Matern Child Health J (2010) 14:774–785
DOI 10.1007/s10995-009-0508-8

Maternal Social Support and Neighborhood Income Inequality as Predictors of Low Birth Weight and Preterm Birth Outcome Disparities: Analysis of South Carolina Pregnancy Risk Assessment and Monitoring System Survey, 2000–2003

Stephen Nkansah-Amankra · Ashish Dhawain · James Robert Hussey · Kathryn J. Luchok

Published online: 31 July 2009

Abstract Effects of income inequality on health and other social systems have been a subject of considerable debate, but only a few studies have used multilevel models to evaluate these relationships. The main objectives of the study were to (1) Evaluate the relationships among neighborhood income inequality, social support and birth outcomes (low birth weight, and preterm delivery) and (2) Assess variations in racial disparities in birth outcomes across neighborhood contexts of income distribution and maternal social support. We evaluated these relationships by using South Carolina Pregnancy Risk Assessment and Monitoring System (PRAMS) survey for 2000–2003 geocoded to 2000 US Census data for South Carolina. Multilevel analysis was used to simultaneously evaluate the association between income inequality (measured as Gini), maternal social relationships and birth outcomes (low birth weight and preterm delivery). The results showed residence in neighborhoods with medium levels of income inequality was independently associated with low birth weight (OR: 2.00; 95% CI 1.14–3.26), but not preterm birth; low social support was an independent risk for low birth weight or preterm births. The evidence suggests that non-Hispanic black mothers were at increased risks of low birth weight or preterm birth primarily due to greater exposures of neighborhood deprivations associated with low income and reduced social support and modified by unequal income distribution.

Keywords Income inequality · Gini coefficient · Social support · Low birth weight · Preterm birth · Neighborhood contexts · Poverty

Introduction

The influence of social support and income inequality on a broad array of health disparities including low birth weight and preterm births is well recognized [1–3]. Conceptually, social support entails some kind of relational transaction presumed to be an important source for reducing negative effects of stress or providing positive affects in the absence of any visible stressors [4–6]. In this regard, Cohen and colleagues [1] have suggested core domains of social support as including emotional, instrumental, informational, appraisal assistance and social integration. A number of studies using these domains of social support either from a partner or other family members have shown the construct as mediating between neighborhood contexts and improved pregnancy outcomes [7–10]. Thus, social support at the community-level is suggested as enhancing appropriate social norms to facilitate improved maternal behaviors and birth outcomes

S. Nkansah-Amankra (✉)
College of Health and Human Sciences, University of Northern Colorado/Colorado School of Public Health, 2410 Gunter Hall, 501-20th St., Campus Box 93, Greeley, CO 80639, USA
e-mail: stephen.namankra@unco.edu; snamankrasc@lycos.com

A. Dhawain
Monmouth Medical Center, Long Branch, NJ 07740, USA

J. R. Hussey
Department of Epidemiology & Biostatistics, Arnold School of Public Health, University of South Carolina, Columbia, SC 29208, USA

K. J. Luchok
South Carolina Access Initiative and Adjunct Faculty, Department of Health Promotion, Education & Behavior, Arnold School of Public Health, University of South Carolina, Columbia, SC 29208, USA

[11–13]. However, the empirical evidence linking social support to improved maternal health and birth outcomes is mixed in neighborhoods with high levels of income inequality [13, 14].

Low birth weight and preterm birth outcomes have become a major source of health disparities among the racial groups in South Carolina and in the United States today [15–17]. For example, a non-Hispanic black infant is more than twice as likely to be born low birth weight or preterm compared to a white infant [7, 16]. In addition, these birth outcomes are the main contributors to infant mortality in the state and in the country [16, 18]. Despite numerous investigations, most of the etiologies linked to the disparities still remain largely unknown [18–20]. However, a number of research studies have suggested social contexts as an important causal path in regard to the observed disparities among the racial groups [21–23]. One such context that has been a part of current public policy debate is unequal income distribution across countries, states and communities [12–14, 22, 23]. In the U.S., South Carolina is one of the states characterized as having a relatively high unequal income distribution [24], and it is unclear whether this exposure contributes to birth outcome disparities and other social relationships among the racial groups in the state.

Some investigators have proposed that social support and social integration are to a large extent determined by neighborhood contexts of income inequality [11, 23, 25, 26]. Thus, high unequal income distribution across communities is suggested as a path toward deleterious health outcomes [11, 13, 21, 22]. For instance, Huynh and colleagues [21] found county residents with high income inequality levels to be at higher risks of preterm delivery and post neonatal mortality. Likewise, Holtgrave and Crosby [13] observed high income inequality was significantly associated with AIDS case rates. In other analyses, high income inequality was found to be associated with low social capital (a contextual social construct related to individual-level social support), low network membership, poverty, percent non-Hispanic black population, morbidity, mortality and prevalence of reproductive ill-health sequelae [13, 21, 27]. Overall, additional findings from a number of studies appears to suggest that social systems and institutions that create wide disparities in unequal income distribution invariably lead to segregation and underinvestment in education, human resources, healthcare and other social structures that provide safety nets for the poor and marginalized groups in a society [27–31]. Thus, the association of neighborhood income inequality and birth outcomes is often suggested to be related to or mediated by the key psychosocial factors (social support, stress) and other contextual constructs linked to poverty, neighborhood income and proportion of non-Hispanic black population in a neighborhood [12, 21, 23, 32].

Based on these perspectives, we evaluated the association between neighborhood income inequality, maternal social support, low birth weight and preterm births among mothers participating in the South Carolina Pregnancy Risk Assessment and Monitoring System (PRAMS) survey, 2000–2003. Our main purpose for this project was to evaluate the extent to which observed disparities in low birth weight or preterm birth outcomes among the racial groups in the state was related to neighborhood income inequality and social support, as well as whether these exposures are modified by income inequality. Previous studies examining these relationships have used either the state, metropolitan or county levels as the unit of analysis, and little or no investigation has been done at the census tract level, despite the fact that the relationships at the census tract level most approximate the socio-cultural context of a neighborhood [12, 27]. The census tract-level is also the jurisdiction where the impact of policies and decisions concerning provisions or organization of human services for improved health outcomes is most likely to have the greatest impacts on health [23, 30, 33]. Specific questions guiding the investigation were:

(1) Is neighborhood income inequality and maternal social support associated with low birth weight and preterm deliveries?
(2) Is there a different association between neighborhood income inequality and low birth weight or preterm births for mothers with different levels of social support, and does this vary with race?

