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SOCIAL INEQUALITIES

Contextual effect of income inequality on birth outcomes

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Background Though associations between income inequality and birth outcome have been suggested, mechanisms underlying this relationship are not known. In this analysis, we examined the relationship between income inequality and preterm birth (PTB) and post-neonatal mortality (PNM) to explore two potential mechanisms—the proposed psychosocial stress and neo-material pathways.

Methods Data on singleton births from 1998 to 2000 were obtained from the CDC's National Center for Health Statistics' Linked Birth and Infant Death files. The Gini Index was utilized to measure income inequality and was divided into tertiles representing high, medium, and low county-level inequality. To determine the association between the birth outcomes and county income inequality and to account for clustering within counties, we employed generalized estimating equation (GEE) modelling.

Results PTB increased from 8.3% in counties with low income inequality to 10.0% in counties with high inequality. The Gini Index remained modestly associated with PTB after adjusting for individual level variables and mean county-level per capita income within the total population (AOR: 1.06; 95% CI 1.03–1.09) as well as within most of the racial/ethnic groups. PNM increased from 1.15 deaths per 1000 live births in low inequality counties to 1.32 in high-inequality counties. However, after adjustment, income inequality was only associated with PNM within the non-Hispanic black population (AOR: 1.20; 95% CI 1.03–1.39).

Conclusions These findings may provide some support for the association between income inequality and PTB. Further research is required to elucidate the biological mechanisms of income inequality.

Keywords Income inequality, Gini coefficient, preterm birth, post-neonatal mortality

The role of community or contextual level variables in health has only recently received in-depth examination. Factors such as social capital, residential segregation, and community level of violence have all been found to be associated with a variety of health outcomes.[1–10] However, a number of studies refute a relationship between community-level characteristics and health.[11–18] Income inequality is one such community-level factor whose effect has been the source of ongoing debate. Defined as an unequal distribution of income within a population, income inequality has been linked to various health outcomes, such as premature mortality, depression, and homicide.[19–22] Issues complicating the interpretation of studies examining the effect of income inequality on health include the populations analysed (heterogeneous vs homogeneous; i.e. US population sample vs Japanese population sample), the consistency of the relationship across health outcomes, the possible confounding or modifying of the relationship by individual-level social position and race, and the elucidation of the underlying biological pathways.[23]

Income inequality has been theorized to operate through several biological pathways. The neo-material interpretation proposes that the inequalities in an individual's access to opportunities and material goods, as well as differential systemic lack of investment in social and physical infrastructure, result in health inequalities.[24] The inequitable distribution of income within a community above and beyond individual wealth, or lack thereof, is one reflection of this disparity in

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opportunities and infrastructure.[24] A second pathway emphasizes more direct biological effects of income inequality; the psychosocial environment interpretation suggests that physiological stress results from the perception that one's social position is inferior to that of his peers.[24,25]

About 50 years ago, researchers in England and Wales found that although there was disparity in mortality rates between the social classes across the lifespan, the greatest disparity existed among infants during the post-neonatal period, defined as 28 days–1 year of age.[26] Thus, the individual and societal material deprivations hypothesized under the neo-material interpretation of income inequality may have a direct influence on infants in the post-neonatal period.[24] This interpretation focuses on the cumulative assault on health by the lack of investment in societal infrastructure and of available resources, which may have the most dire consequences for those with the least individual resources or at the lowest end of the socioeconomic continuum.[23] At the micro level, income inequality affects health by reducing individual resources so that illnesses cannot be readily prevented or treated.[23] The macro effects of income inequality manifest themselves in the lack of or reduced investment in community resources, which support a healthy lifestyle for those with the least individual resources.[23]

The psychosocial environment interpretation of income inequality underscores the injurious effects of stress on health outcomes.[24] Like the neo-material interpretation, the psychosocial environment interpretation has micro and macro considerations. At the micro level, the constant comparison of social status produces increased levels of stress resulting in poor health.[23] However, on the macro level, this competition creates unhealthy communities (higher crime, poor housing, etc.) by reducing trust and social bonds.[23] Stress has previously been shown to be associated with preterm birth (PTB) (less than 37 weeks gestation)[23,24,27–29] and an association between PTB and income inequality may be examined in that light.

