Published in final edited form as:

Matern Child Health J. 2017 August ; 21(8): 1616–1626. doi:10.1007/s10995-016-2251-2.

Transgenerational Transmission of Preterm Birth Risk: The Role of Race and Generational Socio-economic Neighborhood Context

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Abstract

Objectives—We investigated associations of mothers' preterm birth (PTB) status with her infants' PTB risk. We also examined whether this relationship differs by mothers' race and generational socio-economic neighborhood context.

Methods—Participants were 6,592 non-Hispanic (NH) white and NH black mother-infant pairs born in 2009–2011 and 1979–1998, respectively, in Allegheny County, Pennsylvania. Birth records were used to determine gestational age at birth, PTB status (<37 completed weeks of gestation), and PTB subgroups - late and early PTB (34–36 weeks and <34 completed weeks of gestation, respectively). Census data on tract racial composition and household income were used to characterize residential race and economic environment. Logistic regression models were used to calculate Odds Ratios (ORs), Relative Risk Ratios (RRR), and 95% confidence intervals (CIs). Stratified analyses were conducted to assess effect modification.

Results—Overall, 8.21%, 6.63% and 1.58% infants had PTB, LPTB, and EPTB, respectively. Maternal PTB status was associated with a 46% increase in infant PTB (95%CI:1.08–1.98), EPTB (95%CI:0.80–2.69), and LPTB (95%CI:1.04–2.04) risk. Maternal PTB-infant PTB associations, particularly maternal PTB-infant LPTB associations, were stronger among NH blacks, mothers in neighborhoods with a high percentage of NH black residents in both generations, or mothers who moved to neighborhoods with a higher percentage of NH black residents.

Conclusions for Practice—Race and generational socio-economic neighborhood context modify transgenerational transmission of PTB risk. These findings are important for identification of at-risk populations and to inform future mechanistic studies.

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Conflicts of Interest

The authors declare that they have no conflict of interest.

Keywords

Intergenerational; transgenerational; preterm birth; neighborhood; socio-economic status

Introduction

Nationally, preterm birth (PTB), birth before 37 completed weeks of gestation, and associated conditions are responsible for about 35% of infant deaths, making it the single most important cause of infant death (Mathews & MacDorman, 2013). The burden of infant death from prematurity is even higher in some communities. In Allegheny County, Pennsylvania, prematurity and its associated conditions account for 60% of infant deaths (R. Voorhees MD former Acting Director of the Allegheny County Health Department, personal communication, November 26, 2014). Further, PTB has both short-term and long-term consequences for surviving infants, including increased risk for neurological, pulmonary, ophthalmic, and cardiometabolic disorders (Institute of Medicine (US) Committee on Understanding Premature Birth and Assuring Healthy Outcomes, 2007; Sipola-Leppanen et al., 2015; Tepper et al., 2012).

Previous research on risk factors for PTB has largely focused on maternal characteristics (e.g. race, young/advanced age) and perinatal health (e.g. genital tract infection, history of delivering a preterm infant) (Foxman et al., 2014; Tepper et al., 2012). Recent evidence suggests transgenerational transmission of PTB risk. Researchers have reported 1.18–1.54-fold increases in risk of delivering a preterm infant for mothers born preterm (Porter, Fraser, Hunter, Ward, & Varner, 1997; Shah, Shah, & Knowledge Synthesis Group On Determinants Of Preterm/1, 2009; Swamy, Ostbye, & Skjaerven, 2008; Wilcox, Skjaerven, & Lie, 2008).

Other researchers, however, did not find similar associations between maternal and infant PTB status (Castrillio, Rankin, David, & Collins Jr, 2014; Klebanoff, Meirik, & Berendes, 1989; Klebanoff, Schulzinger, Mednick, & Secher, 1997; Magnus, Bakketeig, & Skjaerven, 1993; Selling, Carstensen, Finnstrom, & Sydsjo, 2006). Besides the inconsistency, it is not clear whether associations differ by PTB subgroups, early PTB (birth <34 weeks) and late PTB (birth between 34–36 weeks), maternal race, or neighborhood socio-economic context (Wilcox et al., 2008).

