Published in final edited form as:

J Epidemiol Community Health. 2012 July ; 66(7): . doi:10.1136/jech.2010.132886.

Racial disparities in health-related quality of life in a cohort of very low birth weight 2- and 3-year olds with and without asthma

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Abstract

Background—Children born very low birth weight (VLBW) are at risk for low health-related quality of life (HRQoL), compared to normal birthweight peers, and racial disparities may compound the difference. Asthma is the most pervasive health problem among VLBW children, and is also more common among black than white children, partly due to unfavorable environmental exposures. This study explores racial disparities in HRQoL among VLBW children and examines whether potential disparities can be explained by asthma and neighborhood disadvantage.

Methods—The study population was the Newborn Lung Project, a cohort of infants (n=660) born VLBW in 2003–2004 in Wisconsin, USA, who were followed up at age 2–3. Multi-level linear regression models were used to examine the contributions of asthma, neighborhood disadvantage, and other child and family socio-demographic covariates, to racial disparities in HRQoL at age 2–3. Child's HRQoL was measured using the Pediatric Quality of Life Inventory (PedsQL 4.0).

Results—VLBW, Black, non-Hispanic children, on average, score nearly 4-points lower ($p<0.01$) on HRQoL than do white, non-Hispanic children. Including asthma reduces the difference between black and white children from -3.6 ($p<0.01$) to 0.08 ($p>0.05$). We found no evidence that the relationship between asthma and HRQoL differs by race. The interaction between neighborhood disadvantage and asthma is statistically significant, with further examination suggesting that racial disparities are particularly pronounced in the most advantaged neighborhoods.

Conclusion—We found that the black disadvantage in HRQoL among 2–3 year old VLBW children likely stems from high prevalence of asthma. Neighborhood attributes did not further

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explain the disparity, as the racial difference was particularly pronounced in advantaged neighborhoods.

Keywords

very low birth weight; health-related quality of life; neighborhood; disadvantage; asthma

Introduction

There is an inverse relationship between birth weight and neonatal morbidity^{1,2} and an increasing awareness of the long-term health consequences of being born very low birth weight (VLBW, <1500 grams). Respiratory disease is the most common morbidity in VLBW children, and asthma risk is 3-fold higher in the VLBW than in the general population.³ Not surprisingly, preschoolers born VLBW demonstrate lower health-related quality of life (HRQoL) than their normal birth weight peers,^{4,5} and asthma with its symptoms a likely contributor.^{6,7}

In a nationally representative study of US children,⁷ black children experienced lower HRQoL than their white counterparts. Hence, racial disparities may compound the impact of VLBW on HRQoL. To our knowledge, this has not been explored; nor have potential reasons for such disparity. In a large cohort of premature births in Northern California, black children were found to have over 4 times the odds of white children of receiving oral asthma medications in the first year of life.⁸ Asthma may be on the causal pathway (i.e., effect mediator) explaining racial disparities in HRQoL. Moreover, it is unclear if black VLBW children experience asthma differently than do white VLBW children with asthma, and whether this might affect HRQoL (i.e. race is an effect modifier between asthma and HRQoL). For example, black VLBW children might experience more frequent exposure and greater susceptibility to environmental asthma triggers, than white VLBW children with asthma contributing to more severe morbidity and lower HRQoL.

The social ecological model⁹ suggests that child health, and presumably HRQoL, stem from all ecological niches (individual, family, community, and social policy). Our previous work¹⁰ suggests that neighborhood disadvantage is associated with HRQoL in children born VLBW. Moreover, there is a large literature^{11,12,13,14} to support the influence of neighborhood disadvantage on asthma prevalence especially among minority children. Black, non-Hispanic children are more likely to live in socially disadvantaged neighborhoods,¹⁵ which may cumulatively increase their risk for lower HRQoL, at least partly due to the high asthma prevalence. To our knowledge, the combined contributions of race, asthma, and neighborhood disadvantage on HRQoL have not been examined in the VLBW population.

