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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 with normal-birth-weight 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 unfavourable environmental exposures. This study explores racial disparities in HRQoL among VLBW children and examines whether potential disparities can be explained by asthma and neighbourhood 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. Multilevel linear regression models were used to examine the contributions of asthma, neighbourhood disadvantage, and other child and family socio-demographic covariates, to racial disparities in HRQoL at age 2–3. A child's HRQoL was measured using the Paediatric Quality of Life Inventory 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 ($p>0.05$). The authors found no evidence that the relationship between asthma and HRQoL differs by race. The interaction between neighbourhood disadvantage and asthma is statistically significant, with further examination suggesting that racial disparities are particularly pronounced in the most advantaged neighbourhoods.

Conclusion The authors found that the black disadvantage in HRQoL among 2–3-year-old VLBW children likely stems from a high prevalence of asthma. Neighbourhood attributes did not further explain the disparity, as the racial difference was particularly pronounced in advantaged neighbourhoods.

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 g). Respiratory disease is the most common morbidity in VLBW children, and asthma risk is threefold higher in the VLBW than in the general population.[3] Not surprisingly, preschoolers born VLBW demonstrate a lower health-related quality of life (HRQoL) than their normal-birth-weight peers,[4 5] and asthma with its symptoms is a likely contributor.[6 7]

In a large cohort of premature births in Northern California, black children were found to have over four times the odds of white children of receiving oral asthma medications in the first year of life.[8] It is therefore likely that racial disparity in HRQoL found in a nationally representative study of US children[7] may be more pronounced among VLBW children, and asthma may be on the causal pathway (ie, effect mediator) explaining these racial disparities. Furthermore, it is unclear if black VLBW children experience asthma differently than do white VLBW children with asthma, and whether this might affect HRQoL (ie, race is an effect modifier between asthma and HRQoL). Black children with asthma have a worse symptom severity, miss more school, have more hospitalisations and have more frequent emergency department visits than their white peers with asthma.[9 10] 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. Such a hypothesis is also supported by the fact that black VLBW neonates have similar or better respiratory outcomes than white VLBW neonates in the Neonatal Intensive Care Unit,[11 12] yet appear to experience worse asthma in childhood.

The social ecological model[13] suggests that child health, and presumably HRQoL, stem from all ecological niches (individual, family, community and social policy). Our previous work[14] suggests that neighbourhood disadvantage is associated with HRQoL in children born VLBW. Moreover, there is a large literature[15–18] to support the influence of neighbourhood disadvantage on asthma prevalence, especially among minority children. Black, non-Hispanic children are more likely to live in socially disadvantaged neighbourhoods,[19] 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 neighbourhood 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.[20 21] HRQoL captures not only health difficulties but problems stemming from children's interactions with their surroundings.[22]

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.[23] HRQoL in young children is collected via parent report. Several measures, including the Paediatric Quality of Life Inventory (PedsQL), are reported to have excellent reliability and to be sensitive to changes pre- to postintervention, and are easily administered.[24]

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 neighbourhood disadvantage help explain any racial differences in HRQoL in this cohort. We hypothesise 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 neighbourhoods 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 hospitalised in one of 16 NICUs in Wisconsin or near the state border. The original study obtained follow-up addresses for 979 infants and also collected extensive clinical data. At age 2–3, 748 were alive and located, and of these, 719 children have complete HRQoL data. Data on 59 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). The final sample included 660 children. To test for potential bias from 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. These model estimates were very similar whether cases with missing data were included or excluded. Thus, we restrict our analyses to children (n=660) with complete data.

Outcome measures

Children's HRQoL was measured using the Paediatric Quality of Life Inventory (PedsQL)[25] reported by parents for toddlers aged 2–4. The PedsQL contains 21 items that obtain parental assessment in four 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 better HRQoL.

