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**Stress, Social Support, and Low Birth Weight:
Birth to Twenty Cohort (BT20)**

by
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Abstract:

The role that psychosocial factors play in determining birth weight has been thought to play an analogous role as physical insults during pregnancy. In particular, maternal social support and stress have been studied separately with respect to their association with low birth weight (LBW), with more recent studies examining their interaction. The latter case has found that the level of social support reported by participants can modify the association between perceived levels of stress and LBW status. However, much of the research conducted to study and establish this relationship has mostly taken place within the high income countries (HIC) of Western Europe or the US. The current study takes place in Johannesburg, South Africa in 1990, which is dissimilar to these previous contexts which operated within mostly stable political and social systems. **Objective:** Examine whether an association between stress and LBW exists and if social support is an effect modifier or confounder of this relationship for this study population. **Method:** From the Birth to Twenty birth cohort, 1591 infants had birth weight recorded and their respective mothers self-reported social support and levels of stress in pregnancy, along with their demographic information. Also, information on the infant included sex, gestational age, Apgar score, and Caesarian delivery. **Results:** The adjusted logistic regression between stress and LBW did not find any significant associations (OR 0.90 95% CI 0.64-1.27). Similarly, social support and LBW were not found to be significantly associated (OR 1.09 0.81-1.47). The full model with stress and LBW testing for moderation or confounding by social support was unable to establish social support as an effect modifier or confounder of the relationship between stress and LBW. **Conclusions:** The findings of this study were not able to positively affirm the association between stress and LBW or the moderating effects of social support within this sample population. The lack of significant association may be due to a true lack of association between stress and LBW in this population. However, the lack of precision also maintains the possibility that a relationship may exist between stress and LBW, with or without moderation by social support. Further conclusive studies are needed to definitively establish the association between stress, social support, and LBW with greater precision in a LMIC setting.

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Lower than average birth weight is commonly reported as an adverse pregnancy outcome as it has been found to be a reliable predictor for infant mortality and the later development of unfavorable conditions.^{1,2} Barker first proposed the idea that intrauterine conditions during pregnancy could influence the health of infants, throughout the life course, in his 1989 fetal origins hypothesis, observing the close associations found between low birth weight (LBW) and the risk for developing chronic conditions like coronary heart disease.³ In the US, the systematic collection of birth data through the Collaborative Perinatal Study was the first to empirically establish the increased risks associated with LBW, especially with respect to neurological problems.⁴ Since then, numerous studies of variable scales have been undertaken to establish both the acute and chronic risks associated with LBW for the child, from premature death to high blood pressure.^{5,6} In the face of such mounting evidence, LBW has been recognized by many countries and international organizations as a point of intervention, with the goal to reduce LBW argued to potentially decrease both negative pregnancy and perinatal outcomes, while alleviating the economic burden associated with the management of attributable morbidities.⁷

Despite concerted efforts, however, the prevalence of LBW has been difficult to reduce evenly and remain stagnant in some countries.⁸ For example, despite the increased prenatal resources devoted to preventing LBW in the US, the rate of LBW increased 11.8% between 1980 and 2000 with prevalence increasing from 7.90% in 1990 to 8% in 2014.^{9,10} Racial disparities are also ever-present, with LBW 13% among Black women, 7% among White, and 7% among Hispanics after controlling for differences in socio-economic status, health behaviors, education, and access to prenatal care, emphasizing the additional effect of genetic and cultural differences on LBW risk.^{11,12} In the global context, prevalence of LBW is 15-20% with greater burden on low and middle income countries (LMIC) where LBW prevalence is 16.5% for “less developed” and 18.6% in “least developed” countries.^{13,14} However, despite being much more from the issues related to infant mortality and morbidity, most interventions focused on the reduction of LBW have been based upon research conducted entirely within high income country (HIC) settings. This proves problematic when much of the resources and efforts being devoted to improve LMIC pregnancy and child outcomes are based on observations that have yet to be validated in the appropriate LMIC context.

Furthermore, as efforts in high-income countries have shown, a proportion of LBW can be attributed to indirect factors that go beyond physical care. Though interventions aimed towards the reduction of smoking, alcohol and maternal infections may reduce the risks of LBW significantly, psychosocial factors have also been found to affect birth outcomes.¹⁵ In keeping with these findings, Barker’s hypothesis has been expanded to become the developmental origins of health and disease (DOHaD) approach, which examines the multitudinous means by which various types of environmental cues during the prenatal period could affect the immediate postnatal and later developmental stages of the child.¹⁶

Maternal stress in particular has been posited to affect placental and fetal physiology, with higher levels of reported stress being associated with an increased risk for intrauterine growth restriction (IUGR), preterm birth, and consequent LBW.^{17,18} However, with the exact biological mechanism still under debate, and various pathways ranging from hypothalamic-pituitary-adrenal (HPA) axis dysregulation to uterine imprinting being speculated on, a directly causal or dose-response relationship between maternal stress and negative birth outcomes has been difficult to establish.¹⁹ For example, a literature review of prospective studies examining the relationship between stress and LBW suggest that certain types of stressors such as major life events and chronic stressors are good predictors of LBW, but perceived stress is less consistent.²⁰

Anxiety was also found to increase preterm birth in a North Carolina cohort, but was not found to be significant in another.^{21,22} Moreover, none of these studies were done within a LMIC.