The current analysis was performed in an effort to examine several of the issues surrounding income inequality. The primary objective of this project was to examine the relationship between income inequality at the county level and two birth outcomes, PTB and post-neonatal mortality (PNM), in a population-based sample of US births. Second, we assessed if these relationships remained significant following the inclusion of maternal race/ethnicity and education, a proxy measure for individual-level social position; maternal education is the only individual measure of social position available on birth certificates.

Materials and methods

Study design and sample

We utilized data from the National Linked Birth and Infant Death Dataset compiled by the CDC's National Center for Health Statistics. These data comprise information from birth certificates registered in the US linked to death certificate information. Maternal demographic (race/ethnicity, age, state and county of residence, etc), maternal and infant biological (parity, medical conditions, gestational age, birth weight, etc.), and mortality (underlying cause of death, age at death, etc.) information is included in the dataset.

Data from 1998 to 2000 were used corresponding to the most recent county-level census income data. Separate study populations were created for each birth outcome. The PTB analysis was restricted to singleton infants who were born to non-Hispanic white, non-Hispanic black, Hispanic, and non-Hispanic Asian/Pacific Islander (API) US residents. The number of births from other racial/ethnic groups was too small to include in the analysis. The population was limited to mothers ⩾20 years of age to minimize the effect of maternal age on the evaluation of maternal education. Additionally, births with congenital anomalies were removed from the sample since birth defects are associated with PTB and may be less likely to be influenced by income inequality. The final number of births for the PTB analysis was 9 175 832 births. The PNM analysis was restricted to singleton births with birth weight >2500 g, in addition to the exclusionary criteria above (n = 8 683 986). Excluding infants born with a birth weight <2500 g decreased the possibility of PTB or low birth weight related co-morbidities contributing to PNM and confounding the relationship with income inequality.

Birth outcomes

PTB was defined as <37 completed weeks of gestation. Gestational age was calculated from last menstrual period or the clinical estimate of gestation recorded on the birth certificate. Births with weights that were implausible for the gestational age were excluded from the analyses.[30] PNM was defined as death occurring between 28 days and 1 year of age and was determined from age at death on the death certificate. The PNM rate was calculated as the number of post-neonatal deaths of normal birth weight infants per 1000 live normal birth weight births.

Primary exposure and selected covariates

Income inequality was measured by the Gini Index, calculated using Census 2000 grouped income data. The Gini Index is based on the Lorenz curve, a frequency curve characterizing the distribution of a variable (i.e. income), and an estimate of the area between the curve and a diagonal line representing uniform distribution.[31] The index ranges from zero to one with a higher score indicating greater income inequality. In this analysis, the Gini Index was calculated for each county in the US, using 16 US Census created categories of income distribution. Each eligible record from the Linked Birth and Infant Death Database was matched to its corresponding Gini Index utilizing state and county of residence Federal Information Processing Standards (FIPS) codes. The Gini Index was categorized into tertiles of county exposure: Low Gini, Medium Gini, and High Gini. Therefore, each tertile is composed of similar numbers of counties but not necessarily a similar number of births. We employed county-level income inequality because the smallest geographical data for births and deaths available is at the county level.

The two covariates of interest, maternal race/ethnicity and education, are found on the birth certificate. Maternal race/ethnicity was coded as non-Hispanic black, non-Hispanic white, Hispanic, or non-Hispanic API. Maternal education was categorized as <12 years of schooling (less than high school), completing 12 years (high school), 13–15 years (more than high school but less than college), and ⩾16 years (college or higher).

Other demographic and biological covariates include maternal age, marital status, parity (low and high), and a maternal risk profile variable. Parity was defined as high if the mother was <25 years where the current birth was the third or of higher order.[30] Mothers who were >25 years and the current birth the fourth or of higher order were also designated high parity. All other mothers were designated as low parity.[30] The maternal risk profile variable was based on high or low parity, maternal education, maternal age, and marital status.[30] High risk was defined as mothers who were unmarried, had <12 years of education, and were primiparae aged >30 years or high-parity multiparae. Mothers were classified as low risk if they were married, had ⩾13 years of education, and were primiparae aged 20–29 years or low-parity multiparae >20 years of age. All other mothers were classified as medium risk. Additionally, mean county-level per capita income was entered as a proxy measure of overall county resources.

