to 0.35), racism (Rosenthal & Lobel, 2018; $r = 0.40$), sexism (Rosenthal & Lobel, 2018; $r = 0.38$), and stereotype-related gendered racism (Rosenthal & Lobel, 2018; r's = 0.37 and 0.55) in women of color. Two studies found higher PSS as measured by the NuPDQ among women who perceive less control over their pregnancy (Auerbach et al., 2014, 2017; r's = -0.19 and -0.34, respectively) and an additional report found that NuPDQ scores are correlated with negative feelings about being pregnant (Rosenthal & Lobel, 2018; r's = 0.20 and 0.24). NuPDQ scores are also higher among women experiencing stress from interpersonal relationships, including those undergoing separation or divorce ($r = 0.15$; Staneva et al., 2016) or arguing with a partner more than usual (Staneva et al., 2016; $r = 0.19$). Barcelona de Mendoza et al. (2015) found that NuPDQ scores differentiated women experiencing various types of intimate partner violence (Barcelona de Mendoza et al., 2015). Conversely, relationship satisfaction (Staneva et al., 2016; $r = -0.14$), better rapport with one's mother (Staneva et al., 2016; $r = -0.18$), and perceived social support (Staneva et al., 2017; $r = -0.27$ and -0.29) are associated with lower PSS as measured by the NuPDQ.

An additional indicator of concurrent validity is the association of coping with PSS as measured by the PDQ or NuPDQ. Few studies have investigated this, but the most consistent finding to emerge from these studies is the strong association of avoidant coping with PDQ or NuPDQ scores. Two studies report a large correlation of PDQ scores with avoidant coping (Koletzko et al., 2015; Yali & Lobel, 1999; r's = 0.66 and 0.63, respectively), a third study reported r's of 0.52 to 0.54 with avoidant coping in a study administering the NuPDQ (Hamilton & Lobel, 2008). A recent study created an aggregate emotional distress variable from NuPDQ and STPI anxiety scores and found that after controlling for mid-pregnancy distress, avoidant coping predicted greater emotional distress in late pregnancy (Ibrahim et al., 2019; $\beta = 0.18$, $R^2 = 0.61$, $p < 0.01$), lending greater confidence about the direction of association between this form of coping and women's distress.

Coping through planning and preparation has also been shown to be correlated with greater PSS as measured by the PDQ ($r = 0.18$; Yali & Lobel, 1999) and by the NuPDQ (Hamilton & Lobel, 2008; Ibrahim et al., 2019; r's = 0.17 to 0.35). One of these studies also reported a moderate correlation between PDQ scores and coping via substance use (Yali & Lobel, 1999; $r = 0.24$).

The only way of coping that has been reported to correlate with lower PSS as measured by the PDQ or NuPDQ is positive appraisal, which involves perceiving stressors as

offering some benefit or means of growth. Yali and Lobel (1999) reported an r of − 0.21 between positive appraisal and PDQ scores. Additionally, Ibrahim et al. (2019) found that positive appraisal predicted lower emotional distress (an aggregate of NuPDQ and state anxiety scores) in late pregnancy after controlling for mid-pregnancy distress ($\beta = -0.15$, $R^2 = 0.60$, $p < 0.01$).

A final indicator of concurrent validity is the association of PSS with health behaviors. PDQ scores are inversely correlated with healthier and more nutritious eating in a variety of studies, with correlations ranging from $r = -0.11$ to -0.23 (Lobel et al., 2000; Omidvar et al., 2018; Singh et al., 2017). Singh and colleagues, for example, examined the nutrient composition of food that study participants consumed, such as vitamin B6 and vitamin C, and found that women with lower PSS as measured by the PDQ consumed more of these nutrients.

Associations of health behaviors with NuPDQ scores appear to be even greater than those with PDQ scores. For example, Auerbach et al. (2017) found that PSS as measured by the NuPDQ was one of the strongest predictors of health behaviors in mid- and late pregnancy, even after controlling for other predictors including age, income, and education. Poor sleep quality (Blair et al., 2015; $r = 0.26$), unhealthy eating, smoking, caffeine consumption, other substance use (Auerbach et al., 2014, 2017; Rosenthal et al., 2018; r's = 0.22 to 0.34), and higher antepartum weight gain (Magriples et al., 2015; r not reported) are correlated with higher NuPDQ scores; NuPDQ scores are also inversely associated with health promoting behaviors including healthy eating, vitamin use, and exercise (Auerbach et al., 2014, 2017; r's = − 0.25 to − 0.41).