Materials and Methods

Data for the study came from linked datasets of the South Carolina PRAMS survey for 2000–2003, geocoded to 2000 U.S. Census data (for South Carolina). PRAMS is a state specific population-based surveillance system that collects information on maternal experiences prior, during pregnancy and after childbirth for mothers delivering live births. In South Carolina data collection begins at about 2–6 months after delivery when a probability sample of mothers from the birth certificate data is selected and a mailed package sent. Mothers who do not respond to the initial contact are followed with two additional mailing attempts. Non-respondents are then contacted by telephone for an interview. Finally, PRAMS and birth certificate data are combined and specific weightings applied to represent all mothers delivering live infants in the state. The overall response rate for 2000–2003 was approximately 72%. All maternal-level variables came from the PRAMS dataset and neighborhood variables were operationalized as census tracts from the U.S., 2000 Census data for South Carolina (Summary File Tape 3A).

The protocol for conduct of this study was approved by the Institutional Review Boards of the University of South Carolina and South Carolina Department of Health and Environmental Control (DHEC).

Birth Outcome Measures

The main outcome measures in the study were low birth weight and preterm births. These birth outcomes are internationally recognized and accepted as a direct proxy for assessing infant's ability to survive in the first year of life [18]. Low birth weight was determined as the recorded weight at birth of less than 2,500 g, and gestational age (in weeks) was assessed by the reported date of last normal menstrual period or clinical estimate if the last menstrual period was not available.

Exposures and Selected Covariates

Maternal Social Support and Other Covariates

Maternal social support came from the PRAMS survey and was measured with 6-items reflecting mothers perceived availability of different kinds of support during pregnancy. The response to each item was given as "Yes" or "No". The items in the scale include tangible aid (someone to provide with money-$50, helping with groceries, getting a ride to a clinic when needed), emotional support (someone to listen to problems), informational support (help with finding a job when needed), and belonging support (someone to help if I were sick in bed and needed help). Confirmation with factor analysis showed that all six items loaded highly on one factor and the internal consistency–reliability was 0.86. For the analysis, PRAMS mothers were categorized as high, medium and low social support based on responses to the items [8]. *High social support* indicates 'yes' responses to at least four or more social support items and *Medium social support* refers to 'yes' responses to any two or three items. Mothers reporting 'yes' to one item or indicating 'no' social support was available were considered as having *Low social support*.

Other maternal-level covariates used were maternal race (non-Hispanic black, non-Hispanic white) age (as <20, 20–24, 25–29, 30–34 and >34), income (<$10,000, $10,000–$24,999, $25,000–$39,999, and >$40,000), marital status (married, non-married) and education (<high school, high school, >high school). These covariates were included in the analysis to control for potential confounders in different stages of the statistical modeling process.

Contextual Exposures

Neighborhood Income Inequality Other Contextual Measures

Neighborhood income inequality was measured with the Gini coefficient with values ranging from 0 (perfect equality) to 1 (perfect inequality). The Gini was calculated as midpoints of census tract income categories following the methodology described in Cohen [34]. A higher Gini coefficient indicates greater income inequality, while lower values indicate more equitable income distribution. The calculated values of income inequality for the census tracts ranged from 0.28 (least income inequality) to 0.62 (most income inequality), with a mean value of 0.41. Due to non-linear relationships among neighborhood income distribution and health outcomes [21], the coefficients were further categorized as tertiles of census tract exposures: High Gini, Medium Gini and Low Gini. As such, each original tertile consists of similar numbers of tracts, but not necessarily similar numbers of birth weight or gestational age births.

Because previous studies have shown that neighborhood-level disadvantages including high percentage of non-Hispanic black population, poverty, and median income are associated with income distribution and low birth weight or preterm births, we determined whether these contextual factors could be potential confounders for the association between income inequality and birth outcomes [29, 35, 36]. Neighborhood poverty was calculated as the proportion of census tract residents with income below 1.5 Federal income levels (poverty). In South Carolina, this represented an average amount of $17,074 for a family of four over the period 2000–2003, and was categorized as low poverty (<10% neighborhood residents with income below 1.5 Federal poverty level), medium poverty (10–19.99% residents with income below 1.5 Federal poverty) and high poverty (>20% residents with income below 1.5 Federal poverty level). Likewise, median household income for the 2000–2003 period was $44,044 and income categories were >$44,044; $33,162–$44,044; $29,471–$33,162, $6,250–$29,471 to be consistent with incomes reported by the PRAMS respondents. Finally, the percent non-Hispanic black population in a census tract was recoded as predominantly white (<10% black residents), mixed majority Black (>10–50% residents black) and predominantly Black (>50–90% residents black). The selection of these variables was based on earlier studies which had shown that different exposure levels of poverty, median income and percent non-Hispanic black residents have different effects on health and birth outcomes [32, 35, 37, 38].