Further complicating matters, most studies fail to account for the potential role that social support has in moderating the relationship between stress and birth outcome. Referred to as the “buffering hypothesis”, social support is thought to act as a “buffer” for stress by two means, either by dampening the levels of perceived stress or the stress response.²³ This is in contrast to the “main effects” model, which assumes there to be no interaction between stress and social support, the latter being beneficial for all women irrespective of their stress levels.²⁴

However, the plausibility of an association between social support and stress is more supported. For instance, interventions aimed at improving overall social support or decreasing pregnancy-related stress alone have not been uniformly effective in significantly lowering the risk of negative birth outcomes.^{25,26,27} Instead, research has shown that women with high levels of stress benefit the most from improved social support, especially when corresponding subtypes of social support and stress are targeted.²⁸ For example, out of intimate, friendship, and neighborhood/community support categories, one study found that intimate support in particular was an effective moderator of stress, especially those which were derived from intrapersonal or intimate sources.²⁹ Also, women who reported lower levels of social support were characterized as more likely to be living without their partners, have unplanned pregnancies, be unemployed, and have a history of smoking. Therefore, the amalgamation of these factors could be assumed to affect their level of stress, and place these women at greater risk of having LBW babies.³⁰

Birth to Twenty

The current study takes place within 1990 South Africa, an LMIC, at a period where the country was transitioning towards democracy following more than 40 years under the segregationist National Party (NP) and its *Apartheid* system. Since its establishment in 1948 discontent towards the white supremacist laws of the government had been mounting. Meanwhile, non-White South Africans were being suppressed by increasingly violent means by government forces, most notably with the shooting of unarmed civilians in 1960 and unarmed students in 1976. The latter incident especially, which took place within Soweto-Johannesburg, drew intense scrutiny from international bodies and countries, leading to the United Nations (UN) General Assembly denouncement of apartheid in 1973, UN Security Council arms embargo in 1976, and UK/US economic sanctions in 1985. However, not until the transition of power from Pieter Botha (NP) to F.W. de Klerk in 1989, and the subsequent election of Nelson Mandela in 1994, were non-White South Africans guaranteed equal rights under a new constitution.^{31, 32}

Soweto, an area located within the city of Johannesburg, where the Bt20 study was established, is home to almost exclusively non-White residents, and was witness to violence and discrimination under the apartheid legacy of South Africa. This historical context is important because another aspect to consider when examining pregnancy stress research is that again, a vast majority has been conducted in high-income country settings like the United States or Europe.³³ Soweto itself represents a microcosm of both the cultural and social changes that took place within South Africa. First, the establishment of the gold mining industry created a highly migrant work force, often taking men away from their families, while the Native Lands Act of 1913 created “dysfunctional urban systems” at the vicinity of major cities with urbanization.^{34,35,36} These factors, dissimilar to that of previous research contexts, may differentially impact previously held assumptions on the relationship between social support, stress, and child birth. For example, studies in the US have found that increased paternal support

is associated with decreased levels of stress and better infant birth outcomes.³⁷ It has also been documented that unmarried, single mothers face significantly higher levels of stigma, contributing to stress.³⁸ However, considering the high levels of extra-marital childbearing and adaptive definitions of “fatherhood” being observed, where co-residency is not part of the definition, previous associations cannot be assumed without further investigation.³⁹

The objective of the current study is to explore whether an association between perceived levels of maternal pregnancy stress and LBW exists, within a cohort of women from Soweto-Johannesburg, South Africa. Secondly, the role of social support on stress and LBW will be evaluated to see if it acts as an effect modifier or confounder.

Methods:

The Birth to Twenty (Bt20) longitudinal study has been collecting data in Johannesburg-Soweto, South Africa since its initiation in 1990 with the “Birth to Ten” cohort.⁴⁰ In a prospective cohort study design, eligible pregnant women with expectant due dates coinciding with a pre-specified 7-week enrollment period were recruited and consented to the study. The original purpose of the Bt20 was to systematically examine health of children living within an urban setting, following their development into adolescence.^{41,42}

Recruitment took place in antenatal clinics in public hospitals in the Johannesburg-Soweto area. To be eligible, the woman had to be resident in Johannesburg and/or the surrounding Soweto township (approximately 200 km² with 3.5 million population) and have planned to remain within the area with their child for 6 months after birth. This decision was made in order to focus on women from the area specifically, rather than those coming from more rural areas to deliver in the city’s facilities, to prevent participant attrition. Upon fulfilling these requirements, only singleton offspring were then enrolled into Bt20, totaling to 3,273 children, born between April 23 and June 8, 1990.