Predictive validity

PSS has been shown to predict delivery outcomes (timing and type of delivery) as well as fetal, neonatal, and maternal postpartum outcomes. Saunders et al. (2006) used structural equation modeling to construct a latent factor that included women's NuPDQ score with four other indicators of stress during pregnancy. In a sample of 298 women attempting vaginal childbirth, those with higher prenatal stress as measured by this latent factor were more likely to receive analgesia (intravenous opiates and/or epidural), and in turn, they were more likely to deliver by unplanned surgical delivery (cesarean), even after controlling for medical predictors of analgesia receipt and surgical delivery.

Similarly, two studies find that NuPDQ scores independently predict delivery outcomes, specifically, the timing of delivery (Cole-Lewis et al., 2014; Lobel, Cannella, et al., 2008). In a diverse sample of women, Lobel et al. found that higher NuPDQ scores averaged across pregnancy predicted earlier delivery after controlling for obstetric risk. Similarly, in a study of 920 African–American/Black adolescent and young women, Cole-Lewis et al. found that although NuPDQ scores declined on average from the second to third trimester for the sample as a whole, the decline was significantly smaller for women who delivered preterm.

Two studies have examined associations of PSS with fetal and neonatal variables; both studies used the PDQ. Levine et al. (2017) investigated whether PSS was associated with measures of fetoplacental blood flow and neonatal outcomes in a study of pregnant women carrying a small for gestational age fetus. The authors found, as predicted, that higher PDQ scores were associated with abnormal findings on some measures of fetoplacental blood flow (the pattern of results is too complex to be quantitatively and succinctly summarized here). Unexpectedly, Levine et al. also found that women with high scores on PDQ items related to concerns about physical symptoms and body image were 63.5% less likely to deliver a baby that required admission to the neonatal intensive care unit (an indicator of poor neonatal status). To explain this counter-intuitive finding, the authors speculated that women who were most concerned about their symptoms and body may have practiced more salutary health behaviors, resulting in a more favorable neonatal outcome, although this mechanism was not empirically tested. In contrast, Romero-Gonzalez et al. (2018) found that in a regression model, PDQ scores and Perceived Stress Scale scores in the third trimester together predicted higher newborn cortisol levels (an indicator of stress), accounting for 22% of the variance in this outcome.

Finally, three studies offer evidence of the predictive validity of the PDQ or NuPDQ based on their associations with a diverse set of postpartum variables. Magriples et al. (2015) found that women with moderate and high levels of prenatal distress as measured by the NuPDQ during the second trimester gained the most weight during pregnancy and had retained the most weight assessed 1 year after birth. In a study administering the PDQ to 44 Spanish women during each trimester of pregnancy, Caparros-Gonzalez et al. (2017) reported that women who experienced higher PSS in the third trimester of their pregnancy were more likely to be classified as experiencing postpartum depression based on EPDS scores 2 to 3 weeks following birth ($t = -2.67$, $p < 0.01$). Rosenthal et al. (2018) found that NuPDQ scores across the second and third trimester of pregnancy predicted mothers' assessments of their baby at 6 months and 1 year following birth, including maternal perceptions of inhibition/separation problems and both positive and negative emotionality.

Discussion

A total of 82 articles using the PDQ or NuPDQ were reviewed. Although the instruments have been used most commonly with English-speaking women in the U.S., the number of different translations and locations where they have been used successfully suggests cross-cultural applicability. Even within studies conducted in the U.S., considerable diversity exists in the characteristics of participants, including their obstetric risk status or history, socioeconomic status, and race or ethnicity.

Reliability

Reliability is an important criterion when considering the relation of PSS to other variables, especially variables of great consequence such as maternal and infant birth outcomes. Poor reliability impedes the ability to detect associations, and can therefore produce Type II errors, or concluding that no association exists when in truth, an association does exist. As confirmed by our review, both the PDQ and NuPDQ are internally consistent instruments, with Cronbach's alpha coefficients above the accepted 0.70 criterion (Terwee et al., 2007) in every study using a full version of one of these instruments. Slightly higher coefficients are reported in studies using the 17-item NuPDQ than those using the PDQ as would be expected based on the greater number of items in the former. Thus, the more current and comprehensive NuPDQ appears to be an especially reliable tool to enable measurement of PSS.

Who experiences greatest stress?