Population health scientists advocate for a research agenda focusing on health-related quality of life (HRQoL) rather than pathophysiology or impairment outcomes.^{16,17} Health-related quality of life captures not only health difficulties, but problems stemming from children's interactions with their surroundings.¹⁸ Thus, understanding disparities in HRQoL has important implications for child health interventions. Despite a lack of definitional consensus, HRQoL encompasses physical, social, and emotional well-being and function.¹⁹ HRQoL in young children is collected via parent report. Several measures, including the Pediatric Quality of Life Inventory (PedsQL), are reported to have excellent reliability, be sensitive to changes pre- to post-intervention, and are easily administered.²⁰

The aims of this study are to (1) describe racial differences in HRQoL among a cohort of 2- and 3- year olds born VLBW, and (2) examine whether asthma and neighborhood

disadvantage help explain any racial differences in HRQoL in this cohort. We hypothesize that 1) black VLBW children will experience lower HRQoL than their white counterparts, 2) racial differences in HRQoL will be attributable to greater asthma burden among black VLBW children, 3) black VLBW children with asthma will experience lower HRQoL than their white VLBW peers with asthma, and 4) black children with asthma who live in socially disadvantaged neighborhoods will be particularly vulnerable to low HRQoL.

METHODS

Study Population

The Newborn Lung Project is a regional cohort of infants born very low birth weight in 2003–2004 and hospitalized in one of 16 Newborn Intensive Care Units in Wisconsin or near the state border. The original cohort recruited 979 infants for whom de-identified clinical data and follow-up contact information were collected. At age 2–3, 748 were alive and located. Of these, 719 children have complete HRQoL data collected when the child was between the ages of 2 and 3. The final sample included 660 children. Data on 58 children were omitted from analyses due to missing data on smoking during pregnancy (n=20), maternal education (N=2), asthma (N=16), income (N=10), and prenatal care (N=11). To test for potential bias by omitting missing data, we ran a series of sensitivity analyses including these latter cases with missing data in analyses excluding the covariates with missing data from the model. This did not notably change our model estimates. Thus, we restrict our analyses to children (n=660) with complete data.

Outcome Measures

Children's HRQoL was measured using the Pediatric Quality of Life Inventory²¹ reported by parents for toddlers ages 2–4 (PedsQL). The PedsQL contains 21 items that measure parental assessment in 4 domains: physical, emotional, social, and school/daycare. Parents are asked to rate, on a 5-point scale (0=never a problem to 4=almost always a problem), the degree of difficulty their child faced in the last month with regard to each item. A total score (0–100) reflects scaling and reverse scoring. A higher score indicates higher HRQoL.

Child and family Characteristics (Level 1)

Parental education was categorized as less than high school (HS) education, HS degree or equivalent, post HS schooling including college or technical school, and completion of a college degree and was treated as an ordinal variable. Severity of neonatal health was measured using the Score for Neonatal Acute Physiology (SNAPII),²² an index ranging from 0–115 that comprises 6 physiologically-based items (e.g. blood pressure, temperature, oxygen requirement, and seizures). Child's race and ethnicity was grouped as white, non-Hispanic; black, non-Hispanic (hereafter referred to as black); Hispanic; and other (including American Indian and multi-racial families). Annual family income was categorized as less than \$30,000, between \$30,000 and \$60,000, and greater than \$60,000 and modeled as an ordinal variable. Birth weight was measured in grams and gestational age in weeks. Exposure to environmental tobacco smoke was measured by 2 variables -- whether the mother smoked during pregnancy and whether the child lives with a current smoker. We also included sex of the child, whether or not the child attends daycare, single parent household, and if the mother received no prenatal care. Diagnosis of asthma at age 2 was collected by parent report. The distribution of these variables for the full sample and within racial/ethnic subgroups is presented in Table 1.

Neighborhood Disadvantage (Level 2)

A neighborhood disadvantage index was created using principal component analysis (PCA) of 5 Census tract socio-demographic variables:²³ % families in poverty, % of households with income above state median, % females with bachelor's degree or more, % single mothers, and % of mothers of young children unemployed. PCA²⁴ is a data reduction technique that determines how to combine variables into a single score that captures as much as possible of the overall variability in all the variables and has been previously used in perinatal epidemiologic research.²⁵ Specifically, the 5 Census variables were standardized (after reverse coding % females with bachelor's degree or more and % of households with income above state median) following standard procedure. An overall neighborhood disadvantage score (mean=0, SD=1, and alpha=0.86) was created as an average of items weighted by the item loadings (whose elements measure the strength of the relationship between the variable and principal component).

Statistical Analyses

Multi-level modeling²⁶ was used to examine the contributions of asthma, neighborhood disadvantage, and other child and family socio-demographic covariates to HRQoL. Multi-level models account for the clustering of children (Level 1) in neighborhoods (Level 2) and explicitly model the fixed effects of each covariate on the outcome (β) and the neighborhood variability in this relationship (σ^2).