Baseline rates of PTB (Hamilton, Martin, Osterman, & Curtin, 2015), risk factors for PTB (such as cigarette smoking (Ahern, Pickett, Selvin, & Abrams, 2003) and neighborhood socioeconomic context (Reagan & Salsberry, 2005)), and risks for recurrent PTB (Kistka et al., 2007) have been found to differ across racial groups. Differences in population characteristics, particularly potential biological differences (e.g. genetics) by race, or perhaps race-specific differences in epigenetic/gene-environment interactions (which are areas of future research) support the need for race-specific effect modification considerations when analyzing risk factor-preterm birth associations. With respect to health, race captures aspects of biology, and perhaps more so the lived experiences of racial groups which are determined by society's class hierarchy. Exposure to these experiences at critical times in development, and accumulation of stressors over the life course, are believed to contribute to racial inequalities (Lu & Halfon, 2003). This would have implications for understanding

longstanding racial disparities. Most prior studies examining the transgenerational transmission of PTB risk have been conducted in Nordic countries and among non-Hispanic (NH) white populations, while one U.S. study has examined race-specific associations among African Americans and whites (Castrillio et al., 2014).

Socio-economic factors play an important role in PTB risk (J. F. Bell, Zimmerman, Almgren, Mayer, & Huebner, 2006; Collins Jr, David, Rankin, & Desiredi, 2009; J. W. Collins Jr, K. Rankin, & R. David, 2011). Women that live in disadvantaged neighborhoods are more likely to be of lower socioeconomic position (Luo, Wilkins, & Kramer, 2006), have poorer health (Urquia, Frank, Glazier, & Moineddin, 2007), and engage in risky behaviors (Reagan & Salsberry, 2005). Apart from affecting behaviors, exposure to neighborhood disadvantage is believed to impact health through the dysregulation of stress-related pathways (Karb, Elliott, Dowd, & Morenoff, 2012). Therefore, generational neighborhood socio-economic context is likely a determinant of populations' chronic stress exposure, potentially moderating transgenerational transmission of PTB, which would present opportunities for public health intervention.

A better understanding of the role of both racial and socio-economic neighborhood context in the transgenerational transmission of PTB risk can present opportunities for risk identification in clinical practice and enhance public health efforts to design preventative strategies. Therefore, in the current study, we investigated associations of mothers' PTB status with infant's PTB (and PTB subgroup) status, and examined whether the associations differ by race or intergenerational socio-economic neighborhood context.

Methods

Study Setting and Study population

The current study was based on a collaboration between the University of Pittsburgh Graduate School Of Public Health and the Allegheny County Health Department. We used birth records of live-born singleton, first-born infants from 2009–2011 born in Allegheny County. The birth records of the mothers of these infants (from 1979–1998) were identified through the County Health Department's electronic data system. Deterministic linkage was used to identify records based on mother's exact maiden name and date of birth. This linkage process was supplemented with a manual search of alphabetized names to identify potential matches missed due to misspelling; the full birth records of these were reviewed and a decision made by the statistical analyst as to the feasibility of the record as a match. The source population for this study included 7,235 successfully linked mother-infant birth records, a 75% matching rate which is comparable to that of other birth record intergenerational linkages (Chapman & Gray, 2014; David et al., 2010; Emanuel et al., 1999).. Both infants and their mothers were born in Allegheny County, Pennsylvania. Study protocol was approved by the Institutional Review Board of the University of Pittsburgh; the study was exempt from informed consent. Participants were excluded if they belonged to the following groups (not mutually exclusive): infants with congenital anomalies (N=20), maternal grandmothers (N=10) and mothers (N=73) who were not black or white, mothers who were Hispanic (N=43), infants with gestational age less than 20 weeks (N=4), infants in census tracts with less than 5 births per racial group (either NH black or white) (N=457);

and, missing maternal grandmothers' race (N=2), mothers' race (N=18), mothers' ethnicity (N=53), infants' gestational age (N=41), mothers' gestational age (N=22) or census tract code on mothers' (N=20) or infants' (N=7) birth record. Observations in census tracts with fewer than 5 births were excluded due to our hypothesis that the data were hierarchical (infant birth outcomes nested within mothers' neighborhoods) and we desired to have sufficient births per census tract to reduce bias in our estimates (B. A. Bell, Morgan, Kromrey, & Ferron, 2010). The final dataset included 6,592 linked records.

Data Collection

Infants' birth records were used to obtain information on infant birth characteristics (gestational age at birth) as well as maternal characteristics (maternal age, marital status, health insurance, educational attainment, and address), while mothers' birth records were used to obtain information on mothers' birth characteristics (gestational age at birth) as well as maternal grandmothers' characteristics (e.g. race and address). We appended U.S. Census Bureau data on tract racial composition and household income via census tract code, as described below, to information obtained from infants' and mothers' birth records.