It is problematic that many studies using the PDQ or NuPDQ do not report mean levels of PSS. Nevertheless, based on a majority of studies that do report total or item means, the two instruments yield comparable reports of PSS magnitude. Women appear to experience between "a little" to "moderate" PSS on average as assessed by the PDQ and they are "somewhat" distressed based on NuPDQ assessments. There is also evidence that the instruments are sensitive to maternal characteristics and conditions that influence the degree to which a woman experiences PSS. Younger women, those with obstetric complications or at risk because of their medical history, women experiencing ongoing chronic life stressors, women of color, those of lower SES, and women pregnant for the first time or with an unplanned pregnancy have higher levels of PSS (e.g., Asghari et al., 2016; Auerbach et al., 2014, 2017; Rosenthal & Lobel, 2018). Most of this evidence derives from studies using the NuPDQ, as fewer studies using the PDQ report whether characteristics of their participants are associated with PSS. Cross-national comparisons of studies conducted with the NuPDQ are also revealing; many studies reporting lower PSS with this instrument are from countries such as Australia, New Zealand, and Turkey where women have guaranteed access to health services including prenatal, intrapartum, and postpartum care requiring no out-of-pocket payment (World Health Organization, 2016). This suggests that access to and affordability of care may help to alleviate PSS. Concerns about paying for health care and about the quality of one's care are two frequently endorsed items on the NuPDQ (these items do not appear in the PDQ).

An additional question is whether levels of PSS change over the course of pregnancy. This question is best answered with evidence from studies using the NuPDQ, as the PDQ was designed for use during mid-pregnancy only and does not include items that are more relevant in early or late pregnancy, although a few studies have administered the PDQ repeatedly, finding either stability in PSS or a decline over the course of pregnancy (e.g., Gennaro et al., 2008; Levine et al., 2017). Seven studies administering the NuPDQ repeatedly found declines in total scores over pregnancy [Cole-Lewis et al., 2014; Coussons-Read et al., 2012; Gillespie et al., 2018 (only for multiparas); Hamilton & Lobel, 2008; Lobel, Cannella, et al., 2008; Lobel, Hamilton, et al., 2008; Staneva et al., 2017; Woods-Giscombé et al., 2010 (only for women without previous miscarriage)]. However, total scores are not as informative as item or subscale scores for investigating changes in PSS, because some sources of stress are likely to recede as pregnancy advances (e.g., nausea and vomiting, which usually subside by mid-pregnancy), while stress from other sources (e.g., concerns about labor and delivery) may increase. Exploring whether the factor structure of the NuPDQ changes across pregnancy is an additional area for future investigation. If studies identify a multidimensional factor structure of the NuPDQ, examining changes in subscale scores across pregnancy may also be revealing. For example, although stress related to specific physical symptoms might vary across pregnancy as their occurrence changes, the stress associated with experiencing physical symptoms in general might remain constant. Future studies examining changes in endorsement of individual NuPDQ items or in subscale scores across pregnancy will be valuable to examine such predictions.

Validity

The variety of studies reporting correlations of stress and emotional distress variables with scores on the PDQ and NuPDQ offers evidence of the scales' convergent validity. PSS as measured by the PDQ or NuPDQ is correlated with scores on measures of chronic or daily stress, state anxiety,

and depressive symptoms (e.g., Christian et al., 2013; Hamilton & Lobel, 2008). While statistically significant, the correlations are low enough to indicate that PSS is an independent construct. Notably, we did not locate any study that administered the PDQ or NuPDQ in conjunction with another measure of PSS itself. Alderdice et al. (2012) have identified other PSS instruments that could be used for this purpose, although these instruments differ in their composition of items and response scales and some have serious methodological or conceptual limitations.

To evaluate concurrent validity, we examined correlations of PDQ and NuPDQ scores with individual traits, perceptions and life conditions, ways of coping, and health behaviors. For each, we found evidence to substantiate the concurrent validity of PSS measurement by the PDQ or NuPDQ. For example, PSS is correlated positively with trait anxiety and inversely with optimism and self-esteem (Auerbach et al., 2014; Cannella et al., 2013; Dias & Lobel; 1997; Hamilton & Lobel, 2008; Lobel et al., 2000; Omidvar et al., 2018). Such findings corroborate evidence linking these traits to stress in general population studies (e.g., Carver et al., 2010; Greenberg et al., 1992). The association between traits and PSS in the context of pregnancy is also noteworthy because of evidence that women with higher optimism and self-esteem experience healthier birth outcomes (Bödecs et al., 2011; Lobel et al., 2000; Rini et al., 1999). The health benefits of these traits in pregnancy may be attributable to the lower PSS that they engender, although traits such as optimism may be health protective for pregnant women via other mechanisms, as well (Lobel et al., 2000).