Statistical analyses

Descriptive analysis was performed to characterize the population. To examine whether maternal race/ethnicity or education modified the relationship between income inequality and the birth outcome, the trends in the outcomes by tertiles of the Gini index were evaluated both overall and stratified by race/ethnicity and education. We employed the Cochran–Armitage trend test to determine statistical significance.[32] Owing to the clustered nature of the data with a contextual exposure variable, generalized estimating equation (GEE) modelling was utilized to account for any correlation between observations within the counties.[33] We employed the GENMOD procedure and the REPEATED option (SAS version 8.0, Cary, NC).

Results

The maternal demographic and biological characteristics for the PTB analysis stratified by maternal race/ethnicity are given in Table 1. Minority births composed a third of the study population. Non-Hispanic black and Hispanic mothers tended to

Table 1 Demographic and biological variables by maternal race/ethnicity

Variable	Total (*n* = 9 175 832)	White, non-Hispanic (*n* = 5 793 504; 63.1%)	Black, non-Hispanic (*n* =1 242 995; 13.5%)	Hispanic (*n* = 1 694 963; 18.5%)	Asian/Pacific Islander, non-Hispanic (*n* = 444 370; 4.8%)
Maternal age (%)					
20–24 years	28.3	24.3	40.6	36.4	14.9
25–29 years	31.2	31.2	28.8	32.1	32.8
30–34 years	25.8	28.2	18.9	20.6	32.9
35+ years	14.7	16.2	11.6	10.9	19.3
Maternal education (%)					
<12 years	16.1	8.2	16.5	44.6	9.9
12 years (HS)	32.0	30.9	41.1	30.9	23.7
13–15 years	24.4	26.4	27.9	15.7	21.7
16+ years	27.5	34.5	14.5	8.8	44.6
Marital status (%)					
Married	74.0	83.2	38.3	64.6	89.0
Parity[a] (%)					
Primiparity	35.6	37.9	28.9	29.9	45.5
Low parity	61.8	67.4	45.6	50.0	78.8
High parity	38.2	32.6	54.4	50.0	21.2
Risk level[b] (%)					
Low risk	39.8	47.0	23.6	24.1	52.1
Medium risk	41.1	35.8	58.6	50.0	26.5
High risk	19.1	17.2	17.8	25.9	21.4
County income inequality level (%)					
Low Gini	24.3	31.4	12.9	10.3	15.9
Medium Gini	35.3	37.8	27.5	30.8	42.5
High Gini	40.4	30.8	59.6	58.9	41.6

Study population is 9 175 832 singleton live births in 1998–2000 to mothers ⩾20 years who are US residents, excluding births with congenital anomalies.

[a] Parity was defined as high if the participant was <25 years and the current birth was categorized as the third or of higher order.[30] Mothers who were >25 years and the current birth was defined as the fourth or of higher order were also designated high parity. All others were designated as low parity.

[b] The maternal risk profile variable was based on high or low parity, education, maternal age, and marital status.[30] High risk was defined as mothers who were unmarried, had <12 years of education, and were primiparae aged >30 years or high-parity multiparae. Mothers were classified as low risk if they were married, had ⩾13 years of education, and were primaparae aged 20–29 years or low-parity multiparae >20 years of age. All other mothers were classified as medium risk.

be younger, with >60% of their population <30 years of age. Maternal educational attainment varied by maternal race/ethnicity. Overall, 16% of the study population had received less than a high school education. In contrast, within the Hispanic group, >40% of the mothers attended school for <12 years. A large percentage of the study population (74%) was married. Rates of marriage ranged from ~40% for the non-Hispanic black group to almost 90% of the non-Hispanic API group. Parity and risk-level rates also varied by maternal racial/ethnic group. There was substantial variation in the income inequality level of the county of residence. Whereas almost a third of the non-Hispanic white mothers resided in a county categorized with low-income inequality, <15% of the minority groups did so. Overall, mothers who were non-Hispanic black or Hispanic, less educated, or unmarried were more likely to live in high inequality counties than were other mothers (data not shown).