Our analyses entailed fitting a series of multi-level linear random intercept models. A previous study⁵ suggests that HRQoL in VLBW children has a skewed distribution. To evaluate the appropriateness of a linear model, we also utilized Tobit regression (i.e. allows for ceiling effect of data) and obtained results similar to the linear specification. We report the results of the linear models.

First, the null model (i.e., contains no covariates) describes overall neighborhood (CT) variability in HRQoL. Second, we added child's race to examine both its contributions to explaining HRQoL and neighborhood variability in HRQoL, conditional on other child and family characteristics. The third model added parent-reported asthma. The fourth model added an interaction between asthma and child race and ethnicity. The final models include, first, neighborhood disadvantage, and second, interaction terms between child race and ethnicity, asthma, and neighborhood disadvantage.

For each model we report the estimated fixed effect (β) for each covariate, the standard error of β , neighborhood variability (σ^2) and standard error of σ^2 . A substantial reduction in (σ^2) indicates that the variables in the model help explain the observed differences in HRQoL across neighborhoods.

Multi-level linear regression analyses were conducted in SAS v9.13²⁷ using PROC MIXED. Tobit models were fit in MPlus. The institutional review board at University of Wisconsin-Madison and all participating institutions approved this study.

RESULTS

Race Differences in HRQoL

In Table 4, Model 1 indicates that there is significant between-neighborhood variability in HRQoL ($\sigma^2 = 43.1$, s.e. (σ^2) = 12.5). Model 2 suggests that over 30% of this between-neighborhood variability is attributable to family sociodemographic and child characteristics (Model 2 reduces the variability to $\sigma^2 = 28.8$, s.e. (σ^2) = 13.9).

In Model 2, we test our first hypothesis and find that black race is associated with a statistically significant, nearly 4-point deficit in HRQoL relative to being white, non-Hispanic ($\beta = -3.6$, $s.e.(\beta)=1.7$), even when controlling for other child and family characteristics. Hispanic children and those whose race is reported as “other” do not have HRQoL scores that are different from those of non-Hispanic white children. Lower birth weight, higher neonatal severity, and prenatal smoking exposure are each associated with a lower level of HRQoL. The detrimental effects on HRQoL from lower birth weight persist across all models.

The influence of asthma on the relationship between child’s race and HRQoL

Model 3 adds asthma to the model and demonstrates that asthma has a statistically significant, independent, negative association with HRQoL ($\beta = -3.6$, $s.e.(\beta)=1.2$). Moreover, when asthma is included, the parameter estimate for black race is reduced from -3.6 ($p<0.05$) in Model 2 to 0.08 ($p>0.05$) in Model 3. This confirms our second hypothesis that the lower HRQoL of black children who were born VLBW is substantially due to their greater likelihood of having asthma. The attenuation of the parameter estimate for black children indicates that an asthma diagnosis is likely a significant explanatory contributor to the relationship between black race and HRQoL. However, including asthma diagnosis substantially increases the between neighborhood variability in HRQoL, suggesting cross-level confounding²⁶ (i.e. an increase in between-neighborhood variance associated with an individual-level covariate suggests the individual-level covariate is highly correlated with observed and unobserved contextual factors).

The interaction between child’s race and asthma on HRQoL

Model 4 tests our third hypothesis that the association between asthma and HRQoL is stronger for black children. This hypothesis is not supported, as the results demonstrate a non-significant race by asthma interaction ($p>.05$). When children born with VLBW have asthma, it is associated with worse HRQoL, no matter what the race of the child.

The influences of neighborhood disadvantage, child’s race, and asthma on HRQoL

Model 5 suggests that inclusion of neighborhood disadvantage results in a significant estimate for the interaction between black race and asthma ($\beta=-5.8$, $s.e. (\beta)=2.7$). This suppressor effect of neighborhood disadvantage, coupled with the previously-mentioned increases in between-neighborhood variance (Models 3–5), suggests confounding (at either level 1 or 2) and provides justification for the inclusion of additional two-way and three-way interactions between race, asthma, and neighborhood disadvantage (Model 6).