Child and family characteristics (level 1)

Parental education was categorised 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 distress was measured by the Score for Neonatal Acute Physiology-II,[26] an index ranging from 0 to 115 that comprises six physiologically based items (eg, 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 multiracial families). Annual family income was categorised as less than $30 000, between $30 000 and $60 000 and greater than $60 000, and modelled as an ordinal variable. Birth weight was measured in grams and gestational age in weeks. Exposure to environmental tobacco smoke was measured by two variables—whether the mother smoked during pregnancy and whether the child lives with a current smoker. We also included the sex of the child, whether or not the child attends daycare, single-parent household and whether 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.

Neighbourhood disadvantage (level 2)

A neighbourhood disadvantage index (table 2) was created using a principal-component analysis of five census tract socio-demographic variables[27]: percentage of families in poverty, percentage of households with an income above the state median, percentage of females with a bachelor's degree or more, percentage of single mothers and percentage of unemployed mothers of young children. Principal-component analysis[28] is a data-reduction technique that determines how to combine variables linearly into a single score that captures as much as possible of the overall variability in the variables and has been previously used in perinatal epidemiological research.[29] Specifically, the five census variables were standardised (after reverse-coding the percentage of females with a bachelor's degree or more and the percentage of households with an income above the state median) following the standard procedure. An overall neighbourhood disadvantage score (mean=0, SD=1, and α=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

Multilevel modelling[30] was used to examine the contributions of asthma, neighbourhood disadvantage, and other child and family socio-demographic covariates to HRQoL. Multilevel models account for the clustering of children (Level 1) in neighbourhoods (Level 2) and explicitly model the fixed effects of each covariate on the outcome (β) and the neighbourhood variability (σ^2) around the predicted value.

Our analyses entailed fitting a series of multilevel linear random intercept models. A previous study[5] suggests that HRQoL in VLBW children has a skewed distribution. To evaluate the appropriateness of a linear model, we also utilised Tobit regression (ie, 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 (ie, contains no covariates) describes the overall neighbourhood census tract (CT) variability in HRQoL. Second, we added the child's race to examine their contribution to explaining HRQoL and neighbourhood 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 included, first, neighbourhood disadvantage and, second, interaction terms between child race and ethnicity, asthma and neighbourhood disadvantage.

For each model, we report the estimated fixed effect ($\widehat{\beta}$) for each covariate, the SE of $\widehat{\beta}$, estimated neighbourhood variability ($\widehat{\sigma}^2$) and SE of $\widehat{\sigma}^2$. A substantial reduction in ($\widehat{\sigma}^2$) indicates that the variables in the model help explain the observed differences in HRQoL across neighbourhoods.

Multilevel linear regression analyses were conducted in SAS v9.13[31] using PROC MIXED. Tobit models were fitted in

Table 1 Bivariate analysis of independent and dependent covariates by race and ethnicity* for cohort (N=660) of very-low-birth weight 2- and 3-year-olds in Wisconsin

	Percentage (N)					
Characteristic	**Whole cohort (n=660)**	**Black (n=82)**	**White (n=517)**	**Hispanic (n=32)**	**Other (n=29)**	**p Value**
Total annual income						<0.001
<$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)	
>$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 degree	7.3 (48)	29.3 (24)	3.1 (16)	21.9 (7)	3.5 (1)	
High-school degree or equivalent	21.8 (144)	36.6 (30)	18.2 (94)	40.6 (13)	24.1 (7)	
Some post-high-school	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 as having asthma†	13.9 (92)	48.8 (40)	7.2 (37)	21.9 (7)	27.6 (8)	<0.001
Mother smoked during pregnancy	16.4 (107)	29.3 (24)	7.2 (37)	6.3 (2)	24.1 (7)	<0.001
Child currently lives with a smoker	5.8 (38)	15.8 (13)	3.9 (20)	6.3 (2)	10.3 (8)	<0.001
Child lives in single parent household	22.8 (151)	70.7 (58)	14.7 (76)	37.5 (12)	13.8 (4)	<0.001
Child attends daycare	41.0 (269)	41.5 (34)	40.8 (211)	31.2 (10)	45.8 (13)	0.009
Mother received no prenatal care	2.6 (17)	7.3 (6)	1.4 (7)	12.5 (4)	0	<0.001
	Mean (SD)					
Score of medical severity at birth‡	15.4 (12.7)	20.0 (13.2)	14.3 (12.7)	16.2 (10.4)	17.3 (12.9)	0.006
Birth weight (g)	1078 (280)	1033 (281)	1096 (280)	1038 (309)	1052 (230)	0.13
Gestational age (weeks)	28 (2.8)	27 (2.9)	28 (2.7)	29 (3.1)	29 (3.0)	0.05
Health-related quality of life§	87.4 (11.9)	83.0 (14.3)	88.2 (11.6)	89.8 (8.8)	86.5 (10.7)	0.005
Neighbourhood Disadvantage Index¶	0 (1)	1.4 (1.2)	0 (0.6)	1.0 (1.1)	0 (1)	<0.001