Preterm birth (PTB)

As seen in Table 2, 9% of the total births were categorized as preterm. Non-Hispanic black mothers experienced approximately twice as many PTBs as compared with white mothers (14.8% vs 7.9%). The percentage of Hispanic PTBs was similar to the overall study population. The trend relationship between PTB and income inequality by maternal race/ethnicity and education is also presented in Table 2. For the total study population, as seen in the first column, there was a statistically significant trend of increasing proportion of PTBs across the income inequality gradient and this trend remained significant across maternal education levels ($P < 0.0001$). Following stratification by maternal race/ethnicity, a similar trend was reflected in all of the racial/ethnic groups except for non-Hispanic APIs, where the trend is in the opposite direction.

Crude and adjusted odds ratios for PTB in relation to income inequality are given in Table 3. The first model adjusted for maternal race/ethnicity and education; the second included an additional individual level variable (maternal risk level); and a third model fully adjusted for the above individual level variables, as well as mean county-level per capita income. The odds ratio for the total study population dramatically decreased following adjustment for race/ethnicity. However, in the fully adjusted model, living in a county with high-income inequality remained modestly associated with PTB (AOR: 1.06; 95% CI 1.03–1.09). This limited effect was also seen in each racial/ethnic group with the exception of the non-Hispanic API

Table 2 Percentage preterm birth by county income inequality level, maternal education level, and maternal race/ethnicity

Maternal race/ethnicity an county income inequality	Total (%)	<12 years (%)	12 years (%)	13–15 years (%)	16+ years (%)
Total	9.2	11.1	10.0	9.0	7.2
Low Gini	8.3	10.2	9.0	8.1	7.0
Medium Gini	8.8	10.6	9.6	8.6	7.1
High Gini	10.0	11.7	11.0	9.9	7.5
Trend *P*-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
White, non-Hispanic	7.9	10.4	8.7	7.9	6.7
Low Gini	7.7	9.7	8.5	7.6	6.7
Medium Gini	7.9	10.4	8.6	7.8	6.7
High Gini	8.2	11.2	9.1	8.3	6.8
Trend *P*-value	<0.0001	<0.0001	<0.0001	<0.0001	0.01
Black, non-Hispanic	14.8	17.3	15.3	13.9	12.3
Low Gini	13.5	16.0	14.1	12.9	11.8
Medium Gini	14.3	16.5	14.8	13.4	12.0
High Gini	15.4	17.8	15.8	14.4	12.6
Trend *P*-value	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Hispanic	9.4	9.9	9.4	8.9	8.1
Low Gini	9.2	9.7	9.1	8.7	7.9
Medium Gini	9.1	9.5	9.1	8.6	8.0
High Gini	9.6	10.1	9.5	9.1	8.2
Trend *P*-value	<0.0001	<0.0001	<0.0001	0.0005	0.25
Asian Pacific/Islander, non-Hispanic	8.4	10.7	9.5	8.7	7.2
Low Gini	8.8	12.0	10.1	9.2	7.5
Medium Gini	8.3	10.5	9.2	8.5	7.1
High Gini	8.4	10.5	9.5	8.8	7.3
Trend *P*-value	0.06	0.01	0.15	0.35	0.46

Study population is 9 175 832 singleton live births in 1998–2000 to mothers ⩾20 years of age who are US residents, excluding births with congenital anomalies.

group. Income inequality seemed to exert the most effect within the non-Hispanic black group. A small reduction in risk was seen between the fully adjusted models without and with mean county-level per capita income.

Post-neonatal mortality (PNM)

The population utilized for the PNM analysis was slightly smaller than the analysis population for PTB owing to the exclusion of births weighing <2500 grams. However, the demographic and biological characteristics of the births included in this analysis were similar to those shown in Table 1. As shown in Table 4, there were 1.24 post-neonatal deaths per 1000 live births for the total population. Non-Hispanic black infants experienced post-neonatal death at more than twice the rate of the other racial ethnic groups. Like PTB, the greatest proportion of post-neonatal deaths occurred for the least educated mothers.

As shown in Table 4, the unstratified trend relationship between post-neonatal deaths and income inequality in the total population was statistically significant ($P < 0.0001$). Following stratification by maternal race/ethnicity and education, consistent significant trends were not seen in this analysis of post-neonatal deaths, with substantial variation by maternal race/ethnicity and education level.