Figure 1 depicts the results of a model including a three-way interaction between race, asthma, and neighborhood disadvantage (and all relevant two-way interaction terms) (Model 6). While there are no appreciable differences in HRQoL for children (black and white) without asthma, there is a neighborhood risk gradient in HRQoL whereby black and white children with asthma fare worst. These results suggest that the interactive effects of having asthma and living in a disadvantaged neighborhood are detrimental to the HRQoL of both black and white children. The graph indicates that the three-way interaction arose from white children in the most advantaged neighborhoods not having a decrement in HRQoL with asthma.

DISCUSSION

We examined racial disparities in HRQoL in a regional cohort of 2- and 3-year olds born VLBW. Our results demonstrate significant black-white disparities in HRQoL that appear to operate, largely, through childhood asthma. Moreover, neighborhood disadvantage appears

to be associated with lower HRQoL for children with asthma. To our knowledge, this is the first study to explore multiple ecological determinants of racial disparities in HRQoL in young children born VLBW.

We find nearly 4-point lower HRQoL among black than white VLBW children, controlling for child and family characteristics. Unpacking explanations for this remaining black-white disparity in HRQoL is challenging, yet our results highlight the relevance of asthma. First, above and beyond race and other child and family socioeconomic characteristics, asthma is a statistically significant and clinically meaningful predictor of lower HRQoL. Secondly, the significant association between race and HRQoL is substantially attenuated (virtually eliminated) when asthma is taken into account. That is, we found evidence that asthma is on the causal pathway (i.e. effect mediation) between race and HRQoL. We found no evidence that HRQoL is different for black versus white VLBW children with asthma (i.e. effect modification). This is consistent with the national longitudinal study of Brooks and colleagues³ who found that the increased burden of asthma in the black versus white VLBW populations was due to an increased prevalence of VLBW among black children rather than a differential asthma experience.

We found evidence that, net of child and family characteristics, neighborhood disadvantage independently influences HRQoL among children with asthma. Children with asthma who live in socially disadvantaged neighborhoods may not have access to and quality of resources such as health clinics and safe housing. Alternatively, families may have difficulty accessing resources due to limited transportation, safety, or lack of coordinated systems of care. We expected that living in a socially disadvantaged neighborhood would be particularly harmful for HRQoL of black children with asthma, yet we find no evidence of this. Yet, our findings are consistent with previous research^{14,28} suggesting a persistent black-white disparity in asthma morbidity when individual and neighborhood socioeconomic characteristics are considered. This persistent racial disparity warrants further investigation. For example, there is growing evidence^{12,13} to suggest the importance of process measures (e.g. collective efficacy and community psychosocial stress), residential segregation, and housing quality. Cagney and Browning¹³ demonstrated higher prevalence of asthma, above and beyond family characteristics and neighborhood poverty, in neighborhoods with low levels of collective efficacy and social disorder. Indeed, our findings (although not statistically significant) suggest that black VLBW children with asthma living in socially advantaged neighborhoods fare worse than their white counterparts. Thus, it is plausible that black children with asthma living in more socially advantaged areas experience differential psychosocial and environmental stressors than their white peers with asthma, which contribute to lower HRQoL. Moreover, at highest levels of neighborhood social disadvantage all children fare poorly regardless of their race. The exception to this seems to be children characterized as “other” race, who seem to fare particularly poorly in socially disadvantaged areas. However, these results should be interpreted with caution due to sparse sample sizes.

We acknowledge several limitations to this study. First, these data are cross-sectional which precludes inferring causal relationships between covariates. The relationships we describe are limited to measureable attributes of children, families, and neighborhoods and are merely correlations. It is possible that biases are introduced by not only unobserved characteristics of children and families that influence asthma and HRQoL, but also by virtue that families are not randomly assigned to neighborhoods, but rather they may select or are forced to select their residence based on factors that are also relevant to disease burden and HRQoL. There is no gold standard for measuring pediatric HRQoL. However, as previously mentioned, the PedsQL not only has strong psychometric properties overall,²⁰ but is also appropriate for use with pediatric asthmatic populations.²⁹ Finally, we utilized parent-

reported asthma, which may introduce biases if differences in reporting occur across relevant racial and social sub-groups. We have no means of quantifying potential reporting bias, but rely on previously research.¹⁸ suggesting the strength of parent-reported health status of children. In sensitivity analyses we used a measure of children's use of asthma medication (a marker for at least some access to the medical system) and found similar results. Lastly, the results of our final model should be interpreted with caution as the sample sizes were small (n=34, 18, and 11 for the most, middle, and least disadvantaged groups, respectively). While potentially interesting, this finding requires replication with larger sample sizes.