Statistical Analysis

All our analyses were done with SAS 9.1.3 (SAS, Cary, N.C.). Univariate distribution was assessed initially using Chi square tests and the Cochran–Armitage test for trend. Finally, we used Generalized Linear Mixed Models (SAS PROC GLIMMIX) with a logit link function and binomial distribution to evaluate the relationship between birth outcomes, social support and neighborhood income inequality (Gini coefficient). PROC GLIMMIX permits analysis of random effects (neighborhood contexts) and fixed effects (maternal covariates and resulting interaction terms) models for outcomes that are not necessarily normally distributed [39]. Maternal covariates (income, education, age and marital status) and neighborhood factors (percent non-Hispanic black population, percent poverty, and median income) were used to examine possible confounding effects on low birth weight or preterm birth odds ratio estimates. In all 8060 mothers with valid resident addresses in South Carolina delivered live births for the period 2000–2003. Analysis was further restricted to only non-Hispanic black and non-Hispanic White mothers due to small numbers (1.66%) and heterogeneity of other racial groups. Furthermore, infants with reported birth weight of less than 500 grams (5.24%), gestational age of less than 20 weeks (0.62%) and implausible gestational age or birth weight were excluded from the analysis. However, for uniformity in item responses and to minimize exposure misclassification [39], mothers with incomplete information on all social support items were excluded ($\approx$29%), thus yielding a final sample of 5,730 mothers with complete information on all variables from 548 census tracts across the state. Mothers excluded were more likely to be non-Hispanic black, to deliver low birth weight (LBW) or preterm births (PTB) and to live in high poverty neighborhoods.

Probable multicollinearity associated with contextual factors was assessed with variance inflation factor (VIF) values greater than or equal to 10, and the results did not exceed this threshold value. All models were adjusted with PRAMS post stratification survey weights to take account of over sampling, non-responses and to be representative of women delivering live births in the state. The post stratification weights were constructed based on characteristics most predictive of low birth weight or preterm births including Black racial groups, teenage mothers, relatively older age mothers and low educational status of survey respondents.

We ran a series of models to determine whether the relation between income inequality and birth outcomes is robust to adjustment with maternal-level covariates, social support and neighborhood contexts. Finally, we included a separate product term of income inequality and social support and maternal race using the Greenberg and Kleinbaum [40] framework for testing interactions. For all cases with a significant interaction, we used the SLICE option with the LSMEANS statement to determine which groups had significant effects. All the pairwise comparisons were made after Tukey adjustment and the *P*-value Alpha for all analyses was set at $P = 0.05$ unless otherwise specified.

Results

Descriptive characteristics of the study population are given in Table 1. The unweighted samples include non-Hispanic white mothers ($\approx$56%) and non-Hispanic black mothers ($\approx$44%). The weighted percentage prevalence of low birth weight and preterm births to non-Hispanic black mothers represented 13.2% and 14.2%, respectively during the 2000–2003 survey periods. In contrast, the weighted percentage prevalence of low birth weight and preterm births to White mothers was 6.5% and 8.8%, respectively. The age groups reporting the lowest prevalence of low birth weight and preterm birth varied. Mothers with high social support constituted the largest group ($\approx$85%) and were least likely to report low birth weight or preterm births. Table 1 also shows the preponderance of social gradients in health regardless of which birth outcome measure (low birth weight or preterm birth prevalence) is used at the maternal-level or census tract level. For instance, the prevalence of low birth weight or preterm births decreases with increasing maternal income, education and to a large extent higher levels of maternal social support. Likewise, low birth weight and preterm births are lower for married women and whites. The gradients for contextual determinants suggest that mothers living in neighborhoods with low levels of income inequality were likely to report lower prevalence of low birth weight and preterm births than their counterparts in higher Gini neighborhoods. Similar observations were made for other census tract variables, and the Cochran–Armitage test for trend showed a statistically significant trend of increasing proportion of adverse birth outcomes across all levels of exposures variables ($P < .0001$).

Table 1 Sample characteristics of South Carolina Pregnancy Risk Assessment and Monitoring System (PRAMS) respondents with selected neighborhood factors according to percentage low birth weight and preterm birth outcomes, 2000–2003

Variable	Number (%)[†]	Percentage of births that are[§]	
	N = 5730	Low birth weight	Preterm
Age (years)			
<20	24.7	7.5	10.0
20–24	19.0	7.8	9.6
25–29	10.9	10.6	10.8
30–34	29.1	8.7	11.9
>35	16.4	11.4	13.6
Maternal race			
Non-Hispanic black	44.5	13.2	14.2
Non-Hispanic white	55.5	6.5	8.8
Marital status			
Married	53.1	6.7	9.3
Non-married	46.9	11.7	12.5
Education			
Less than high school	22.0	11.0	12.5
High school	39.2	9.3	10.8
More than high school	38.8	7.0	9.5
Maternal income			
<$10000	27.1	12.4	12.0
$10000–$24999	28.6	9.3	11.9
$25000–$39999	16.2	7.6	11.0
≥$40000	28.0	6.0	8.7
Social support			
Low	6.6	10.0	14.2
Medium	8.2	9.9	12.4
High	85.2	8.5	10.2
Gini coefficient			
Low Gini	33.5	7.1	9.5
Medium Gini	33.3	9.1	10.7
High Gini	33.2	10.2	11.8
Poverty			
Low poverty (<10% residents)	15.9	6.3	8.9
Medium poverty (10–20%)	28.6	8.1	10.7
High poverty (>20%)	55.5	9.9	11.1
Percent Non-Hispanic black			
Predominantly white (<10% Black)	18.7	6.8	9.2
Mix majority Black (10–50% Black)	55.8	8.5	10.4
Predominantly Black (50–90% Black)	25.5	11.1	12.3
Median income			
>$44,044	22.2	7.1	9.3
$33162–$44044	35.4	8.4	11.5
$29471–$33162	15.5	8.8	8.9
$ 6250–$29471	27.0	10.9	11.7

Notes: PRAMS is the Pregnancy Risk Assessment and Monitoring System. The PRAMS study population is 5730 live births in 2000–2003 to mothers resident in South Carolina, and excluding mothers from the other ethnic groups, births with congenital anomalies, birth weight less than 500 g, and gestation weeks less than 20 weeks

[†] Based on unweighted PRAMS data which are indicative of only mothers participating in the PRAMS 2000–2003 survey periods

[§] The weight variable adjusts for the survey over-sampling and non-responses to yield population estimates for the state. The Cochran–Armitage test for trend remained statistically significant across all levels of maternal covariates and neighborhood income categories at $P < .0001$ for two-sided test