PSS as measured by the PDQ or NuPDQ is also associated with unfavorable perceptions of one's pregnancy, such as ambivalence (Koletzko et al., 2015), and with indicators of stressful life conditions, including various forms of discrimination experienced by women of color (Earnshaw et al., 2013; Rosenthal et al., 2018; Rosenthal & Lobel, 2018). Correlations of PSS with interpersonal problems or violence offer additional evidence of concurrent validity; as does evidence of lower PSS among women reporting greater relationship satisfaction or social support.

As to the particular ways that women cope with stress during pregnancy, there has been limited investigation examining whether these are correlated with the magnitude of PSS that women experience. The most consistent finding across existing studies is the association of avoidant coping with greater PSS, mirroring considerable research in other populations suggesting that avoidance is a maladaptive form of coping (Zimmer-Gembeck & Skinner, 2016). Other prenatal coping findings originate from studies of unique samples. Coping through preparation for the baby's arrival, for example, was correlated with greater PSS in a sample of high-risk pregnant women. This way of coping may raise the specter of a poor outcome in women who are at greatest risk for it, and thus elevate PSS (Giurgescu et al., 2006; see review by Guardino & Dunkel Schetter, 2014). Thus far, Ibrahim et al. (2019) appear to be the only investigators to offer evidence linking coping with changes in PSS (as a component of prenatal emotional distress) across pregnancy. Such results promote greater confidence in the direction of association between coping and PSS, but such findings require replication.

The few studies that have investigated associations of prenatal health behaviors with PSS as measured by the PDQ and NuPDQ find that healthier eating, prenatal vitamin use, exercise, and getting enough sleep are inversely correlated with PSS (Auerbach et al., 2014, 2017; Blair et al., 2015), whereas health impairing behaviors including cigarette smoking and skipping meals are moderately, positively correlated with PSS (e.g., Auerbach et al., 2014). Investigating stress-related health behaviors in pregnancy is a critical topic for further study to clarify the mechanisms that explain the impact of PSS on birth outcomes. Although a number of scholars posit that women's behaviors are an important causal pathway, we currently have little evidence to substantiate this. Neuroendocrine, immunological, cardiovascular, and metabolic mechanisms linking PSS to birth outcomes have been relatively better-documented (e.g., Christian, 2012; Coussons-Read, 2012), but these are likely to operate in conjunction with important behaviors such as eating, substance use, sleep, and physical exercise.

A final criterion used to evaluate the measurement of PSS by the PDQ or NuPDQ involves predictive validity, or the ability of scores on these instruments to predict fetal, infant, or maternal outcomes. For several reasons, this type of validity may provide the strongest standard of evidence by which to evaluate a PSS instrument. One reason is that evidence of predictive validity can only be culled from studies employing prospective, longitudinal designs, which eliminate uncertainty about the direction of association. Second, many of the outcomes that are typically examined, such as birth weight, gestational age at birth, maternal weight gain, or infant cortisol levels, are objectively measured, offering robust confirmation of the impact of PSS. Third, birth outcomes have great consequence for the survival and life-long health and well-being of offspring. Low birth weight and preterm birth are leading causes of infant mortality and infant morbidity, and they elevate the likelihood of poor physical and mental health as well as cognitive, emotional, and neurodevelopmental problems that may persist into childhood, adolescence, and adulthood (Brydges et al., 2018; Mürner-Lavanchy & Anderson, 2018; Saigal & Doyle, 2008).

Despite the importance of establishing predictive validity, very few studies have been conducted to examine

whether PSS as measured by the PDQ or NuPDQ predicts physical and mental health outcomes. Greater PSS as measured by the PDQ predicts NICU admission (Levine et al., 2017), postpartum depressive symptoms (Caparros-Gonzalez et al., 2017), and neonatal cortisol levels (Caparros-Gonzalez et al., 2017). Prediction of adverse birth outcomes, defined as earlier/preterm birth or as lower birth weight, has been established only by studies using the NuPDQ. Higher scores on the NuPDQ also predict greater weight gain and weight retention in pregnant and postpartum women, respectively, and in conjunction with other indicators of prenatal stress, NuPDQ scores predict unplanned surgical delivery (Saunders et al., 2006), which is itself associated with poor maternal and infant outcomes under some conditions (Lobel & DeLuca, 2007; Ye et al., 2016).

Limitations and strengths

Although a thorough and comprehensive search was conducted to locate studies for this review, it is limited by the fact that only published research was included. We are aware of several ongoing studies that are using the NuPDQ; thus, we expect that additional findings not yet subjected to peer review will add to the corpus of evidence reviewed here and will expand topics that have received little attention as of yet.