Despite these limitations, the study strengths underscore its population health significance. We utilize a measure of HRQoL rather than measures of impairments or disability. To our knowledge, this is the first study to explore not only overall racial disparities in HRQoL among VLBW children, but also the potential mechanisms associated with a common and costly chronic disease in the VLBW population--asthma. We provide evidence for the importance of social context (neighborhood disadvantage) on understanding the inter-relationships between race, asthma, and HRQoL.

A growing number of babies are born VLBW, with consequences for both their own quality of life, and society's use of resources to address potential negative outcomes. Racial disparities in VLBW have implications for subsequent disparities in a range of outcomes for children and society. Understanding how we might intervene to reduce the negative outcomes of VLBW, such as asthma, or to buffer their implications for HRQoL, seem appropriate societal concerns. Our study suggests that prevention of asthma in VLBW babies would have important implications for the HRQoL of children born VLBW, particularly black children. Moreover, our study suggests that the neighborhood context within which asthma arises may be an important ecological niche within which to intervene or focus attention to improve both asthma and its HRQoL consequences.

Acknowledgments

Dr. McManus acknowledges the Robert Wood Johnson Health and Society Scholar Program for funding this research. This research was also funded by the National Heart, Blood, and Lung Institute (HL038149).

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Evidence Box Data

What is already known on this topic

- Very low birth weight (< 1500 grams, VLBW) children are at heightened risk for developmental difficulties including cognitive, neuromotor, and physical health.
- VLBW children have lower health-related quality of life and risk for asthma (HRQoL) than their normal birth weight peers. Asthma risk is substantially increased for black, non-Hispanic VLBW children and children living in disadvantaged neighborhoods.
- To our knowledge, no study has examined racial disparities in HRQoL among VLBW preschoolers, generally, nor the additive or interactive effects of child's race, asthma and neighborhood disadvantage.

What this study adds

- This study utilizes multi-level linear regression modeling to describe the contributions of child's race, asthma, and neighborhood disadvantage on health-related quality of life (HRQoL) conditional on a host of child and family health and socio-demographic covariates, in a cohort of very low birth weight (VLBW) children.
- In a regional cohort of VLBW 2- and 3- year olds, black, non-Hispanic children demonstrate a statistically significant and clinically meaningful lower HRQoL than their white, non-Hispanic counterparts.
- Asthma explains most of the observed association between black race and HRQoL.
- The HRQoL of children born VLBW is particularly compromised for children with asthma living in more disadvantaged neighborhoods.

Figure 1.

Health-related quality of life, by neighborhood disadvantage, for white and black children with and without asthma, conditional on child and family characteristics*

* conditional on birth weight, gestational age and neonatal severity at mean values, living in single parent household, and being exposed to prenatal smoking, living with a smoker, no prenatal care, and child attends daycare.

** Neighborhood disadvantage was derived from principal component analysis of 5 socioeconomic indicators measured at the Census tract level. For interpretation, index scores were categorized as advantaged (>1 SD from mean), disadvantaged (> -1 SD below the mean), and otherwise, middle disadvantage.

Table 1

Bivariate analysis of independent and dependent covariates by race and ethnicity¹ for cohort (N=660) of very low birth weight 2- and 3- year olds in Wisconsin