Prenatal interviews for the assessment of exposures were primarily administered through the “Antenatal Questionnaire” in the prenatal period (80%), however there were 187 women (20%) who were assessed in the early postnatal period due to unforeseen circumstances with the recruitment process.⁴³ The interview itself was given by trained multilingual interviewers, using back-translations to make sure that questions were being translated correctly, as intended. This portion was crucial considering that South Africa has 11 official languages in use, with Zulu, Sotho, and English being most frequently needed within the study.⁴⁴

Antenatal Questionnaire

Composed of 16 sections, the questionnaire assessed both physical and psychosocial aspects of the maternal environment. Of particular interest in this analysis were the information on demographic characteristics of the pregnant woman, previous pregnancies, disease history of the pregnancy, living situation (marital status, cohabitation), education, employment status, smoking, alcohol use, social support, and stress.

Social Economic Status (SES)

Two measures of SES were used in the study. First, an asset score summing the total number of all owned goods was used to approximate SES for women, which has been proven to be a “simple and reliable” measure for use in LMIC settings.⁴⁵ Second, a household crowding index was approximated by dividing the number of people living in a household by the number of rooms available in the home. Crowding has also been shown to be highly correlated with

“urban deprivation” and increased morbidity, which was used in consideration of the rapid urbanization behind Soweto’s formation.⁴⁶

Stress

Sixteen items were listed in the stress questionnaire, asking whether the participant or close family members had experienced any of the stressors within the last 6 months. All questions had two levels (yes/no) except for two questions. The first question, asking about being in danger of being killed, had 3 levels (by criminals, ‘officials’, or during political activities) which were combined into a single ‘yes’ level, denoting that the respondent had experienced the threat of being killed, with the fourth level recoded as a ‘no’. For the last question, about whether the respondent had experienced any problems with their other children, the last 2 levels of ‘no’ and ‘no other child’ were combined into a single ‘no’ level in order to dichotomize the response categories of the question. Afterwards, the stress variables were combined into a single summary variable, with scores going from less to more stress with each unit increase, and ranging from 0 to 11.

Social Support

Nine items from the social support section of the antenatal questionnaire were used to create the social support score. All items had 3 levels from least to most support, except for 2 which were part of skip logics with 2 levels each (yes/no). Except for the first 3 questions, all questions had to be reverse coded in order to go in the same direction from least to most support. Questions included those asking participants about having persons to talk with to having a friend who also has a newborn infant. Summary scores for social support were then created by summing the 9 item scores from the survey. Summary scores ranged from 11 to 22, going from less to more social support with each unit increase.

Delivery Form

Births of cohort enrollees, infants of consented pregnant women, were accounted for by interviewers, who were stationed at every delivery room within various public facilities during the enrollment period between April 23 and July 8 of 1990. Also, birth and death certificates, as well as hospital records were searched in order to record information on births. Delivery information of interest recorded in the form included the sex of the child, estimated gestational weeks (based on the last date of menstruation), method of delivery, and Apgar scores. For birth weights, less than 2500g was defined as ‘low birth weight’ while those greater than or equal to 2500g but below 4000g were categorized as ‘normal birth weight’.

Analysis

Statistical analyses were performed in stages to test for effect modification using SAS® software. Frequencies of each demographic, pregnancy, and birth for each birth weight category were found. Mean and standard deviations were found for continuous variables, while the number and column percent was recorded for categorical variables. Afterwards, bivariate analyses were run using logistic regression to find the odds ratio, confidence interval, and p-value for each. Additionally, simple logistic regressions were used to examine if there was an association between stress or social support with LBW. A multiple logistic regression was also run to examine if there was any association between stress and social support together with LBW. Final multivariable logistic regression models were adjusted for variables significantly associated

with birth weight groups to see whether the change in beta estimates of stress were 10% or more. The variables included into the final models included maternal age, time of interview, SES asset score, gestational age, parity and maternal disease history. In addition, the subtypes of stress and social support were created by exploratory factor analysis (EFA) using MPLUS, and tested for association with LBW. Briefly, EFA was conducted using the responses to 16-questions and 9-questions of stress and social support, respectively. The factors were extracted using the principle component method, followed by geomin rotation, and then the rotated pattern was interpreted. The responses that had factor loadings of .3 or more were considered as loading on the respective factor. We labeled each factor based on the interpretability of the responses that loaded on the factor.

Results:

Descriptive Statistics and Bivariate Associations

(Table 1) The total sample used for analysis consisted of 1591 children, with 157 (9.9%) in the LBW and 1427 (89.7%) in the normal birth weight (NBW) group. Seven infants, with birth weights recorded above 4000g and therefore macrosomic, were excluded from analysis. There were significant differences found between the overall sample and those available for analysis in terms of their demographic characteristics. Though the overall sample had ethnic distributions with 76% Black, 10% White, 11% Mixed-race, and 3% Indian, the sample population available for analysis was restricted to those observations which had birth weight data recorded, and was heavily skewed with 84% Black, 1% White, 14% Mixed-race, and 1% Indian.