Outcomes and Predictors—The primary outcomes of interest were infant risk of PTB and PTB subgroups. We extracted gestational age from the infants' birth record and created a categorical variable, term birth (birth at 37 completed weeks of gestation) or PTB (birth prior to 37 completed weeks of gestation). Late preterm birth (LPTB) was defined as birth between 34–36 weeks completed gestation, while early preterm birth (EPTB) was defined as birth before 34 completed gestational weeks. The primary exposure was mothers' PTB status. We extracted gestational age from the mothers' birth record and created a categorical variable of term versus PTB status, as described above.

Race and Socio-economic Neighborhood Factors—We included participants who self-identified as NH white or black. Race was categorized as a binary variable. Addresses at the time of birth from the mothers' birth records were assigned to US Census tract codes as follows: 1979–1985 births to 1980 tract codes, 1986–1995 births to 1990 tract codes, and 1996–1998 births to 2000 tract codes. We had 578 census tracts representing maternal grandmothers' neighborhoods. Similarly, addresses from infants' birth records, 2009–2011 births, were assigned to 2010 tract codes. We had 350 census tracts representing mothers' neighborhoods. The percentage of NH blacks (among total NH residents) per tract formed the continuous measure of neighborhood racial composition. We created a categorical variable for neighborhood racial composition as follows: low (<13%), medium (13–50%), or high (>50%). In the 2010 U.S. Census, 13% of Allegheny County residents self-identified as NH blacks, and comparable cut-offs have been used by other researchers (Baker & Hellerstedt, 2006; Nkansah-Amankra, Luchok, Hussey, Watkins, & Liu, 2010). We used census data to calculate county-wide tertiles for household income. Based on these calculations, household income of \$34,999 (for grandmothers' neighborhoods; 1980, 1990 and 2000 dollars) and \$24,999 (for mothers' neighborhoods; 2010 dollars) were the upper threshold for the lowest tertile of income in the county. This county-specific income cut-off point was applied to each tract and used to determine the percentage of households in that tract that were low income. The percentage of households with low income in the tract

formed the continuous measure of neighborhood economic composition. We then created a categorical variable for neighborhood economic composition based on percentages of households with low income: high poverty (34–100% households with low income) and low poverty (<34% households with low income). Other researchers have used quintiles of household income (J. W. Collins Jr, K. M. Rankin, & R. J. David, 2011) or the federal poverty level (Nkansah-Amankra, 2010) to determine the cut-off. We chose to use the above mentioned approach as it would provide a comparison of each census tract to the overall county.

We also created intergenerational socio-economic neighborhood context variables to capture differences in residential racial and economic neighborhood context between the grandmothers' and mothers' generations. For neighborhood racial composition we used the category for racial composition described above (high, medium, and low percentage of NH blacks) and defined the groups as follows: high-high, medium-medium, low-low, "change to lower" (high to medium/low or medium to low), and "change to higher" (low to medium/high or medium to high). For instance, the high-high group had both grandmother and mother who lived in neighborhoods which fell in the high percentage NH black category. The "change to lower" group had grandmother who lived in a neighborhood with a high percentage of NH black residents and a mother who lived in a neighborhood with either a medium or low percentage of NH black residents, or the grandmother lived in a neighborhood with a medium percentage of NH black residents while the mother lived in a neighborhood with low percentage of NH black residents. Similarly, for neighborhood economic composition, we used the following categories: high-high, low-low, high-low, and low-high poverty. The latter two suggest upward and downward social mobility, respectively.

Confounders—We obtained information on the following potential confounders from infants' birth records: maternal age (continuous variable), maternal marital status (unmarried versus married), maternal education level (< high school, high school, and at least some college), and maternal health insurance (payer for delivery: Medicaid versus private/self-pay health insurance). We did not adjust for chronic (pre-pregnancy) hypertension, gestational hypertension, chronic diabetes, gestational diabetes, vaginal bleeding, smoking during first trimester, adequacy of prenatal care utilization, and adequacy of gestational weight gain, because of concerns with reliability of the variables (DiGiuseppe, Aron, Ranbom, Harper, & Rosenthal, 2002), and to avoid over-adjustment in statistical models with variables that could be in the causal pathway (Schisterman, Cole, & Platt, 2009).