Other limitations are attributable to weaknesses of the studies reviewed themselves. One weakness is that a large number of studies fail to report important characteristics of their sample or details of their methods. Prior pregnancy, for example, which is not consistently reported, is likely to influence the magnitude of PSS that a woman experiences, as changes that are typical in pregnancy may be perceived as less stressful if they are familiar. This is substantiated by the one study which documents that PSS is lower among women who have given birth previously (Woods-Giscombé et al., 2010); additional research indicates that women experience lower PSS as pregnancy progresses (Coussons-Read et al., 2012; Lobel, Cannella, et al., 2008; Staneva et al., 2017). Yet parity, gravidity, and other important obstetric characteristics that may influence PSS such as medical risk status are not consistently reported.

Another detail not reported by many studies is the timing of administration of the PDQ or NuPDQ. This is a serious oversight because there is some evidence that the timing of stress exposure during pregnancy influences birth outcomes (Lobel & Dunkel Schetter, 2016), although findings are inconsistent and much of the evidence is from research examining general, non-specific stress. Some such studies suggest that the first trimester of pregnancy is a particularly vulnerable period (Glynn et al., 2001; Lederman et al., 2004; Torche & Kleinhaus, 2012), whereas other evidence indicates that high stress during the third trimester, especially in comparison to the second trimester, increases the likelihood of adverse outcomes such as preterm birth (Hedegaard et al., 1993). Studies that employ repeated measurement of PSS are needed to answer questions about the magnitude and impact of this type of stress at different times across pregnancy.

Despite these limitations, the present review has a number of strengths. Focusing on studies that use the same or a closely related measure to examine PSS enables meaningful comparisons across investigations, enhancing the validity of conclusions about the magnitude, correlates, and likely impact of PSS. This has not been done previously because prior reviews have evaluated studies using a variety of PSS measures and methodological approaches that cannot be well-summarized or compared, including some measures with unknown reliability (Alderdice et al., 2012). The sheer number of studies included in this review and the fact that the studies are heterogeneous in sample composition also enhance the validity of conclusions reported here.

Future directions and clinical implications

The PDQ and NuPDQ appear to be sound psychometric instruments but of the two, the NuPDQ offers several conceptual and methodological advantages and there is somewhat more evidence for its psychometric properties. The NuPDQ can be used at any timepoint in pregnancy, and is well-suited for repeated assessment, making it a valuable tool for research to resolve existing contradictions about whether women are more likely to experience stress during particular time periods of pregnancy and whether particular patterns of stress across the 40-week period of gestation are more predictive of adverse birth outcomes. Numerous other important questions concerning PSS have yet to be investigated but require valid and reliable measurement: how, for example, do aspects of a woman's employment, health care, and interpersonal relationships elevate or alleviate stress during pregnancy?

A reliable and valid measure of PSS can also be used for clinical purposes, to identify women at high stress who may benefit from additional monitoring, support, or referral to pertinent resources. Although depression screening has become increasingly common in pregnancy (Accortt & Wong, 2017), there has been little effort as of yet to screen women for high stress. Identifying and alleviating PSS is an important goal in its own right but may also improve health and well-being for women and their offspring. This is especially critical for women of color in the US, who have been shown to experience greater stress before, during and after pregnancy compared to White women (Dominguez et al., 2008; Rosenthal & Lobel, 2011). Growing

evidence demonstrates that racial disparities in adverse birth outcomes among American women are attributable in part to the higher levels of stress that African American women experience during pregnancy (Giscombé & Lobel, 2005; Rosenthal & Lobel, 2011, 2018). Existing research suggests that interventions incorporating yoga and meditation may reduce PSS, although studies have been plagued by methodological problems and by difficulties engaging and retaining pregnant women (Mahaffey & Lobel, 2019). Two well-conducted studies of mindfulness meditation found short-term benefits but these did not persist (Guardino et al., 2014; Vieten & Astin, 2008). Such single modality interventions may not be sufficient to alleviate the diverse stressors that affect pregnant women. There is a pressing need to develop effective interventions; these might, for example, combine mind–body techniques with other evidence-based methods that promote coping skills and self-care (Mahaffey & Lobel, 2019).

Conclusions

This review demonstrates that PSS can be identified and quantified in a methodologically robust manner. The stressors and resulting emotional distress that women may experience during pregnancy are not merely uncomfortable and taxing, but also affect their physical and mental health and the health and development of their offspring. The ability to assess PSS reliably and validly is imperative to advance research and enable intervention to effectively protect the health and well-being of women and their children. The NuPDQ appears to be an especially appropriate tool for this vital purpose.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Human and animal rights and Informed consent This article does not contain any studies with human participants or animals performed by either of the authors.

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