*Includes black, non-Hispanic, white, non-Hispanic and Hispanic; the 'Other' category was omitted for this table because of the small cell sizes.
†Parent-reported asthma.
‡Neonatal severity is measured using the Score for Neonatal Acute Physiology-II (range 0–115), higher score-associated with greater severity.
§Health-related quality of life, measured using the Paediatric Quality of Life Inventory, scores ranging from 0 to 100; higher scores indicate a higher health-related quality of life.
¶The Neighbourhood Disadvantage Index sums the standardised neighbourhood variables, weighted by their factor loadings.

MPlus.[32] The institutional review board at University of Wisconsin-Madison and all participating institutions approved this study.

RESULTS

Race differences in HRQoL

In table 3, Model 1 indicates that there is a significant between-neighbourhood variability in HRQoL ($\widehat{\sigma}^2$=43.1, SE ($\widehat{\sigma}^2$)=12.5). Model 2 suggests that over 30% of this between-neighbourhood variability is attributable to family sociodemographic and child characteristics (Model 2 reduces the variability to $\widehat{\sigma}^2$=28.8, SE ($\widehat{\sigma}^2$)=13.9).

In Model 2, we test our first hypothesis and find that black race is associated with a statistically significant, nearly four-point deficit in HRQoL relative to being white, non-Hispanic (β =−3.6, SE (β)=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 of lower birth weight persist across all models.

Table 2 Descriptive statistics and factor loadings of neighbourhood disadvantage characteristics for a cohort of children (n=660), age 2–3, who were born very low birth weight

Characteristic	**Percentage (SE %)**	**Range across CT (%)**	**Factor loading**
Neighbourhood disadvantage			
Percentage of families living in poverty	8 (0.001)	0 to 61	0.95
Percentage of households with incomes above the state median	48 (0.006)	4 to 88	−0.77
Percentage of females with a bachelor's degree	15 (0.003)	0 to 45	−0.57
Percentage with a single female head of household	3 (0.001)	0 to 21	0.84
Percentage of unemployed mothers of young children	4 (0.002)	0 to 44	0.57
	Mean		
Summative Neighbourhood Disadvantage Index*	0	−2 to 4	

*Neighbourhood Disadvantage Index sums the standardised neighbourhood variables, weighted by their factor loadings.

Influence of asthma on the relationship between a child's race and HRQoL

Model 3 adds asthma and demonstrates that asthma has a statistically significant, independent, negative association with HRQoL (β =−3.6, SE (β)=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 neighbourhood variability in HRQoL, suggesting cross-level confounding[30] (ie, an increase in between-neighbourhood variance associated with an individual-level covariate suggests the

Table 3 Fixed and random effects for a series of linear multilevel random intercept models of quality of life among a cohort (n=660), aged 2–3, who were born very low birth weight