The crude and adjusted odds ratios for low birth weight and preterm births according to neighborhood income inequality and maternal social support are shown in Table 2. The first model (unadjusted) examined each association of the Gini coefficient, maternal social support and birth outcomes (low birth weight or preterm birth); the second model included income, in an attempt to examine the influence of maternal income across levels of income inequality and social relationships; the third model added all maternal covariates (income, marital status, age, education). In the final model, we included maternal covariates and neighborhood factors as possible confounders of the relationship between income inequality and birth outcomes [41]. We did not include maternal race in the models, because we conceptualized race as the main mediating variable, and therefore its adjustment would underestimate income inequality (exposure) and birth outcome relationships [40]. The unadjusted odds ratio showed that mothers living in high (OR = 2.21; 95% CI: 1.34, 3.65) and medium (OR = 2.09; 95% CI: 1.27, 3.43) income inequality neighborhoods were estimated to have more than a two-fold increased risk of low birth weight compared with mothers living in low Gini areas (Table 2). However, risks associated with income inequality for preterm births for mothers living in similar neighborhoods appeared to be less significant. Similarly, the crude odds ratio for mothers reporting medium social support or low social support showed respective risks of 14% and 66% higher for low birth weight, and similar crude estimates are shown for preterm births (Table 2). However, these effects were somewhat reduced for almost all the models when maternal income was included, but the odds ratios remained

Table 2 Crude and adjusted odds ratios (95% confidence interval) using multilevel binomial logit models for the association between PRAMS mothers' social support neighborhood income inequality exposures and birth outcomes, 2000–2003

Variables	Unadjusted OR	Adjusted OR[a]	Adjusted OR[b]	Adjusted OR[c]
Low birth weight				
Gini coefficient				
Low Gini	Referent	Referent	Referent	Referent
Medium Gini	2.09 (1.27, 3.43)	1.87 (1.13, 3.08)	1.86 (1.13, 3.07)	2.00 (1.14, 3.26)
High Gini	2.21 (1.34, 3.65)	1.74 (1.05, 2.89)	1.66 (1.00, 2.75)	1.35 (0.71, 2.57)
Social support				
High support	Referent	Referent	Referent	Referent
Medium support	1.14 (1.04, 1.25)	0.84 (0.76, 0.92)	0.89 (0.76, 0.92)	0.89 (0.81, 0.98)
Low support	1.66 (1.50, 1.84)	1.43 (1.28, 1.59)	1.43 (1.28, 1.59)	1.42 (1.28, 1.59)
Preterm births				
Gini coefficient				
Low Gini	Referent	Referent	Referent	Referent
Medium Gini	1.51 (0.96, 2.37)	1.50 (1.01, 2.53)	1.31 (0.65, 1.68)	1.47 (0.89, 2.44)
High Gini	1.67 (1.06, 2.64)	1.62 (1.02, 2.58)	1.04 (0.83, 2.09)	1.21 (0.67, 2.20)
Social support				
High support	Referent	Referent	Referent	Referent
Medium support	1.22 (1.11, 1.34)	1.05 (0.96, 1.16)	1.07 (0.97, 1.18)	1.07 (0.97, 1.18)
Low support	2.20 (1.96, 2.46)	1.90 (1.69, 2.13)	1.90 (1.69, 2.13)	1.90 (1.69, 2.14)

Pregnancy Risk Assessment and Monitoring System (PRAMS) for South Carolina, singleton live birth Cohort File, 2000–2003. Infants with gestational age <20 weeks and birth weight <500 g, and mothers with complete information on all variables were used for the multivariable analysis

[a] Adjusted for maternal income

[b] Adjusted for other maternal covariates (income, marital status, age, education)

[c] Adjusted for all maternal covariates (income, marital status, age, education) and neighborhood factors (median income, poverty and percent non-Hispanic black)

All models include variable weight statement to account for sample selection, non-response and to generalize to represent population of women delivering lives births

statistically significant for some models (Table 2). Whereas mothers living in medium Gini neighborhoods were significantly at an increased risk of low birth weight, mothers resident in high Gini census tracts were less at risk. No significant risks were observed for preterm births. The effect remained relatively stable when other maternal covariates (age, education, marital status, and income) were included in the income model. In the fully adjusted model consisting of maternal covariates and neighborhood contexts, the risk associated with income inequality on low birth weight was a two-fold higher risk for mothers living in the medium Gini neighborhoods compared to mothers resident in low Gini census tracts. Likewise, mothers reporting low social support were at increased risk for low birth weight or preterm birth delivery.

Table 3 presents multivariable models for neighborhood income inequality adjusted for maternal race, social support, neighborhood contexts (median income, percent non-Hispanic black population and poverty) and the two birth outcomes (low birth weight and preterm births). After adjustment for race, mothers in medium Gini neighborhoods were relatively at a higher risk of delivering low birth weight, yet no statistically significant effects were observed in preterm births (compare the crude estimates in Table 3 columns 2 and 3). Inclusion of social support exposures showed that the risk of low birth weight for mothers living in medium Gini neighborhoods increases somewhat, while the risk for mothers living in high Gini neighborhoods decreases. No statistically significant changes were observed for infants delivered preterm. Likewise, when neighborhood contexts were added to income inequality models, the risk of low birth weight appeared statistically significant only for mothers living in medium Gini neighborhoods, and no statistically significant effects were observed for preterm births across all census tract areas. However, in the fully adjusted models that includes maternal race and other risk factors (results not shown), only mothers living in medium poverty neighborhoods were at increased risk of delivering low birth weight (OR: 1.96; confidence interval 1.20, 3.36).