The only significantly different maternal factor associated with infant birth weight was parity, where mothers of NBW infants were more parous with a mean of 1.3 births (SE 1.4) compared to mothers of LBW infants (1.3 births SE 1.4). Simple logistic regression also showed that increasing parity decreased the odds of LBW by 15% per birth (95% CI 0.74-0.97). All other maternal characteristics were not found to be statistically different between the two groups, but the direction of odds ratios were as expected from previous literature findings.

In terms of maternal disease history, there were no statistically significant factors associated with birth weight category. However, child characteristics such as sex, gestational age, and Apgar score at 5 minutes were significantly associated with birth weight category. On average, LBW infants had a mean birth weight of 2118.4g (SE 354.0), while NBW infants' mean birth weight were 3150.4g (SE 349.8). In terms of child sex, male infants had 31% decreased odds of being LBW, compared to female infants (95% CI 0.49-0.97). Being born at less than 37 weeks (preterm) was also associated with 5.17 increased odds of being LBW than those born at greater than or equal to 37 weeks (95% CI 2.77-9.65). Lastly, a unit increase in Apgar score at 5 minutes was found to be significantly associated with birth weight, with a lower mean score of 9.4 (SE 1.2) in LBW and 9.8 (SE 0.7) in NBW infants ($p < 0.001$).

Stress and Social Support

(Table 2) For this analysis, the sample was only restricted to those respondents who had completed all the items in both the social support and stress surveys ($n=1104$). Social support was found to be significantly associated with stress, with a unit increase in social support score decreasing stress scores by 0.17 units (95% CI -0.22, -0.11). The expected, inverse relationship remained significant even after adjustment for various maternal factors such as timing of interview, age, parity and disease history (β -0.12 95% CI -0.20, -0.04), excluding factors

associated with the infant. However, though significantly associated, social support only explained 3% of the variability in stress unadjusted and 5% when adjusted.

Main Effects of Stress

(Figure 1) Average summary stress scores for NBW were 2.4 (SE 2.1), which was the same for the LBW group (SE 2.3). The distribution of the scores were found to be almost identical, with skewing to the right as women reported lower levels of stress in general. LBW also had more women reporting no stressors at all, which may have lowered the average stress score.

(Table 3a) The sample was restricted to those respondents who had completed all of the items in the stress survey, which decreased the sample to 809 observations but increased the prevalence of LBW to 19% in this sample. Overall, stress was not found to be significantly associated with LBW, with a unit increase in overall stress decreasing the odds of LBW by 1% when unadjusted (95% CI 0.86-1.13). When adjusted, a unit increase in stress decreased the odds of LBW by 10% (95% CI 0.64-1.27), but adjustment also decreased the sample size to 307 observations with 5% LBW prevalence, and again was not significant at the 0.05 level.

Main Effects of Social Support

The sample available for analysis was restricted to only those who had valid responses for both the social support survey and LBW (n=643), where the percentage of LBW was around 7%, which is 3% less than in the overall sample. (Figure 2) Average summary social support scores for NBW were 19.1 (SE 2.1), which was almost the same for the LBW group which had a mean of 19.3 (SE 1.9). The distribution of the scores were found to be almost identical, with skewing to the left as women reported high levels of support in general.

(Table 3b) The summary score was not significantly associated with LBW, with a unit increase in social support increasing the odds of LBW by 5% (95% CI 0.90-1.22). When adjusted, the likelihood for LBW remained the same, as well as being not significant (95% CI 0.80-1.47), with all else held constant. Overall, a unit increase in social support increased the likelihood of LBW, but all associations were marginal and not significant.

Testing for Effect Modification

(Table 4) Model 2 contains both stress, social support, and their interaction term. Centering was also achieved in order to simplify interpretation, by subtracting the average of stress and social support from their original values, creating a new interaction term as well. Interaction between stress and social support was not found to be significant both before and after adjustment for other confounder (95% CI 0.79-1.11). Therefore, there is not sufficient evidence to suggest that social support is an effect modifier between stress and LBW.

Testing for Confounding

(Table 5) Model 3 containing both stress and social support was restricted to only those respondents with birth weight data who had answered both the stress and social support surveys entirely (N=517). Before adjustment, LBW prevalence in the sample was 7%, with a one-unit increase in stress increasing the odds of LBW by 11% (95% CI 0.93-1.32), holding social support constant. A unit increase in social support however only increased the odds of LBW by 1% (95% CI 0.85-1.18), holding stress constant. With adjustment, LBW prevalence decreased to 5% along with sample size (N=225), with the odds for LBW associated with stress (OR 0.92 95% CI

0.64-1.32) and social support (OR 1.03 95% CI 0.75-1.43) remaining not significant. Therefore, the results do not support the presence of confounding by social support on the relationship between stress and LBW.