Variable	Model 1: null	Model 2: socio-demographic	Model 3: asthma	Model 4: asthma by race	Model 5: neighbourhood disadvantage	Model 6: neighbourhood 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		048 (1.9)	2.1 (1.8)	0.98 (21)	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 (g)		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)
Mother 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 a 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
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 a 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‡						
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)
Neighbourhood disadvantage§					0.09 (0.2)	0.39 (0.3)
Child's race×neighbourhood disadvantage						
WNH×disadvantage						Reference
BNH×disadvantage						−0.21 (0.5)
Hisp×disadvantage						−0.28 (0.4)
Other×disadvantage						2.9 (1.2)
Neighbourhood disadvantage×asthma						
Disadvantage×asthma						−2.1 (0.8)*
Disadvantage×no asthma						Reference
Neighbourhood disadvantage×asthma×race						
Disadvantage×WNH×asthma						Reference
Disadvantage×BNH×asthma						1.2 (0.8)
Disadvantage×Hisp×asthma						−0.79 (1.1)
Disadvantage×Other×asthma						−3.4 (1.6)*
	Random-effects σ^2 SE (σ^2)					
Between-neighbourhood 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

*p<0.05; **p<0.01; ***p<0.001.
†Neonatal severity is measured using the Score for Neonatal Acute Physiology-II (range 0–115), higher score associated with greater severity.
‡Measured by parent report.
§Neighbourhood Disadvantage Index sums the standardised neighbourhood variables, weighted by their factor loadings.
BNH, black, non-Hispanic; Hisp, Hispanic; WNH, white, non-Hispanic.

individual-level covariate asthma is highly correlated with observed and unobserved contextual factors).

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 ($p>0.05$). When children born with VLBW have asthma, it is associated with worse HRQoL, no matter what the race of the child.

Influence of neighbourhood disadvantage, child's race and asthma on HRQoL

Model 5 suggests that inclusion of neighbourhood disadvantage results in a significant estimate for the interaction between black race and asthma ($\beta=-5.8$, SE (β)=2.7). This suppressor effect of neighbourhood disadvantage, coupled with the previously mentioned increases in between-neighbourhood 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 neighbourhood disadvantage (Model 6).

Figure 1 depicts the results of a model including a three-way interaction between race, asthma and neighbourhood 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 neighbourhood 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 neighbourhood 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 neighbourhoods not having a decrement in HRQoL with asthma.

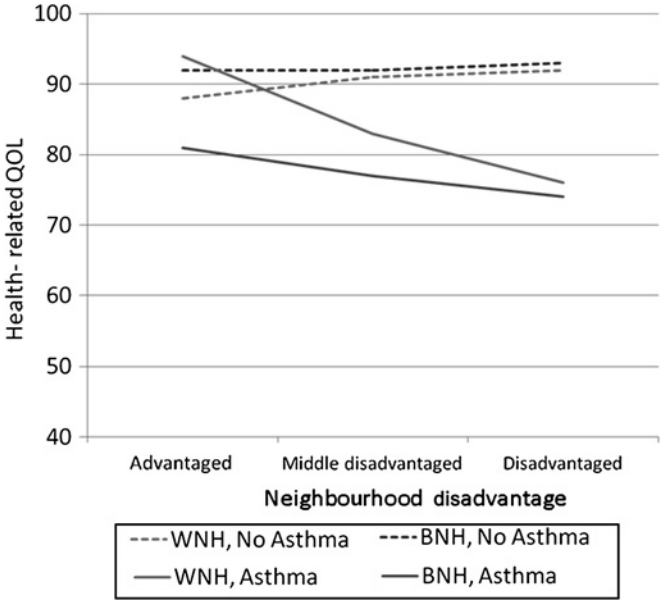

Figure 1 Health-related quality of life (QOL), by neighbourhood disadvantage, for white, non-Hispanic (WNH) and black, non-Hispanic (BNH) children with and without asthma, conditional on child and family characteristics (conditional on birth weight, gestational age and neonatal severity at mean values, living in a single-parent household, and being exposed to prenatal smoking, living with a smoker, no prenatal care and child attending daycare). Neighborhood disadvantage was derived from a principal-component analysis of five socio-economic indicators measured at the census tract level. For interpretation, index scores were categorized as advantaged (>−1 SD below mean), disadvantaged (>1 SD above the mean) and otherwise, middle disadvantage (mean).