Statistical Analyses

We performed bivariate analyses, using Chi-square and Student's *t* tests to examine relationships between covariates and infant PTB (and PTB subgroup) status. As previously mentioned, census tracts with fewer than 5 births were excluded. Using the likelihood ratio statistic, based on Laplacian Approximation, we tested the statistical significance of the intra-class correlation coefficient which was used to estimate the clustering of PTB by census tract. We found no statistically significant clustering of PTB by census tract and proceeded with single-level models. We used binomial logistic regression with maximum likelihood approximation for analyses investigating overall PTB status as an outcome (PTB

versus term birth); odds ratios (ORs) and their 95% confidence intervals (CIs) were used to assess associations. We used multinomial logistic regression with maximum likelihood approximation for statistical analyses investigating status of PTB subgroup (EPTB, LPTB and term birth). In these analyses, relative risk ratios (RRRs) and their 95% CIs were used to assess associations. These models were adjusted for mothers' race, maternal age (grand-mean centered), marital status, educational attainment, health insurance, and intergenerational socio-economic neighborhood context. To evaluate whether associations differ by race, we repeated the analyses stratified by mothers' race (i.e. NH black or NH white mothers). To examine whether associations differ based on neighborhood context, we repeated the same analyses stratified by categories defining intergenerational neighborhood racial composition and economic composition. Analyses stratified by neighborhood racial composition were controlled for economic composition, and vice versa. Analyses were conducted using Stata, version 13.1, software (Stata Corporation, College Station, Texas). Associations were deemed statistically significant if $p < 0.05$.

Results

Among 6,592 infants included in the study, 8.21%, 6.63% and 1.58% had PTB, LPTB, and EPTB, respectively. Selected characteristics by PTB status and PTB subgroup status are shown in Table 1. Compared with term infants, preterm infants were more likely to have NH black mothers, unmarried mothers, less educated mothers, and families that have lived in neighborhoods with a higher NH black population and lower income households.

Mothers who were themselves born preterm had higher rates of PTB (12.6%), LPTB (9.71%) and EPTB (2.89%) infants, compared to mothers who were born at term (7.86%, 6.39%, and 1.47%, respectively) (all $p < 0.05$, Table 2). In fully adjusted models, maternal PTB status was associated with 46% increases in infant PTB (95%CI:1.08–1.98), EPTB (95%CI:0.80–2.69), and LPTB (95%CI:1.04–2.04) risk (Table 3).

Infants of NH black mothers, compared with NH white mothers, had shorter gestational age (38.57 weeks vs. 38.96 weeks) and higher rates of PTB (10.33% vs. 7.37%) (all $p < 0.05$). Compared with NH white mothers, NH black mothers had shorter gestational age at their own birth (38.61 weeks vs. 39.47 weeks), were more like to have been born preterm (13.72% vs. 4.84%), and were more likely to have PTB infants whether they were themselves born at term (9.54% vs. 7.26%) or preterm (15.29% vs. 9.61%) (all $p < 0.05$, Table 2). In adjusted logistic regression models, NH black mothers who were themselves preterm at birth were more likely to have infants with PTB (OR=1.63; 95%CI:1.10–2.43) and LPTB (RRR=1.68; 95%CI:1.07–2.64), compared with NH black mothers who were born at term. Similar associations among NH white mothers were weaker and not statistically significant for PTB (OR=1.24; 95%CI:0.77–2.00) and LPTB (RRR=1.20; 95%CI:0.71–2.03) (Table 3). On the other hand, we observed similar maternal PTB status – EPTB associations among NH blacks (RRR=1.47; 95%CI:0.69–3.12) or NH whites (RRR=1.46; 95%CI:0.52–4.13).

Rates of PTB were highest in high-high (grand maternal-maternal) percent black neighborhoods (11.03%) and lowest in low-low percent black neighborhoods (6.94%) (Table

4). In adjusted logistic regression models, among mothers in “change to higher” percent black neighborhoods mothers who were born preterm were more likely to have PTB infants, compared with women who were born at term (OR=2.33; 95%CI:1.27–4.28). Similar, but not statistically significant, association was observed in the high-high percent black neighborhood group (OR=1.73; 95%CI:0.93–3.23). Associations in other groups defined by percent black neighborhoods of maternal grandmothers and mothers were weaker (OR ranging between 1.01 and 1.23) and statistically non-significant (Table 5).