The crude and adjusted odds ratios for PNM are given in Table 5. Like the PTB analysis, the odds ratio found for the total study population was dramatically smaller within each racial/ethnic group. However, among the non-Hispanic black mothers, exposure to a medium-level of income inequality increased the risk of post-neonatal death after adjusting for education, risk level, and mean county-level per capita income (AOR: 1.20; 95% CI 1.03–1.39). The stratified analysis showed no significant relationships within the other racial/ethnic groups.

Discussion

For the overall study population, county-level income inequality was associated with PTB, after adjustment for maternal race/ethnicity and maternal education, an individual-level measure of social position. The inclusion of maternal race/ethnicity and education in the PTB models substantially reduced the odds ratios of county-level income inequality but did not eliminate its effect. Additionally, the odds ratios of county-level income inequality did not change after the inclusion of mean county-level per capita income. The modest relationship maintained statistical significance following adjustment for or stratification by race/ethnicity and maternal education, indicating that income inequality is not entirely a surrogate measure for those individual-level demographic factors. The complete lack of significant results in the non-Hispanic API group may be owing to the inherent heterogeneity

Table 3 Crude and adjusted odds ratios for preterm birth (PTB) according to county income inequality, stratified by maternal race/ethnicity

Maternal race/ethnicity and county income inequality	Crude OR	AOR[a]	AOR[b]	AOR[c]
Total study population				
Low Gini	Referent	Referent	Referent	Referent
Medium Gini	1.07 (1.03–1.07)	1.02 (0.99–1.04)	1.01 (0.98–1.04)	1.01 (0.98–1.04)
High Gini	1.23 (1.18–1.29)	1.08 (1.04–1.07)	1.07 (1.04–1.10)	1.06 (1.03–1.09)
White, non-Hispanic				
Low Gini	Referent	Referent	Referent	Referent
Medium Gini	1.02 (0.99–1.05)	1.02 (1.00–1.05)	1.02 (0.99–1.05)	1.02 (0.99–1.04)
High Gini	1.06 (1.02–1.10)	1.07 (1.04–1.11)	1.06 (1.03–1.10)	1.05 (1.02–1.08)
Black, non-Hispanic				
Low Gini	Referent	Referent	Referent	Referent
Medium Gini	1.08 (1.03–1.13)	1.05 (1.00–1.10)	1.05 (1.00–1.10)	1.05 (1.00–1.10)
High Gini	1.17 (1.12–1.23)	1.13 (1.08–1.19)	1.13 (1.08–1.19)	1.12 (1.07–1.18)
Hispanic				
Low Gini	Referent	Referent	Referent	Referent
Medium Gini	0.99 (0.94–1.04)	0.98 (0.94–1.04)	0.98 (0.93–1.03)	0.98 (0.93–1.03)
High Gini	1.05 (1.00–1.10)	1.04 (0.99–1.10)	1.04 (0.99–1.09)	1.04 (0.99–1.08)
Asian/Pacific Islander, non-Hispanic				
Low Gini	Referent	Referent	Referent	Referent
Medium Gini	0.93 (0.85–1.02)	0.92 (0.85–0.99)	0.91 (0.85–0.98)	0.91 (0.87–0.99)
High Gini	0.95 (0.89–1.02)	0.94 (0.88–1.00)	0.94 (0.88–1.00)	0.93 (0.85–0.98)

Study population is 9 175 832 singleton live births in 1998–2000 to mothers ⩾20 years of age who are US residents, excluding births with congenital anomalies.

[a] Adjusted for maternal education (and maternal race/ethnicity in models for total population).

[b] Adjusted for maternal education, risk level (and maternal race/ethnicity in models for total population).

[c] Adjusted for maternal education, risk level, county per capita income (and maternal race/ethnicity in models for total population).