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, neighbourhood 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 a four-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 potential impact of asthma. Above and beyond race and other child and family socio-economic characteristics, asthma is a statistically significant and clinically meaningful predictor of lower HRQoL. Furthermore, 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 casual pathway (ie, effect mediation) between race and HRQoL. We found no evidence that HRQoL differs between black versus white VLBW children with asthma (ie, effect modification).

We found evidence that, net of child and family characteristics, neighbourhood disadvantage independently influences HRQoL among children with asthma. Children with asthma who live in socially disadvantaged neighbourhoods may not have access to, and the quality of, resources such as health clinics and safe housing. Alternatively, families may have difficulty accessing resources owing to limited transportation, safety or lack of coordinated systems of care. Nonetheless, our findings are consistent with previous research[14 33] suggesting a persistent black–white disparity in asthma morbidity, even when adjusting for individual and neighbourhood socio-economic characteristics. This persistent racial disparity warrants further investigation. For example, there is growing evidence[16 17] to suggest the importance of process (eg, collective efficacy and community psychosocial stress), residential segregation and housing quality. Cagney and Browning[17] demonstrated a higher prevalence of asthma, not explained by family characteristics and neighbourhood poverty, in neighbourhoods with low levels of collective efficacy and social disorder.

We expected that living in a socially disadvantaged neighbourhood would be particularly harmful for HRQoL of black children with asthma, yet we find no evidence of this. Instead, our findings (although not statistically significant) suggest that black VLBW children with asthma living in socially advantaged neighbourhoods fare worse than their white counterparts. Thus, it is plausible that black children with asthma living in more socially advantaged areas experience differential psychosocial (eg, racial discrimination) and environmental stressors than their white peers with asthma, which contribute to a lower HRQoL. Moreover, at the worst levels of neighbourhood social disadvantage, all children fare poorly regardless of their race. The exception to this seems to be children characterised as 'other' race, who seem to fare particularly poorly in socially disadvantaged areas. However, these results should be interpreted with caution owing to sparse sample sizes.

We acknowledge several limitations to this study. First, these data are cross-sectional, which precludes inferring causal

relationships. The relationships we describe are difficult to fully capture through measured characteristics. It is possible that biases are introduced not only by unobserved characteristics of children and families that influence asthma and HRQoL, but also by virtue of the fact that families are not randomly assigned to neighbourhoods, but rather 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 paediatric HRQoL. However, as previously mentioned, the PedsQL not only has strong psychometric properties overall,[24] but also is appropriate for use with paediatric asthmatic populations.[6] Finally, we utilised parent-reported asthma, which may introduce biases if differences in reporting occur across relevant racial and social subgroups. We have no means of quantifying potential reporting bias but rely on previously research[3] 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 the model including the interactions between race, asthma and neighbourhood social disadvantage 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 utilise 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 (neighbourhood 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 that manifest early in the life course have implications for subsequent disparities in a range of long-term 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 the neighbourhood 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.

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Competing interests None.

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What is already known on this subject

- Very-low-birth-weight (VLBW; <1500 g) children are at heightened risk for poorer overall physical health.
- VLBW children have a lower health-related quality of life (HRQoL) and risk for asthma than their normal-birth-weight peers. Asthma risk is substantially increased for black, non-Hispanic VLBW children and children living in disadvantaged neighbourhoods.
- To our knowledge, no study has examined racial disparities in HRQoL among VLBW preschoolers, generally, or the additive or interactive effects of child's race, asthma and neighbourhood disadvantage.

What this study adds

- This study utilises multilevel linear regression modelling to describe the contributions of child's race, asthma and neighbourhood disadvantage on HRQoL conditional on a host of child and family health and socio-demographic covariates, in a cohort of 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 neighbourhoods.

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