Rates of PTB differed only slightly across intergenerational economic neighborhood context – highest among high-high poverty (9.84%) and lowest among low-low poverty (7.09%) (Table 4). In adjusted logistic regression models, associations of mothers’ PTB with infant PTB status were similar (ORs ranging between 1.30 and 1.72) and not statistically significant, across groups defined by intergenerational economic neighborhood context (Table 5).

Discussion

In the current study, we found that mothers who were preterm at their own birth were more likely to have preterm infants. The maternal PTB status and infant PTB status (particularly LPTB) associations were stronger (and statistically significant) among NH black mothers, mothers who lived in neighborhoods with a high percentage of NH black residents at their own birth and their infants’ birth, or mothers who moved to neighborhoods with a higher percentage of NH black residents at their infants’ birth.

This study is one of the few studies that examined associations of mothers’ PTB status with infant PTB and PTB subgroups – EPTB and LPTB. Wilcox et al., in a study based on the Norwegian Medical Birth Registry, found that women (N=191,282) who were born (1967–1988) preterm had a 1.54-fold (95%CI:1.42–1.67) risk for having a PTB infant (born 2004), compared with mothers born at term (Wilcox et al., 2008). They concluded that these findings support the transgenerational heritability of PTB risk. This was the only study we identified that examined PTB subgroups; they reported a strong, and statistically significant, association between maternal PTB and infant EPTB. In that study no data on LPTB were reported. One limitation of the study by Wilcox et al. was that they did not adjust for any covariates. To our knowledge, our study is the first to look at both LPTB and EPTB in the context of the transgenerational transmission of PTB risk. Swamy et al., in a study (N=1,167,506) based on the same Norwegian Medical Birth Registry, reported a 1.40-fold (95%CI:1.30–1.50) increased risk of having a preterm infant for women who were born at 33–36 weeks, compared with women who were born at term (Swamy et al., 2008). The findings of this study, which adjusted for a number of covariates, are similar to those of our study. In a US study conducted using Utah birth certificate data of mothers (born in 1947–1957) and their infants (born in 1970–1992), Porter et al. reported a 1.18-fold (95%CI:1.02–1.37) increase in PTB risk for mothers who were born preterm, versus term (Porter et al., 1997). In another US study (Castrillio et al., 2014) conducted using Illinois birth certificate data of mothers (110,396 NH whites and 33,149 blacks) born in 1956–1976 and their infants born in 1989–1991, Castrillio et al. reported a marginally significant 10% increase in risk of preterm birth for NH black and white mothers who were born preterm (95%CI:1.0–1.2),

relative to term born mothers. The noted difference in magnitude of associations between European and US studies is potentially related to differences in the constitution of the two populations with respect to factors such as racial differences in PTB or risk factors, as well as higher heterogeneity in biologic factors among US, rather than European, populations. Castrillo et al.'s study is the only other study that examined the race-specific transgenerational transmission of PTB risk, and therefore the most comparable to our study. Differences in findings, between their study and ours, are possibly due to differences in population characteristics or differences in adjustment variables.

On the other hand, associations were not statistically significant in several other studies, although most estimates were suggestive of positive associations between maternal PTB status and infant PTB risk (Klebanoff et al., 1989; Klebanoff et al., 1997; Magnus et al., 1993). Winkvist et al., in their study using the Swedish Medical Birth Registry, reported a non-significant 10% increased risk (95%CI:0.69–1.76) of PTB among 4,746 infants (born 1973–1990), for mothers (born 1955–1972) who were born preterm, versus term (Winkvist, Mogren, & Hogberg, 1998). In another study (Selling et al., 2006) using the Swedish Medical Birth Registry, Selling et al. reported a non-significant 24% increased risk (95%CI: 0.95–1.62) of PTB among 38,720 infants (born prior to 2001) if mothers (born 1973–1975) were themselves born preterm, relative to term.