Additional Analyses

Exploratory factor analyses

(Table 6a) Subtypes of stress were created through exploratory factor analysis. Four factors were identified: community violence, financial, familial, and marital stress. Community violence included whether the respondent had been in danger of being killed and witnessed a violent crime. Financial stress included being in so much debt so as to be worried about repayment, having too little money for basics, and not being able to find a job. Familial stress involved having problems with drugs or alcohol, experienced a serious fight or alienation, been arrested, given material help to others, having a family member with serious disability, and problems with your other children. Lastly, marital stress involved having gone through a break-up and experienced domestic abuse.

LBW prevalence remained around 7% for all subtypes and the unadjusted estimates did not find more than a 5% increase in the odds of LBW for a per unit increase in community violence (95% CI 0.59-1.74), familial (95% CI 0.50-1.71), and marital (95% CI 0.63-1.70) stress scores. However, a unit increase in financial stress was found to increase the likelihood of LBW by 16%, though it was also not significant (95% CI 0.88-1.53). After adjustment, the prevalence of LBW decreased to 5% for all samples except financial, where it was 4%. All subtypes were also found to be associated with a non-significant decrease in the odds of LBW. The greatest, however, was for marital stress, where a unit increase made the odds of LBW 53% less (95% CI 0.10-2.29), holding all else constant. All adjusted results remained not significant at the 0.05 level.

(Table 6b) Additionally, subtypes of social support were created similarly as for stress. These were then labeled as being personal/social, intimate, and community support. The personal/social support factor included having people who could help you in case of need and being able to talk to someone about personal problems. The intimate support factor included being able to talk to your husband or partner about your problems and feeling that your husband or partner made things more difficult because of his actions. Community support included belonging in a church or other organization, the frequency of meetings, and feeling that the nurses at the clinic were helpful.

None of the individual domains of social support identified in the EFA were associated with LBW either. The unadjusted social support sample had a LBW prevalence of 5%, which is half of that found in the overall sample. First, a unit increase in personal/social support was associated with a non-significant increase in the odds of LBW by 7% (95% CI 0.95-1.20), while a unit increase in intimate and community support was associated with a non-significant decrease in the likelihood by 9% each (95% CI 0.73-1.14; 0.69-1.20). When adjusted, a unit increase in both personal/social (OR 1.10 95% CI 0.85-1.41) and intimate support (OR 1.01 95% CI 0.63-1.64) were associated with a non-significant increase in the odds of LBW for each unit increase in score, while a unit increase in community support was associated with a non-significant decrease in the odds of LBW by 2% (95% CI 0.57-1.67).

Discussion:

Though stress was found to be significantly and inversely correlated with social support, they were not significantly associated with the odds of LBW independently, or in conjunction. Furthermore, social support was not found to be an effect modifier or confounder for stress in its relationship to LBW. Previously, research on pregnancy outcomes has found a significant relationship between stress and low birth weight. Biologically, it has been proposed that low social support and high levels of stress have been found to trigger the release of “pro-inflammatory cytokines,” disrupting immune function and increasing the chances of preterm birth and preeclampsia.⁴⁷ Social support in particular, with higher levels being reported in planned pregnancies, lower levels of smoking, and cohabitating relationships, has been found to positively influence the weight of the child.⁴⁸

However, cultural differences have also been known to have an influence on this moderation model. In a US study looking at the role of familialism among pregnant Latino women, researchers found that familialism was positively associated with social support and negatively associated with “perceived stress” and anxiety. Familialism is the Latino belief in which “close family relationships” are valued, in contrast to the highly individualistic values generally found in HIC and higher SES groups. The greater emphasis placed on a “supportive family relationship” has especially been argued to be the greatest contributor to the “Latino health paradox” in the US. To elaborate, despite living within a predominantly disadvantaged SES, Latinos present better health statistics than the general US population. The paradox, however, is that their health also significantly deteriorates with prolonged residence in the US, the phenomenon of which is called the “healthy migrant effect”. Furthermore, within the study, both social support and stress were not found to be significantly associated with infant birth weight equally. Social support, especially intimate and personal, and birth weight were only significant in conjunction when observed in foreign-born Latinas. This was not found among US-born Latinas or European Americans, as well as for the association between stress and birth weight.⁴⁹

In terms of social support and LBW, the results of this study suggest that the cultural context of social support is also an important consideration to make when looking for an association. For example, though the South African women within this sample population would be assumed to have experienced higher levels of stress due to the instability associated with the disruption of the family unit, “compensation” may have taken place through cultural mechanisms which favors the “extended family household”.⁵⁰ In the same vein, however, social support may also be closely related to stress by means of resource limitation, with an increasing household crowding index meaning that less economic resources are available for everyone. Therefore, the previously established models dealing with social support, stress, and LBW, need be more extensively studied in various cultures apart from the HIC systems like the US and Western Europe. Even general constructs such as stress and social support, may have been developed with country-specific assumptions in mind, proving less generalizable for dissimilar study contexts.