Characteristic	% (N)				p-value
	Whole Cohort (n=660)	Black (n=82)	White (n=517)	Hispanic (n=32)	Other (n=29)
Total Annual Income					<0.001
Less than \$30,000	32.1 (212)	78.1 (64)	21.9 (113)	81.3 (26)	24.1 (7)
\$30,000 – \$60,000	32.4 (214)	17.1 (14)	36.0 (186)	15.6 (5)	31.0 (9)
More than \$60,000	35.6 (235)	4.9 (4)	42.2 (218)	3.1 (1)	44.8 (13)
Parental Education					<0.0001
Less Than a High school (HS) Degree	7.3 (48)	29.3 (24)	3.1 (16)	21.9 (7)	3.5 (1)
HS Degree or Equivalent	21.8 (144)	36.6 (30)	18.2 (94)	40.6 (13)	24.1 (7)
Some post HS	35.9 (237)	22.0 (18)	38.3 (198)	31.3 (10)	31.0 (9)
Bachelor Degree	35.1 (232)	12.2 (10)	40.4 (293)	6.3 (2)	41.4 (12)
Sex of the Child					0.54
Boys	48.3 (319)	48.8 (40)	47.8 (247)	46.9 (15)	48.3 (14)
Girls	51.7 (342)	51.2 (42)	52.2 (270)	53.1 (17)	51.7 (15)
Child Diagnosed with Asthma ²	13.9 (92)	48.8 (40)	7.2 (37)	21.9 (7)	27.6 (8)
Mother smoked during pregnancy	16.4 (107)	29.3 (24)	7.2 (37)	6.3 (2)	24.1 (7)
Child currently lives with a smoker	5.8 (38)	15.8 (13)	3.9 (20)	6.3 (2)	10.3 (8)
Child lives in single parent household	22.8 (151)	70.7 (58)	14.7 (76)	37.5 (12)	13.8 (4)
Child attends daycare	41.0 (269)	41.5 (34)	40.8 (211)	31.2 (10)	45.8 (13)
Mother received no prenatal care	2.6 (17)	7.3 (6)	1.4 (7)	12.5 (4)	0
				Mean (SD)	
Score of medical severity at birth ³	15.4 (12.7)	20.0 (13.2)	14.3 (12.7)	16.2 (10.4)	17.3 (12.9)
Birthweight in grams	1078 (280)	1033 (281)	1096 (280)	1038 (309)	1052 (230)
Gestational Age in weeks	28 (2.8)	27 (2.9)	28 (2.7)	29 (3.1)	29 (3.0)
HRQoL ⁴	87.4 (11.9)	83.0 (14.3)	88.2 (11.6)	89.8 (8.8)	86.5 (10.7)
Neighborhood Disadvantage Score ⁵	0 (1)	1.4 (1.2)	0 (0.6)	1.0 (1.1)	0(1)

- ¹ Includes black, non-Hispanic, white, non-Hispanic and Hispanic; the “Other” category was omitted for this table due to small cell sizes
- ² Parent-reported asthma
- ³ Neonatal severity is measured using the SNAP-II (range 0–115), higher score associated greater severity
- ⁴ Health-related quality of life, measured using the PedsQL, scores range from 0–100; higher scores indicate higher HRQoL
- ⁵ Neighborhood Disadvantage Index sums the standardized neighborhood variables, weighted by their factor loadings

Table 2

Descriptive statistics and factor loadings of neighborhood disadvantage characteristics for a cohort of children (n=661), age 2–3, who were born very low birth weight

Characteristic	% (s.e. %)	Range Across CT (%)	Factor Loading
Neighborhood Disadvantage			
Percent families living in poverty	8 (0.001)	0–61	0.95
Percent of households with incomes above state median	48 (0.006)	4 – 88	–0.77
Percent Females with Bachelor's Degree	15 (0.003)	0–45	–0.57
Percent single female head of household	3 (0.001)	0–21	0.84
Percent of mothers of young children who are unemployed	4 (0.002)	0–44	0.57
	Mean		
Summative Neighborhood Disadvantage Index¹	0	–2 – 4	

¹ Neighborhood Disadvantage Index sums the standardized neighborhood variables, weighted by their factor loadings

Table 3

Fixed and random effects for a series of linear multi-level random intercept models of quality of life among a cohort (n=660), age 2–3, who were born very low birth weight (VLBW).