Table 4 Post-neonatal deaths per 1000 live births by county income inequality, maternal education, and maternal race/ethnicity

Maternal race/ethnicity and county income inequality	Total	<12 years	12 years	13–15 years	16+ years
Total	1.24	2.16	1.52	1.02	0.58
Low Gini	1.15	2.22	1.45	0.97	0.61
Medium Gini	1.21	2.16	1.53	0.98	0.56
High Gini	1.32	2.13	1.55	1.13	0.58
Trend *P*-value	<0.0001	0.46	0.09	0.02	0.50
White, non-Hispanic	1.11	3.06	1.42	0.91	0.53
Low Gini	1.10	2.77	1.40	0.92	0.60
Medium Gini	1.09	3.01	1.42	0.88	0.50
High Gini	1.12	3.37	1.45	0.94	0.51
Trend *P*-value	0.59	0.005	0.54	0.72	0.05
Black, non-Hispanic	2.34	4.22	2.52	1.70	1.05
Low Gini	1.92	3.47	2.39	1.59	0.78
Medium Gini	2.52	4.27	2.96	1.67	1.23
High Gini	2.35	4.30	2.34	1.74	1.05
Trend *P*-value	0.06	0.25	0.09	0.47	0.41
Hispanic	1.01	1.15	1.00	0.85	0.61
Low Gini	1.00	1.12	1.01	0.88	–[a]
Medium Gini	1.03	1.17	0.99	0.87	0.65
High Gini	1.01	1.15	1.01	0.84	0.59
Trend *P*-value	0.91	0.95	0.97	0.80	0.65
Asian Pacific/Islander, non-Hispanic	0.90	1.18	1.24	0.98	0.62
Low Gini	0.89	–[a]	–[a]	–[a]	0.70
Medium Gini	0.87	1.30	1.07	1.01	0.58
High Gini	0.94	1.37	1.42	0.85	0.63
Trend *P*-value	0.58	0.04	0.36	0.24	0.82

Study population is 8 683 986 singleton live births in 1998–2000 to mothers ⩾20 years of age who are US residents, excluding births with congenital anomalies or birth weight <2500 g.

[a] Rates based on <20 deaths are considered unreliable and are not presented.

of the API group. This group is composed of individuals from a variety of ethnic backgrounds whose individual characteristics are extremely diverse. Within our study population, no one ethnic group dominated the non-Hispanic API group. The predominant group within the non-Hispanic API cohort was categorized as 'combined other Asian or Pacific Islander' (21.3%). The largest single ethnic group was Chinese-American (18.1%). In comparison, a substantial majority of the Hispanic population is composed of Mexican-Americans (71.5%).

This analysis may provide some evidence in support of an association between income inequality and PTB mediated by psychosocial factors. The biological mechanism of psychosocial stress lies in the person–environment interaction.[29] The perception of a disparity in social position based on individual resources (material, social, psychological, or biological) relative to one's peers can threaten the health of an individual.[24] Birth may be precipitously induced by the stress-induced activation of the maternal-placental-fetal endocrine systems.[28] In addition, maternal stress may also influence the immune response to infections, which can result in stimulation of pro-inflammatory mechanisms and premature birth.[28]

There has been little previous research on the association between income inequality and PTB. However, researchers have found associations between PTB and other community-level variables. Census tract level variables such as median household income, proportion of unemployed males, and prevalence of female headed households have been found to be related to PTB at varying significance.[34–36]

The effect of income inequality on PNM was not as consistent as on PTB. These inconsistent findings are similar to those in the literature. Szwarcwald *et al*. demonstrated that the Gini Index was not correlated with PNM in a population of Brazilian infants.[37] However, an index that measured concentration of poverty was significantly correlated to PNM following adjustment for neighbourhood poverty rate and average monthly income.[37] Other research has indicated that community-level factors such as the distribution of lower salaries, low median income, concentration of poverty, high crime, and limited access to primary care, are associated with PNM.[38,39] These findings indicate that PNM may be more influenced by an absolute lack of resources than by relative differences in the availability of resources.