Limitation:

The sample size of this study was adversely restricted by the amount of missing data associated with each survey measure and demographic factor controlled for within adjusted analyses. For example, certain ethnic groups were greatly underrepresented in the analyses as their birth weight data was unavailable, also information on the use of tobacco products and alcohol consumption was incomplete for a majority of women. Therefore, more systematic and

objective means of measurement would be needed to draw conclusions as to whether the missing data was due to a true lack of substance use or a result of underreporting. The constant fluctuations in the sub samples used for analysis also may have limited the power of the study to detect any effect for certain, which may have been caused by the lower than expected prevalence of LBW within the sample population, the earliest figures for prevalence being from the 1998 Demographic Health Services (DHS) survey.

LBW is commonly used as an adverse pregnancy outcome to indicate suboptimal intrauterine conditions that reduce nutrient or oxygen supply to the fetus and preterm birth. Though the latter was controlled for with gestational age, LBW may not have been a sensitive enough marker in measuring intrauterine growth restriction (IUGR) and related fetal distress. Boasting “excellent validity and precision,” LBW is especially useful in low-resource LMIC settings, however, LBW has also been reported to perform poorly as a proxy for IUGR. Although imperfect, when compared to anthropometric measures like height-for-age (HAZ), weight-for-age (WAZ), weight-for-height (WHZ), and BMI-for-age (BMIZ) Z-scores, low birth weight does not perform as well to account for infants that are born small for gestational age (SGA) and not those who are “pathologically” small due to IUGR.^{51, 52} Anthropometric measurements also allow for cross national comparisons, as international growth standards made available through the efforts of the World Health Organization (WHO) and the INTERGROWTH-21st Project have incorporated a standardized, sex-specific instrument to measure for abnormalities in child size and growth.^{53, 54} However, such measurements were not collected for the study at the time of infant birth, and therefore could not be utilized for analysis. For this reason, it would be highly recommended that future studies capture additional maternal and infant information to provide a more robust and finely differentiated adverse pregnancy outcome for use.

The use of surveys, which were not validated, may have also contributed to the lack of significant findings in the study. Though social support and stress were significantly correlated with each other, within the expected direction, the magnitude was very low (β -0.12). However, based on how similar the distribution of the two constructs were for both groups, the measures may not have been sensitive enough in measuring differential levels of social support and stress. A validated survey may remedy this lack of sensitivity, and better determine the presence of an association. The results using this validated measure may also surprisingly replicate the same null results as this study, with no association found between stress or social support level with LBW. Yet, without validation of proper measurement, definite conclusions cannot be made on the possibilities of these results.

As for the level of general stress, the particular South African context at the time of the study may also have been inappropriate in order to garner the differential effect of stress on pregnancy outcome. At the time of this study South Africa had been going through one of its most historic shifts as the country was in the process of transitioning into a democratic system. Heavily influential since its formalization in 1948, however, the *Apartheid* government had already established significant changes in the people, distorting patterns of life that proved to be detrimental to the health and well-being of its Black and other non-White minority population. The struggles of the oppressed, largely Black populace, driven to political violence at various points, may have contributed to the making of a highly stressful period. Moreover, the women from this cohort are coming from Soweto, the place for one of the most remembered violent clash between student protestors and government police. Therefore, it may be appropriate to assume that women within this cohort, which was heavily represented by Black and multi-racial women, would have been generally experiencing high levels of stress. Alternatively, it is also

possible that the lack of significant association found between stress and LBW is a result of “resilience,” whereby the higher levels of stress throughout the lifetime of these women have made them less biologically responsive to these stressors and therefore less likely to have LBW infants.⁵⁵ In all, these possibilities will remain uncertain until further conclusive studies are carried out studying the relationship between stress, social support, and adverse pregnancy outcome within this population.