Variable	Model 1 Null	Model 2 Socio-Dem	Model 3 Asthma	Model 4 Asthma by Race	Model 5 Neighborhood Disadvantage	Model 6 Neighborhood disadvantage, race, and asthma
Fixed Effects β se (β)						
Intercept	87.5 (0.48) ***	90.9 (6.9) ***	88.8 (6.7) ***	92.8 (6.7) ***	91.1 (7.1) ***	90.2 (6.1) ***
Parent's Education		−0.30 (0.70)	0.28 (0.68)	0.28 (0.68)	0.08 (0.71)	0.36 (0.73)
Neonatal health severity (mean) [†]		−0.10 (0.05) *	−0.05 (0.04)	−0.05 (0.04)	−0.06 (0.05)	−0.04 (0.05)
Child's race						
White, non-Hispanic		Reference	Reference	Reference	Reference	Reference
Black, non-Hispanic		−3.6 (1.7) *	0.08 (1.7)	−1.37 (3.0)	0.64 (2.4)	1.9 (3.3)
Hispanic		0.48 (1.9)	2.1 (1.8)	0.98 (2.1)	0.99 (2.2)	2.2 (2.5)
Other		−0.48 (2.8)	0.09 (2.7)	−1.4 (3.0)	−0.87 (3.4)	−2.0 (3.4)
Family Income		0.18 (0.79)	0.09 (0.76)	0.16 (0.78)	0.33 (0.82)	0.18 (0.81)
Birth weight (grams)		0.005 (0.003) *	0.005 (0.003) *	0.005 (0.003) *	0.005 (0.003) *	0.005 (0.003) *
Gestational age (weeks)		−0.23 (0.28)	−0.31 (0.27)	−0.31 (0.27)	−0.20 (0.27)	−0.27 (0.27)
Mom smoked during pregnancy						
Yes		−3.32 (1.4) *	−2.4 (1.4)	−2.3 (1.4)	−2.4 (1.5)	−2.1 (1.5)
No		Reference	Reference	Reference	Reference	Reference
Child attends daycare						
Yes		0.32 (0.63)	0.39 (0.60)	0.29 (0.59)	0.15 (0.63)	0.13 (0.63)
No		Reference	Reference	Reference	Reference	Reference
Child's Sex						
Male		−1.6 (0.98)	−0.56 (0.93)	−0.55 (0.90)	−0.53 (0.98)	−0.46 (0.97)
Female		Reference	Reference	Reference	Reference	Reference
Child lives in single-parent household						
Yes		−3.3 (1.4) *	−1.1 (1.4)	−1.19 (1.5)	−1.38 (1.5)	−1.0 (1.5)
No		Reference	Reference	Reference	Reference	Reference

Variable	Model 1 Null	Model 2 Socio-Dem	Model 3 Asthma	Model 4 Asthma by Race	Model 5 Neighborhood Disadvantage	Model 6 Neighborhood disadvantage, race, and asthma
Fixed Effects β se (β)						
Mother received no prenatal care						
Yes		1.1 (2.9)	1.1 (2.9)	1.0 (2.7)	1.5 (3.0)	1.5 (2.2)
No		Reference	Reference	Reference	Reference	Reference
Child lives with current smoker						
Yes		3.1 (2.1)	2.6 (2.0)	2.3 (2.0)	2.2 (2.1)	1.9 (2.1)
No		Reference	Reference	Reference	Reference	Reference
Child has asthma ²						
Yes			-6.2 (1.7)***	-5.6 (2.1)**	-4.1 (1.1)**	-5.2 (2.1)*
No			Reference	Reference	Reference	Reference
Child's Race*Asthma						
WNH*Asthma				Reference	Reference	Reference
BNH*Asthma				-2.59 (2.0)	-5.8 (2.7)*	-9.5 (5.0)*
Hisp*Asthma				3.41 (4.6)	1.5 (4.3)	2.4 (5.4)
Other*Asthma				6.44 (2.9)	2.7 (6.7)	4.3 (6.7)
Neighborhood disadvantage ³					0.09 (0.2)	0.39 (0.3)
Child's Race*Neighborhood disadvantage						
WNH*Disadvantage					Reference	Reference
BNH*Disadvantage						-0.21 (0.5)
Hisp*Disadvantage						-0.28 (0.4)
Other*Disadvantage						2.9 (1.2)
Neighborhood disadvantage*Asthma						
Disadvantage*Asthma						-2.1 (0.8)*
Disadvantage*No Asthma						Reference
Neighborhood Dis*Asthma*Race						
Disadvantage*WNH*Asthma						Reference
Disadvantage*BNH*Asthma						1.2 (0.8)
Disadvantage*Hisp*Asthma						-0.79 (1.1)

Variable	Model 1 Null	Model 2 Socio-Dem	Model 3 Asthma	Model 4 Asthma by Race	Model 5 Neighborhood Disadvantage	Model 6 Neighborhood disadvantage, race, and asthma
Fixed Effects β se (β)						
Disadvantage*Other*Asthma						-3.4 (1.6)*
Random Effects σ^2 se (σ^2)						
Between neighborhood variability	43.1 (12.5)**	28.8 (13.9)*	59.1 (14.1)****	57.9 (14.1)****	58.0 (14.7)**	58.0(14.7)**
-2 Res Log Likelihood	5577.3	4787.7	4628.6	4463.9	4280.9	4251.1

¹ Neonatal severity is measured using the SNAP-II (range 0–115), higher score associated greater severity

² measured by parent-report

³ Neighborhood Disadvantage Index sums the standardized neighborhood variables, weighted by their factor loadings

*** p<0.001

** p<0.01,

* p<0.05