Table 3 Crude and adjusted odds ratios (with 95% confidence interval) using multilevel binomial logit models for preterm and low birth weight according to PRAMS mothers' neighborhood income inequality, maternal race, social support and the resulting interactions, 2000–2003

Model	Gini coefficient		
	Low Gini[§]	Medium Gini	High Gini[†]
Low birth weight			
Unadjusted model	Referent	2.09 (1.27, 3.43)	2.21 (1.34, 3.65)
Adjusted for			
Maternal race	Referent	1.72 (1.04, 2.83)	1.32 (0.80, 2.19)
Social support	Referent	2.14 (1.29, 3.55)	2.14 (1.28, 3.58)
Neighborhood poverty	Referent	1.96 (1.15, 3.37)	1.81 (0.99, 3.30)
Median income	Referent	2.02 (1.18, 3.45)	1.65 (0.88, 3.08)
Percent non-Hispanic black population	Referent	2.01 (1.20, 3.36)	1.50 (0.85, 2.66)
Preterm births			
Unadjusted model	Referent	1.51 (0.96, 2.37)	1.67 (1.06, 2.64)
Adjusted for			
Maternal race	Referent	1.40 (0.88, 2.22)	1.12 (0.70, 1.78)
Social support	Referent	1.54 (0.97, 2.45)	1.56 (0.98, 2.49)
Neighborhood poverty	Referent	1.47 (0.90, 2.40)	1.41 (0.82, 2.44)
Median income	Referent	1.56 (0.95, 2.54)	1.45 (0.82, 2.57)
Neighborhood non-Hispanic black population	Referent	1.49 (0.94, 2.39)	1.23 (0.73, 2.07)

Data source: Pregnancy Risk Assessment and Monitoring System (PRAMS) for South Carolina, singleton live birth Cohort File, 2000–2003. Infants with gestational age <20 weeks and birth weight <500 g, and mothers not responding to all social support and network items were excluded from the multivariable analysis

Gini coefficient distribution across the census tract is follows: Mean 0.408 (standard deviation 0.0499), Minimum 0.278, Maximum 0.616

All models include variable weight statement to account for sample selection, non-response and to generalize to represent population of women delivering lives births

[§] Census tracts with the least inequalities in income distribution

[†] Census tracts with the highest inequalities in income

Does the Effect of Neighborhood Income Distribution on Low Birth Weight or Preterm Births Vary Across Racial Groups and Maternal Social Support Levels?

Tables 4 and 5 show how the relationship between income inequality and low birth weight or preterm births was modified by maternal race and social support exposures. For instance, among the white mothers there was no relationship between residence in neighborhoods with medium or high levels of income inequality and the risk of low birth weight or preterm delivery (Table 4). In contrast, residence in medium Gini or high Gini neighborhoods was a strong risk factor for low birth weight or preterm births among non-Hispanic black mothers. The interaction model between Gini coefficients and maternal social support was statistically significant ($P = 0.0001$) suggesting that the effect of income inequality on low birth weight or preterm birth was higher among mothers reporting low levels of social support.

Table 5 shows the interaction models for the association between maternal race and low birth weight or preterm births for different levels of social support. The results indicate that non-Hispanic black mothers reporting low or medium support were at increased risks of more than five-fold and three-fold, respectively for low birth weight compared to white mothers with high social support. In contrast, the interaction model predicting low birth weight among white mothers showed that the risk was less than two-fold for mothers reporting medium or low social support. Nonetheless, among the non-Hispanic black mothers there appears to be no relationship between social support and preterm delivery, while white mothers reporting low support were at an almost five-fold risk of preterm delivery.

Discussion

The results of these analyses suggest that residence in a neighborhood with medium levels of income inequality was associated with a higher risk of low birth weight. This association was found to be independent of maternal socio-economic factors and neighborhood percent non-Hispanic black population, poverty and neighborhood median

Table 4 Multilevel binomial logit models for low birth weight and preterm according to PRAMS mothers' neighborhood income inequality, race, social support and the resulting interactions, 2000–2003

Model	Medium Gini neighborhoods OR (95% CI)	High Gini neighborhoods OR (95% CI)
Low birth weight		
Gini coefficient × maternal race		
Non-Hispanic black	7.45 (4.04, 13.74)	5.02 (2.71, 9.31)
Non-Hispanic white	1.61 (0.88, 2.96)	1.40 (0.75, 2.61)
Gini coefficient × *social support*		
Medium support	2.08 (1.05, 4.11)	2.10 (1.05, 4.19)
Low support	3.26 (1.64, 6.48)	2.84 (1.39, 5.77)
Preterm births		
Gini coefficient × maternal race		
Non-Hispanic black	2.55 (1.46, 4.48)	3.40 (1.93, 5.98)
Non-Hispanic white	1.40 (0.48, 1.50)	0.85 (0.48, 1.50)
Gini coefficient × social support		
Medium support	1.33 (1.28, 8.34)	2.35 (1.25, 4.43)
Low support	4.45 (2.38, 8.34)	0.92 (0.48, 1.77)

Data source: Pregnancy Risk Assessment and Monitoring System (PRAMS) for South Carolina, singleton live birth Cohort File, 2000–2003. Infants with gestational age <20 weeks and birth weight <500 g, and mothers not responding to all social support and network items were excluded from the multivariable analysis

Gini coefficient distribution across the census tract is follows: Mean 0.408 (standard deviation 0.0499), Minimum 0.278, Maximum 0.616

All models include variable weight statement to account for sample selection, non-response and to generalize to represent population of women delivering lives births

Non-Hispanic white mothers resident in low Gini neighborhoods were the referent group

Mothers resident in low Gini neighborhoods with high social support served as the referent group

Table 5 Binomial logit interaction models examining relationships between maternal race and low birth weight or preterm births for different levels of effects for social support, 2000–2003

Model	Medium support OR (95% CI)	Low support OR (95% CI)
Low birth weight		
Maternal race × social support		
Non-Hispanic black	3.89 (3.29, 4.60)	5.51 (4.54, 6.89)
Non-Hispanic white	1.25 (1.06, 1.48)	1.82 (1.53, 2.17)
Preterm births		
Maternal race × social support		
Non-Hispanic black	0.94 (0.73, 1.21)	1.04 (0.85, 1.28)
Non-Hispanic white	1.11 (0.95, 1.30)	4.94 (4.26, 5.72)

Data source: Pregnancy Risk Assessment and Monitoring System (PRAMS) for South Carolina, singleton live birth Cohort File, 2000–2003. Infants with gestational age <20 weeks and birth weight <500 g, and mothers not responding to all social support and network items were excluded from the multivariable analysis