In sum, despite these inconsistencies, previous findings suggest positive association of maternal and infant PTB status. The majority of studies in this area have been performed in Nordic countries in predominantly white populations. The major strength of this study is that it is one of the few that were conducted in the US using a transgenerational dataset (Chapman & Gray, 2014; David et al., 2010; Emanuel et al., 1999; Porter et al., 1997). In addition, to our knowledge, it is one of two studies that examined racial differences in transgenerational PTB associations (Castrillio et al., 2014), and the first to explore differences by intergenerational socio-economic neighborhood context. Another strength of the current study was our ability to control for several important potential confounders. Of note, we did not adjust for a number of covariates, such as chronic (pre-pregnancy) hypertension, gestational hypertension, chronic diabetes, gestational diabetes, vaginal bleeding, smoking during first trimester, adequacy of prenatal care utilization, and adequacy of gestational weight gain, because of concerns with reliability of the variables, and to avoid over-adjustment in statistical models with variables that could be in the causal pathway. As a sensitivity analysis, we included these health and obstetric factors in the models and found that the estimate was only slightly attenuated and remained statistically significant for transgenerational association of PTB (OR=1.52; 95%CI:1.02–2.28).

The biological mechanisms for the observed transgenerational associations are not fully known. The heritability of gestational age has been reported in parent-offspring, monozygotic and dizygotic twin, and sibling studies (Clausson, Lichtenstein, & Cnattingius, 2000; Plunkett et al., 2009; Svensson et al., 2009; Ward, Argyle, Meade, & Nelson, 2005); and, genetic variations (from candidate gene and genome-wide association studies) that confer PTB risk have been identified (Plunkett et al., 2011). Such studies suggest the potential role of genetic and environmental factors in transgenerational transmission of PTB risk. Epigenetics, which reflects the interaction of environmental stressors with underlying

genetic susceptibility, is another potential mechanism for these transgenerational PTB associations, as well as differences by race and socioeconomic neighborhood context. Only few epigenetic studies exist in this area (Burris et al., 2012; Menon, Conneely, & Smith, 2012). Observed stronger transgenerational transmission of PTB risk among NH blacks and mothers who live in NH black neighborhoods may be due to genetic, environmental, or epigenetic factors, in addition to the higher baseline rates of PTB in these populations. Additionally, white and black populations have been reported to live in distinctly different contexts in the U.S. (Collins et al., 1997; Pickett et al., 2002), thus likely to have different risk profiles. These are areas for potential future investigations.

Some limitations of the current study include the following. We were not able to examine the association of mothers' PTB with infant PTB subgroups among groups defined by transgenerational socio-economic neighborhood context due to small numbers in these stratified analyses. We used birth records to obtain variables for our analyses, which do not always have reliable data. However, concerns typically arise with data on maternal health and obstetric factors and these were not included in our original analyses. Additionally, vital statistics have a high percentage of partially complete birth records. However, all the covariates included in these analyses had < 10% missing observations. Another limitation is that mothers included in the dataset were fairly young and both the mother and infant had to be born in Allegheny County to be included in the study, thus limiting the generalizability of our findings. The characteristics of the mother-infant dyads not included in the source population (i.e. the unmatched sample) are unknown and comparisons between the matched and unmatched sample could not be made; however, our match rate was comparable to that of other intergenerational birth record linkages. PTB is a heterogeneous condition, based on the preceding event that precipitated it (spontaneous or induced). Data on PTB subtypes (by preceding event) were not available from the birth records. Therefore, we were not able to assess whether the associations hold for the different subgroups of PTB defined by events preceding it. Lastly, there is the potential for structural confounding (Messer, Oakes, & Mason, 2010), particularly in the race-specific analyses. Among NH whites the data were sparse for individuals residing generationally in neighborhoods with a high percentage of NH black residents; among NH blacks few individuals lived generationally in neighborhoods with a low percentage of NH black residents or low poverty.

In conclusion, we found that mothers, particularly NH black mothers, were at higher risk of having a preterm infant if they were themselves born preterm. In addition, mothers who resided in neighborhoods with a high percentage of NH black residents during their birth and at the birth of their infants, or mothers who moved to a neighborhood with a higher percentage of NH black residents, than the neighborhood into which they were born, were at higher risk of having a preterm infant. The findings of this research are important for identification of at-risk populations in clinical practice, and have public health implications for understanding the persistence racial/ethnic disparities in the U.S. More research is needed to identify potential mechanisms (environmental, genetic, or epigenetic) by which PTB risk is transmitted across generations as well as mechanisms by which differences in transgenerational associations of PTB risk occur by racial/socioeconomic groups or generational change in socioeconomic status. Our findings will inform the design and

conduct of such mechanistic studies. A better understanding of these relationships will provide opportunities for public health interventions that could reduce the risk of PTB.

Acknowledgments

We would like to thank Ronald Voorhees, MD, the former acting Director of the Allegheny County Health Department and John Kokenda, Statistical Analyst at the Allegheny County Health Department. Dr. Ncube was supported by the Reproductive, Perinatal and Pediatric Epidemiology Training Program of the National Institute of Child Health and Human Development (T32 HD052462). There was no funding for this study.