Table 5 Crude and adjusted odds ratios for post-neonatal mortality (PNM) according to county income inequality, stratified by maternal race/ethnicity

Maternal race/ethnicity and county income inequality	Crude OR	AOR[a]	AOR[b]	AOR[c]
Total study population				
Low Gini	Referent	Referent	Referent	Referent
Medium Gini	1.06 (0.97–1.15)	1.02 (0.95–1.09)	1.02 (0.95–1.09)	1.01 (0.94–1.08)
High Gini	1.15 (1.05–1.26)	1.02 (0.95–1.10)	1.02 (0.95–1.09)	1.00 (0.93–1.07)
White, non-Hispanic				
Low Gini	Referent	Referent	Referent	Referent
Medium Gini	0.99 (0.90–1.08)	0.98 (0.91–1.06)	0.98 (0.91–1.06)	0.97 (0.90–1.05)
High Gini	1.02 (0.92–1.12)	1.03 (0.95–1.12)	1.03 (0.95–1.12)	1.01 (0.93–1.09)
Black, non-Hispanic				
Low Gini	Referent	Referent	Referent	Referent
Medium Gini	1.32 (1.11–1.57)	1.20 (1.03–1.41)	1.20 (1.02–1.40)	1.20 (1.03–1.39)
High Gini	1.23 (1.05–1.44)	1.08 (0.94–1.26)	1.08 (0.93–1.25)	1.08 (0.92–1.27)
Hispanic				
Low Gini	Referent	Referent	Referent	Referent
Medium Gini	1.02 (0.85–1.23)	1.01 (0.84–1.21)	1.00 (0.84–1.20)	1.00 (0.83–1.19)
High Gini	1.00 (0.84–1.21)	1.00 (0.83–1.20)	0.99 (0.83–1.19)	0.99 (0.82–1.18)
Asian/Pacific Islander, non-Hispanic				
Low Gini	Referent	Referent	Referent	Referent
Medium Gini	0.99 (0.69–1.43)	0.96 (0.68–1.37)	0.96 (0.68–1.37)	0.96 (0.68–1.36)
High Gini	1.07 (0.76–1.50)	1.05 (0.76–1.46)	1.06 (0.76–1.46)	1.05 (0.76–1.45)

Study population is 8 683 986 singleton live births in 1998–2000 to mothers ⩾20 years of age who are US residents, excluding births with congenital anomalies or birth weight <2500 g.

[a] Adjusted for maternal education (and maternal race/ethnicity in models for total population).

[b] Adjusted for maternal education, risk level (and maternal race/ethnicity in models for total population).

[c] Adjusted for maternal education, risk level, county per capita income (and maternal race/ethnicity in models for total population).

The results of the adjusted regression models (i.e. the smaller effect of income inequality and the lack of a gradient from medium to high income inequality for the total study population, as well as within each racial/ethnic group) do not support an association between PNM and income inequality. However, an effect of residing in medium and high income inequality counties for the non-Hispanic black population was found. According to the neo-material interpretation, income inequality and its resulting lack of investment in resources most dramatically affects the groups with the least absolute individual resources whereas other groups may be better at compensating with personal resources.[23] In this study, the non-Hispanic black mothers seem to have the fewest socioeconomic resources. The non-Hispanic black mothers are the youngest and the least likely to be married of the racial/ethnic groups; in addition almost 60% of the non-Hispanic black mothers have a high school education or less.

The ability to observe a relationship between income inequality and PNM in the overall study population may require the utilization of a different geographic level. The deprivations associated with the neo-material interpretation may vary depending on the size of the geographic area from which income inequality is calculated. For instance, state-level inequality may have greater influence on the availability of health care or other related services (e.g. Medicaid, SCHIP or WIC) than does county-level inequality. Alternatively, county-level inequality may have a more direct influence on the proximity of individual health providers or other services beneficial to one's health. For some psychosocial or material factors, the county level may be too coarse to examine relevant exposures; however, it is the smallest geographical area available using US national data.

The analysis shows that there is a modest but consistent relationship between income inequality and PTB that is not fully explained by the measured individual-level characteristics. These results, as well as the more isolated association of income inequality and PNM in the non-Hispanic black population merit further research to delineate the potential mechanism(s) underlying relationships between income inequality and health. Exploring the consistency of the association between income inequality and birth outcomes at various geographic levels (i.e. state, county, neighbourhood, and census tract levels) may help increase the understanding of the connection between community characteristics and individual health.

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KEY MESSAGES

- Income inequality is associated with preterm birth in a cohort of US births, as well as within several racial/ethnic groups.
- This association is independent of a mother's individual level of social position, as measured by educational attainment, and mean county-level per capita income.

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