All models include variable weight statement to account for sample selection, non-response and to generalize to represent population of women delivering lives births

Non-Hispanic white mothers resident in low Gini neighborhoods were the referent group

Mothers resident in low Gini neighborhoods with high social support served as the referent group

income. In contrast, no statistically significant association was found for preterm deliveries. The risk patterns for the association between low birth weight or preterm delivery and social support suggests higher risks for mothers with low social support. Thus, consistent with our research question 1 (association of neighborhood income distribution, social support and low birth weight or preterm birth), we found only mothers living in a medium tertile distribution of neighborhood income inequality to be at a risk of low birth weight, and mothers with low social support systems were independently at increased risk of low birth weight or preterm births. Furthermore, the findings also suggest that neighborhood constructs including percent poverty, percent non-Hispanic black population, median income and income inequality distribution may be measuring different domains of neighborhood deprivations associated with poor maternal and child health outcomes.

The relationship between neighborhood income inequality and low birth weight or preterm births was also modified by social support. Mothers with low or medium support (compared with mothers with high support and living in low Gini neighborhoods) were at increased risk of low birth weight or preterm births. However, the pattern showed that mothers with low support were at relatively higher risks of low birth weight or preterm births. Indeed, the heterogeneity associated with maternal social support and risk of low birth weight or preterm deliveries showed substantial differences between the two racial groups such that presenting average risk effects would have been misleading in terms of the relationship between neighborhood income inequality risk exposures. Nonetheless, the overall relationship between maternal race and preterm delivery also indicated that white mothers reporting low social support were at a statistically significant risk of preterm delivery compared with white mothers with high social support.

These findings suggest that the disparity in low birth weight and preterm births among the racial groups in the state might be related to distal processes of neighborhood unequal income distribution and mediating influences of psychosocial factors linked to maternal race. In terms of etiological relationships, two main hypotheses (neo-material and psychosocial stress) are posited to explain the distal effects of income inequality on maternal birth outcomes. The neo-material perspectives suggest that neighborhood income inequality is a surrogate measure of societal underinvestment in healthcare and other social resources needed to improve prenatal health care [14, 16, 41]. Thus, this perspective reflects a systematic lack of development in both human and social infrastructure needed to improve maternal health. At the census tract level (neighborhood), this manifests as economic disparities among the population groups where a pattern of legislative expenditures on social services, public goods, well-maintained public spaces and provision of services are always directed to the well-resourced communities. The resulting disparities among neighborhoods lead to inequalities in distribution of and access to material resources, socioeconomic status, and neglect of existing infrastructure. This leads to unequal distribution of burdens of diseases and other adverse health outcomes including low birth weight or preterm birth [4, 22, 25, 41]. Additionally, the pattern of residential segregation also exacerbates low birth weight and preterm birth outcome disparities through differential distribution of racial groups into different neighborhood exposures [42]. Although our study did not measure residential segregation across neighborhoods of the state, the pattern of differential distribution of White and non-Hispanic black mothers was very much in evidence in the bivariate distribution. Therefore, White and non-Hispanic black mothers are likely to experience different neighborhood qualities including crime, poverty, and access to other social resources, service opportunities as well as safe places to walk and socialize with other neighbors.

The psychosocial mechanism suggests that income inequality affect disparities in birth outcomes through increased neighborhood stressors. In this regard, the utility of social support in a social context is to buffer or ameliorate the detrimental effects of neighborhood stressors on maternal psychological and emotional wellbeing during pregnancy. Wilkinson [22, 24] argues that a high level of income inequality and its associated disadvantages create an imbalance in community social relations and the social status differentials lead to erosion of trust and a general climate of reduced social engagements among the population. The resulting isolation, together with insecurity is suggested to exacerbate a maternal psycho-neuroendocrine hormonal release to affect birth weight or gestational length and other behaviors including smoking and drug use, each of which is a known proximate mediator of adverse pregnancy outcomes. In contrast, residents of neighborhoods with low levels of income inequality are able to participate in meaningful social activities including becoming engaged in civil society groups, thereby creating an opportunity for mothers to share pregnancy-related information, receive advice and become emotionally connected to pregnancy-related experiences of other women. Thus, the level of improved maternal health correlates strongly with the degree to which the populations show higher participation in the community's social life and other activities linked to improved social networks in more equitable income distribution neighborhoods. However, our finding that women living in medium Gini neighborhoods compared to those in high Gini neighborhoods were at increased risk is intriguing and difficult to explain. This unexpected finding might be related to exceptional resilience existing in individuals and families of women living in high Gini neighborhoods, but clearly this needs more research to unravel the precise mechanism of resilience on pregnancy outcomes across neighborhoods.

In the United States, given that race is a key determinant of social class status and/or access to resources (education, income, employment, insurance, healthcare and residential location) necessary for improved maternal and child health outcomes, the extent to which maternal race should be regarded as a mediator instead of being a true confounder (to be adjusted for) is unclear in studies [14–16]. For example, in one study adjusting for maternal race (as a confounder) resulted in reduced income inequality effect on preterm birth and infant mortality [21], whereas in another study no such effects were observed on birth outcomes [43]. If maternal race is conceptualized as the main causal route for improved birth outcomes, then it could be argued that race is a mediator of the relationship between income inequality and improved infant health. In our analysis, controlling for maternal race almost reduced all associations between neighborhood income inequality and birth outcomes. Similarly, because income is related to the social status and thus social relationships, controlling for maternal income almost reduced all associations between income inequality and social relationships (medium social support). Thus maternal race could be described as a partial mediator of the relationships and hence its adjustment may be unwarranted in studies.