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Significance

What is already known on this subject?

Accumulating evidence suggests that mothers who were preterm at their own birth are more likely to have preterm infants. Race and socio-economic neighborhood context are associated with birth outcomes, including preterm birth.

What this study adds

Maternal race and generational neighborhood socioeconomic context may modify transgenerational transmission of preterm birth risk. Associations are stronger among non-Hispanic black mothers, mothers in neighborhoods with a high percentage of non-Hispanic black residents in both generations, or mothers who moved to neighborhoods with a higher percentage of non-Hispanic black residents.

Table 1
 Mother and Maternal Grandparent Characteristics of Infants Born 2009–2011, by Infants' Preterm Birth, and Preterm Birth, Status: an Intergenerational Study, Allegheny County, Pennsylvania

	Term Births N=6,051		Preterm Births N=541		Subgroups of Preterm Birth			
	n	%	n	%	n	%	n	%
Mothers' characteristics								
Race **								
Non-Hispanic white	4,384	72.45	349	64.51	295	67.51	54	51.92
Non-Hispanic black	1,667	27.55	192	35.49	142	32.49	50	48.08
Age *								
Less than 20	1,312	21.68	133	24.58	108	24.71	25	24.04
20 to 24	1,979	32.71	187	34.57	142	32.49	45	43.27
25 to 32	2,760	45.61	221	40.85	187	42.79	34	32.69
Marital status **								
Married	2,326	38.44	163	30.13	144	32.95	19	18.27
Unmarried	3,722	61.51	378	69.87	293	67.05	85	81.73
Unknown	3		0		0		0	
Health insurance **								
Private/self-pay	3,680	60.82	275	50.83	231	52.86	44	42.31
Medicaid	1,950	32.23	228	42.14	174	39.82	54	51.92
Unknown	421		38		32		6	
Educational attainment **								
< high school	835	13.80	99	18.30	75	17.16	24	23.08
High school	1,601	26.46	182	33.64	141	32.27	41	39.42
At least some college	3,603	59.54	258	47.69	220	50.34	38	36.54
Unknown	12		2		1		1	
Neighborhood characteristics								
Intergenerational neighborhood racial composition * ^a								

	Term Births N=6,051		Preterm Births N=541		Subgroups of Preterm Birth			
	n	%	n	%	Late Preterm Births N=437		Early Preterm Births N=104	
Mothers' characteristics								
High-high % black	621	10.26	77	14.23	58	13.27	19	18.27
Medium-medium % black	323	5.34	34	6.28	29	6.64	5	4.81
Low-low % black	3,311	54.72	247	45.66	213	48.74	34	32.69
Change to lower % black	770	12.73	82	15.16	60	13.73	22	21.15
Change to higher % black	1,026	16.96	101	18.67	77	17.62	24	23.08
Neighborhood economic composition ^a ^b								
High-high poverty	1,759	29.07	192	35.49	133	30.43	59	56.73
Low-low poverty	2,436	40.26	186	34.38	165	37.76	21	20.19
High-low poverty	1,466	24.23	128	23.66	108	24.71	20	19.23
Low-high poverty	390	6.45	35	6.47	31	7.09	4	3.85

^{**} Characteristics are significantly different between term and preterm infants ($P < 0.001$)

^{*} Characteristics are significantly different between term and preterm infants ($P < 0.05$)

^a Percent of residents who are NH black in the maternal grandmother and mother's census tract

^b Percent of households in lowest income tertile in maternal grandmother and mother's census tract

Preterm birth, and Preterm Birth Subgroup, Status of Infants Born 2009–2011, by Mothers' Race and Preterm Birth Status: an Intergenerational Study, Allegheny County, Pennsylvania

Table 2

		All mothers N=6,592				NH white mothers N=4,733				NH black mothers N=1,859			
		Term birth		Preterm birth		Term birth		Preterm birth		Term birth		Preterm birth	
<i>Infant Characteristics</i>		n	%	n	%	n	%	n	%	n	%	n	%
Preterm birth status													
Term birth		5,628	92.14	423	87.40	4,177	92.74	207	90.39	1,451	90.46	216	84.71
Preterm birth		480	7.86	61	12.60	327	7.26	22	9.61	153	9.54	39	15.29
Preterm birth subgroups													
Late preterm birth		390	6.39	47	9.71	277	6.15	18	7.86	113	7.04	29	11.37
Early preterm birth		90	1.47	14	2.89	50	1.11	4	1.75	40	2.49	10	3.92