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APPENDIX

Table 1. Maternal and child characteristics of the Birth to Twenty cohort (N=1591) by birth weight categories and odds ratios comparing low to normal birth weight				
	Low (n=157) N (col %) or Mean±SD	Normal (n=1427) N (col %) or Mean±SD	Odds Ratio (95% CI)	P value
Time of Interview				
Prenatal	40 (61.5)	704 (81.3)	0.37 (0.22-0.62)	<0.001*
Postnatal	25 (38.5)	162 (18.7)	Reference	
Demographics				
Ethnicity				
<i>White</i>	1 (0.64)	8 (0.56)	Reference	
<i>Black</i>	121 (77.1)	1214 (85.1)	0.80 (0.10-6.43)	0.832
<i>Multi-racial</i> (“Coloured”)	28 (17.8)	193 (13.5)	1.16 (0.14-9.63)	0.890
<i>Indian</i>	7 (4.5)	12 (0.8)	4.67 (0.48-45.55)	0.185
Maternal age (years)	24.5±6.2	25.3±5.9	0.98 (0.95-1.01)	0.110
Parity	1.0±1.1	1.3±1.4	0.85 (0.74-0.97)	0.019*
Marital Status				
<i>Married</i>	19 (29.7)	215 (24.9)	1.29 (0.73-2.77)	0.376
<i>Widowed/Divorced</i>	3 (4.7)	36 (4.2)	1.22 (0.36-4.11)	0.753
<i>Single</i>	42 (65.6)	613 (71.0)	Reference	
Living Status				
<i>With child's father/partner</i>	23 (37.7)	365 (43.6)	0.78 (0.46-1.34)	0.370
<i>No sexual partner</i>	38 (62.3)	472 (56.4)	Reference	
Married-Cohabiting	23 (38.3)	364 (43.8)	1.25 (0.73-2.15)	0.410
Unmarried-Cohabiting	6 (13.3)	157 (24.2)	2.07 (0.86-4.99)	0.103
Maternal Education >Level 9	37 (56.9)	522 (60.3)	0.87 (0.52-1.45)	0.595
House Type				
<i>Flat, House</i>	43 (69.4)	659 (77.3)	0.67 (0.38-1.17)	0.158
<i>Other (shack, hostel, shared house)</i>	19 (30.7)	194 (22.7)	Reference	
Working	24 (36.9)	280 (32.4)	1.22 (0.73-2.06)	0.451
Insurance	5 (8.5)	69 (8.7)	0.97 (0.38-2.50)	0.949
Homeownership	11 (17.5)	175 (20.6)	0.81 (0.42-1.59)	0.547
Household Crowding Index	2.8±1.2	3.0±1.6	0.89 (0.74-1.07)	0.224
Asset index	11.5±2.8	11.7±2.1	0.97 (0.86-1.09)	0.611

Maternal History				
Disease history	18 (30.0)	300 (35.9)	0.77 (0.43-1.35)	0.359
Hospital admissions for pregnancy	6 (10.7)	57 (7.3)	1.53 (0.63-3.71)	0.351
Smoking (Cigarettes)	6 (9.2)	41 (4.8)	2.03 (0.83-4.97)	0.122
Alcohol (ever)	3 (4.6)	40 (4.7)	0.98 (0.30-3.27)	0.977
Snuff	7 (12.3)	85 (10.4)	1.20 (0.53-2.73)	0.663
Child				
Weight (g)	2118.4 (354.0)	3150.4 (349.8)		
Sex				
<i>Male</i>	64 (40.8)	712 (49.9)	0.69 (0.49-0.97)	0.031*
<i>Female</i>	93 (59.2)	715 (50.1)	Reference	
Gestational Age (weeks)	35.7±3.1	37.9±1.4		
<36 weeks	22 (47.8)	84 (15.1)	5.17 (2.77-9.65)	<0.0001*
≥36 weeks	24 (52.2)	474 (85.0)	Reference	
Apgar Score at 5 minutes	9.4±1.2	9.8±0.7	0.63 (0.54-0.75)	<0.0001*
Cesarean delivery	18 (11.6)	109 (7.8)	1.56 (0.92-2.65)	0.009*

*Significant at $\alpha=0.05$ level

† Age and parity are continuous and are per unit increase in year of age or birth

†† Totals may not sum to the total sample size for each column

	Unadjusted β (95% CI)	R^2	Adjusted† β (95% CI)	R^2
Social Support	-0.17 (-0.22, -0.11)*	0.03	-0.12 (-0.20, -0.04)*	0.05

†Adjusted for maternal age, time of interview, SES asset score, parity, and maternal disease history.

	N	Low Mean (SD)	N	Normal Mean (SD)	Odds Ratio Crude (95% CI)	Odds Ratio Adjusted† (95% CI)
Summary Score	157	2.4 (2.25)	652	2.4 (2.09)	0.99 (0.86-1.13)	0.90 (0.64-1.27)

†Adjusted for Maternal age, time of interview, SES asset score, gestational age, parity, and maternal disease history.

Table 3b. Social support scores (less to more support) by birth weight categories and odds ratios comparing low to normal birth weight

	N	Low Mean (SD)	N	Normal Mean (SD)	Odds Ratio Crude (95% CI)	Odds Ratio Adjusted† (95% CI)
Summary Score	45	19.3 (1.95)	598	19.1 (2.14)	1.05 (0.90-1.22)	1.09 (0.81-1.47)

†Adjusted for Maternal age, time of interview, SES asset score, gestational age, parity, and maternal disease history.

Table 4. **Model 2:** Multiple regression model testing for interaction between low birth weight and summary scores

	Odds Ratio Crude (95% CI)	Odds Ratio Adjusted (95% CI)†	Odds Ratio Centered - Mean (95% CI)†
	N=517	N=225	N=225
Stress	1.16 (0.27-4.97)	3.57 (0.13-95.15)	0.94 (0.65-1.35)
Social Support	1.13 (0.85-1.51)	1.23 (0.71-2.16)	1.06 (0.76-1.47)
Social Support*Stress	0.99 (0.92-1.07)	0.93 (0.79-1.11)	0.93 (0.79-1.11)

†Adjusted for Maternal age, time of interview, SES asset score, gestational age, parity, and maternal disease history.