To the best of our knowledge this study is the first cross-sectional design to evaluate relationships among census tract income inequality, social support and low birth weight and preterm births using a broader range of maternal socioeconomic status (income, education, marital status) and neighborhood contexts (poverty, median income, percent non-Hispanic black population). It is also the first study of its type to control for maternal and neighborhood income before examining the additional contribution of income inequality and maternal social processes on birth outcomes. Three previous studies [6, 21, 43] share some similarities with this study. Huynh et al. [21], found a mother's residence in a county with a high or medium level of income inequality to be associated with risk of preterm delivery or post neonatal mortality, and that the effect was strongest for non-Hispanic black infants compared to Whites. Another study in England showed that neighborhood income inequality was independently associated with low birth weight and very low birth weight [43]. Likewise Buka and colleagues [6], found effects of neighborhood support on low birth weight to be stronger for white mothers than non-Hispanic black mothers. However, our study is different from previous studies in recognizing and conceptualizing complexities of neighborhood income inequality as well as the modifying effects of race and social support in determining birth outcomes. The findings also reinforce the observation that causes of disparities in birth outcomes and other social relationships are distinct among the racial groups, primarily due to different neighborhood locations and overwhelming imbalance in the distribution of material and other social resources favoring predominantly white neighborhoods.

Nonetheless, the results of the study must be weighed against some limitations inherent in observational studies. First, measures of primary healthcare factors (availability, access to healthcare, quality, cultural competence of providers) as important determinants of healthcare use have the potential to reduce adverse effects of income inequality and other disadvantages among the racial groups. Our inability to control for any health system factors at the census tract level might have confounded the negative effects of income inequality across some population groups. Future studies should consider examining the role of healthcare system factors in mitigating the negative affects associated with high neighborhood income inequality. Second, the social support instrument used in this study was based on items originally intended for different population groups. Further, the extent to which the PRAMS study instrument has validity and reliability in regard to theoretical models of social support and the study population has not been evaluated. Third, the cross-sectional design of the study makes it almost impossible to infer causality, that is, it is not possible to establish temporal precedence of causal relations of neighborhood contexts, social processes and birth outcomes. Fourth, our data had relatively large missing data ($\approx 29\%$) on mothers' social support and income variables, thus the association between birth outcomes and income inequality may have been severely underestimated. Fifth, income inequality exposure categories were assessed at the census tract level, and it is unclear whether this is the most appropriate unit for assessing the effect of income distribution on maternal and child health outcomes. On one hand, if income inequality effects on healthcare are through budgetary and resource allocations or other political decisions made at the state level, then using the census tract as the unit of analysis may be inappropriate. On the other hand, if the connection is through increased maternal psychosocial factors due to neighborhood stressors, relative deprivations (resulting from widening socioeconomic gradients) or depletion of social support, then the census tract is the most appropriate unit for determining the effect of income inequality on maternal and child health outcomes in this study. Indeed, the results of this study and others suggest that census tract income inequality may directly affect health outcomes through impact on individual-level social and other socioeconomic factors related to residential segregation and social class status [32, 44, 45].

Conclusion

Although being poor increases the likelihood of living in disadvantaged neighborhoods, this study demonstrates that there seems to be additional contextual effects of income inequality that result in low birth weight but not preterm births. These effects are likely to be mediated by social support available in different neighborhoods with different levels of income distribution. Our results also indicate that income inequality, poverty, neighborhood percent of non-Hispanic black population and neighborhood median income may represent distinct constructs of disadvantages associated with deprivations. And that material deprivations resulting from unequal income distribution may actually provide a basis for the differences in observed social engagements or relationships across different neighborhood contexts. The policy implications of the study suggest that effective health interventions to address low birth weight and preterm births or other health disparities need to recognize the mediating and moderating processes of income distribution at the neighborhood level and other social determinants of unequal income distribution. Interventions to improve social support or networks need to recognize the levels of social resources or cohesion in each population subgroup to avoid adding support resources to those already available. It is important for public health advocacy to consider making proposals to municipal and state legislators to adopt living wage laws, for low income mothers or workers in order to meet basic needs for improved health outcomes across the state.

Acknowledgement The authors would like to express their deep appreciation to the South Carolina Department of Health and Environmental Control for their generous efforts in providing the geocoded data for the study. We are also grateful for the comments from anonymous reviewers and Editor-in-Chief of Maternal and Child Health Journal.