Infant Risk of Preterm Birth and Preterm Birth Subgroups by Mothers' Preterm Birth and Gestational Age: an Intergenerational Study, Allegheny County, Pennsylvania

Table 3

	Infant PTB risk		Infant LPTB risk		Infant EPTB risk	
	OR	95% CI	RRR	95% CI	RRR	95% CI
<i>All</i>						
Preterm birth mothers ^{a c}	1.46	1.08, 1.98	1.46	1.04, 2.04	1.46	0.80, 2.69
<i>Non-Hispanic white</i>						
Preterm birth mothers ^{b c}	1.24	0.77, 2.00	1.20	0.71, 2.03	1.46	0.52, 4.13
<i>Non-Hispanic black</i>						
Preterm birth mothers ^{b c}	1.63	1.10, 2.43	1.68	1.07, 2.64	1.47	0.69, 3.12

^a Adjusted for mothers' race, maternal age, marital status, educational attainment, health insurance, intergenerational neighborhood racial composition and poverty

^b Adjusted for maternal age, marital status, educational attainment, health insurance, intergenerational neighborhood racial composition and poverty

^c Preterm versus term mothers

Table 4

Preterm birth, and Preterm Birth Subgroup, Status of Infants Born 2009–2011, by Intergenerational Socio-economic Neighborhood Context: an Intergenerational Study, Allegheny County, Pennsylvania

<i>Infant Characteristics</i>	High-high % black N=698		Medium-medium % black N=357		Low-low % black N=3,558		Change to lower % black N=852		Change to higher % black N=1,127	
	n	%	n	%	n	%	n	%	n	%
<i>Preterm birth status</i>										
Term birth	621	88.97	323	90.48	3,311	93.06	770	90.38	1,026	91.04
Preterm birth	77	11.03	34	9.52	247	6.94	82	9.62	101	8.96
<i>Preterm birth subgroups</i>										
Late preterm birth	58	8.31	29	8.12	213	5.99	60	7.04	77	6.83
Early preterm birth	19	2.72	5	1.40	34	0.96	22	2.58	24	2.13

<i>Infant Characteristics</i>	High-high poverty N=1,951		Low-low poverty N=2,622		High-low poverty N=1,594		Low-high poverty N=425	
	n	%	n	%	n	%	n	%
<i>Preterm birth status</i>								
Term birth	1,759	90.16	2,436	92.91	1,466	91.97	390	91.76
Preterm birth	192	9.84	186	7.09	128	8.03	35	8.24
<i>Preterm birth subgroups</i>								
Late preterm birth	133	6.82	165	6.29	108	6.78	31	7.29
Early preterm birth	59	3.02	21	0.80	20	1.25	4	0.94

Table 5

Infant Risk of Preterm Birth by Generational Socio-economic Neighborhood Context: an Intergenerational Study, Allegheny County, Pennsylvania

	Infant PTB risk	
	OR	95% CI
Racial neighborhood context^a		
<i>High-high % black</i>		
Preterm birth mothers ^c	1.73	0.93, 3.23
<i>Medium-medium % black</i>		
Preterm birth mothers ^c	1.05	0.29, 3.80
<i>Low-low % black</i>		
Preterm birth mothers ^c	1.23	0.68, 2.23
<i>Change to lower % black</i>		
Preterm birth mothers ^c	1.01	0.47, 2.14
<i>Change to higher % black</i>		
Preterm birth mothers ^c	2.33	1.27, 4.28
Economic neighborhood context^b		
<i>High-high poverty</i>		
Preterm birth mothers ^c	1.51	0.99, 2.31
<i>Low-low poverty</i>		
Preterm birth mothers ^c	1.30	0.66, 2.56
<i>High-low poverty</i>		
Preterm birth mothers ^c	1.50	0.76, 2.96
<i>Low-high poverty</i>		
Preterm birth mothers ^c	1.72	0.53, 5.64

^a Adjusted for mothers' race, maternal age, marital status, educational attainment, health insurance, intergenerational neighborhood poverty

^b Adjusted for mothers' race, maternal age, marital status, educational attainment, health insurance, intergenerational neighborhood racial composition

^c Preterm versus term mothers