Table 5. **Model 3:** Multiple regression model for low birth weight with summary scores

	Odds Ratio Crude (95% CI)	Odds Ratio Adjusted† (95% CI)
	N=517	N=225
Stress	1.11 (0.93-1.32)	0.92 (0.64-1.32)
Social Support	1.01 (0.85-1.18)	1.03 (0.75-1.43)

†Adjusted for Maternal age, time of interview, SES asset score, gestational age, parity, and maternal disease history.

Table 6a. Stress scores (less to more stressed) by birth weight categories and odds ratios comparing low to normal birth weight

	N	Low Mean (SD)	N	Normal Mean (SD)	Odds Ratio Crude (95% CI)	Odds Ratio Adjusted† (95% CI)
Community violence	64	0.2 (0.48)	844	0.2 (0.47)	1.01 (0.59-1.74)	0.88 (0.24-3.22)
Financial	64	0.9 (1.05)	849	0.8 (0.86)	1.16 (0.88-1.53)	0.81 (0.43-1.52)
Familial	61	0.9 (1.17)	765	0.8 (1.02)	1.05 (0.82-1.35)	0.89 (0.49-1.64)
Marital	63	0.2 (0.56)	827	0.2 (0.50)	1.03 (0.63-1.70)	0.47 (0.10-2.29)

†Adjusted for Maternal age, time of interview, SES asset score, gestational age, parity, and maternal disease history.

Table 6b. Social support scores (less to more support) by birth weight categories and odds ratios comparing low to normal birth weight

	N	Low Mean (SD)	N	Normal Mean (SD)	Odds Ratio Crude (95% CI) N=643	Odds Ratio Adjusted† (95% CI) N=242
Personal/Social	64	8.1 (1.93)	853	7.7 (2.58)	1.07 (0.95-1.20)	1.10 (0.85-1.41)
Intimate	62	4.9 (1.23)	813	5.0 (1.10)	0.91 (0.73-1.14)	1.01 (0.63-1.64)
Community	47	7.1 (1.11)	635	7.2 (1.03)	0.91 (0.69-1.20)	0.98 (0.57-1.67)

†Adjusted for Maternal age, time of interview, SES asset score, gestational age, parity, and maternal disease history.

Figure 1. Histogram of summary stress scores by birth weight categories

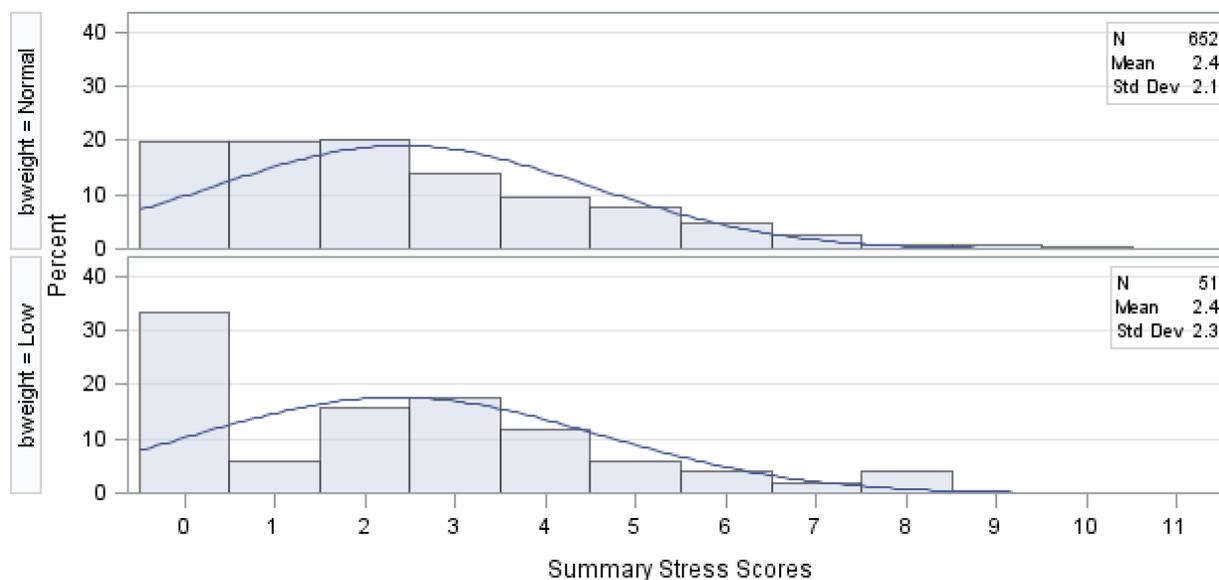


Figure 2. Histogram of summary social support scores by birth weight categories