References

1. Cohen, S., Gottlieb, B. H., & Underwood, L. G. (2000). Social relationships and health. In *Social Support measurement and interventions-a guide for health and social scientists*: Oxford University Press: New York, NY.
2. Lynch, J., Smith, G. D., Hillemeier, M., Shaw, M., Raghunathan, T., & Kaplan, G. (2001). Income inequality, the psychosocial environment, and health: Comparisons of wealthy nations. *The Lancet, 358*, 194–200.
3. Uchino, B. N. (2004). *Social support and physical health*. New Haven: Yale University.
4. Marmot, M. G. (1998). Improvement of social environment to improve health. *Lancet, 351*, 57–60.
5. Buka, S. L., Brennan, R. T., Rich-Edwards, J. W., Raudenbush, S. W., & Earls, F. (2003). Neighborhood support and the birth weight of urban infants. *American Journal of Epidemiology, 157*, 1–8.
6. Norbeck, J. S., Dejoseph, J. F., & Smith, R. T. (1996). A randomized trial of an empirically-derived social support intervention to prevent low birth weight among African-American women. *Social Science and Medicine, 43*, 947–954.
7. Feldman, P. J., Dunkel-Schetter, C., Sandman, C. A., & Wadhwa, P. D. (2000). Maternal social support predicts birth weight and fetal growth in human pregnancy. *Psychosomatic Medicine, 62*, 715–725.
8. Elsenbruch, S., Beson, S., Rucke, M., Rose, M., Dudenhausen, J., Pincus-Knackstedt, M. K., et al. (2007). Social support during pregnancy: Effects on maternal depressive symptoms, smoking and pregnancy outcome. *Human Reproduction, 22*, 869–877.
9. Lynch, J., & Davey Smith, G. (2002). Income inequality and health: The end of the story? *International Journal Epidemiology, 31*, 549–551.
10. Berkman, L. F., Glass, T., Brissette, I., & Seeman, T. E. (2000). From social integration to health: Durkheim in the new millennium. *Social Science Medicine, 51*, 843–857.
11. Holtgrave, D. R., & Crosby, R. A. (2003). Social capital, poverty, and income inequality as predictors of gonorrhea, syphilis, Chlamydia and AIDS case rates in the United States. *Sexually Transmitted Information, 79*, 62–64.
12. Coburn, D. (2000). Income inequality, social cohesion and the health status of populations: The role of neo-liberalism. *Social Science Medicine, 51*, 135–146.
13. Cooper, R. S. (2001). Social inequality, ethnicity and cardiovascular disease. *International Journal Epidemiology, 30*, S48–S52.
14. Wilkinson, R. G., & Pickett, K. E. (2006). Income inequality and population health: A review and explanation of the evidence. *Social Science Medicine, 62*, 1768–1784.
15. SCAN PRAMS. http://scangis.dhec.sc.gov/scan/prams2/support/aboutprams.htm. Accessed 5 Dec 2007.
16. Martin, J. A., Hamilton, B. E., Sutton, P. D., Ventura, S. J., Menacker, F., & Munson, M. L. (2003). Births: Final data for 2003 national vital statistics. *Reports-Center for Disease Control and Prevention, 54*(2), 1–25.
17. Kids Count. http://www.sckidscount.org/report05/nopre.asp. Accessed 26 May 2007.
18. David, R. J., & Collins, J. W. (1997). Differing birth weight among infants of U.S. born Blacks, African-born Blacks and U.S. born Whites. *The New England Journal of Medicine, 337*, 1209–1214.
19. Collins, J. W., Jr., David, R. J., Prachland, N. G., & Pierce, M. L. (2003). Low birth weight across generations. *Maternal and Child Health Journal, 7*, 229–237.
20. Okah, F. A., Cai, J., & Hoff, G. L. (2005). Term-gestation low birth weight and health-compromising behaviors during pregnancy. *Obstetrics and Gynecology, 105*, 543–550.
21. Huynh, M., Parker, J. D., Harper, S., Pamuk, E., & Schoendorf, K. C. (2005). Contextual effect of income inequality on birth outcomes. *International Journal of Epidemiology, 34*, 888–895.
22. Wilkinson, R. G. (2004). Why is violence more common where inequality is greater? *Annals of New York Academy of Sciences, 1036*, 1–12.
23. Wilkinson, R. G. (2006). The impact of inequality. *Social Research, 73*, 711–732.
24. Carey, R. T., & Becker, R. H. (2006). *The South Carolina-US income gap analysis data*. The Strom Thurmond Institute.
25. Gallant, M. P. (2003). The influence of social support on chronic illness self-management: A review and directions for research. *Health Education & Behavior, 30*, 170–195.
26. World Bank. (2007). *Poverty analysis: Measuring inequality*. http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTPOVERTY/EXTPA. Accessed 17 Sept 2007.
27. Kawachi, I., Kennedy, B. P., Lochner, K., & Prothrow-Stith, D. (1997). Social capital, income inequality, and mortality. *American Journal of Public Health, 87*, 1491–1498.
28. Fiscella, K., & Franks, P. (1997). Poverty or income inequality as predictor of mortality: Longitudinal cohort study. *British Medical Journal, 314*, 1724–1728.
29. LeClere, F. B., & Soobader, M.-J. (2000). The effect of income inequality on the health of selected US demographic groups. *American Journal Public Health, 90*, 1892–1897.
30. Schulz, A., & Northridge, M. A. (2004). Social determinants of health: Implications for environmental health promotion. *Health Education & Behavior, 3*, 455–471.
31. Ellen, I. G. (2000). Is segregation bad for your health? The case of low birth weight. *Brookings-Wharton Papers on Urban Affairs*.
32. Ronzio, C. R. (2003). Urban premature mortality in the U.S. between 1980 and 1990: Changing roles of income inequality and social spending. *Journal of Public Health Policy, 24*, 386–400.
33. Massey, D. S., & Fischer, M. J. (2000). How segregation concentrates poverty. *Ethnicity Racial Studies, 23*, 670–691.
34. Cohen, P. N. GINI code. www.unc.edu/~pnc/gini.sas. Accessed 1 Dec 2007.
35. Ronzio, C. R., Pamuk, E., & Squires, G. D. (2004). The politics of preventable deaths: Local spending, income inequality, and premature mortality in US cities. *Journal of Epidemiology and Community Health, 58*, 175–179.
36. Schabenberger, O. (2006). *Introducing the GLIMMIX procedure for generalized linear mixed models. Statistics and data analysis paper 196–230*. Cary, NC: SAS Institute Inc.

37. Subramanian, S. V., Belli, P., & Kawachi, I. (2002). The macroeconomic determinants of health. *Annual Review of Public Health, 23*, 287–302.
38. Subramanian, S. V., & Kawachi, I. (2004). Income inequality and health: What have we learned so far? *Epidemiology Reviews, 26*, 78–91.
39. Savitz, D. A. (2003). *Interpreting epidemiologic evidence—strategies for study design and analysis*. New York: Oxford University Press.
40. Greenberg, R. S., & Kleinbaum, D. G. (1985). Mathematical modeling strategies for the analysis of epidemiologic research. *Public Health Annual Review, 6*, 223–245.
41. Dibben, C., Sigala, M., & Macfarlane, A. (2006). Area deprivation, individual factors and low birth weight in England: Is there evidence of an “area effect”? *Journal of Epidemiology and Community Health, 60*, 1053–1059.
42. Wagstaff, A., & Doorslaer, V. (2000). Income inequality and health: What does the literature tell us? *Annual of Review Public Health, 21*, 543–567.
43. Macinko, J. A., Shi, L., Starfield, B., & Wulu, J. T. (2003). Income inequality and health: A critical review of the literature. *Medical Care Research Review, 60*, 407–452.
44. Soobader, M.-J., & LeClere, F. B. (1999). Aggregation and the measurement of income inequality: Effects on morbidity. *Social Science and Medicine, 48*, 733–744.
45. Muramatsu, N. (2003). County-level income inequality and depression among older Americans. *Health Services Research, 38*, 1863–1884.