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Low Birthweight and Psychoeducational Outcomes: Investigation of an African-American birth cohort

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Abstract

African-Americans experience more than double the prevalence of low birth weight/premature birth compared to their Caucasian counterparts reflecting a public health crisis and a significant social justice concern. However, there is a paucity of low birth weight (LBW) outcome studies in African-American samples. There are even fewer that investigate developmental outcomes within the moderately low birth weight range (i.e., 1500 to 2500 g), the most prevalent category of LBW births. This study investigates the relationship between low birth weight and various psychoeducational outcomes in a prospectively designed African-American birth cohort. Multivariate logit analyses of the Johns Hopkins University Pathways to Adulthood study compared low birth weight children with normal birth weight children on a number of outcome measures at seven and eight years of age. Results revealed that children born within the lowest birthweight category produced the most adverse findings, from both a statistical and clinical standpoint, on measures of cognitive ability, academic achievement, speech, language, auditory processing, and visual-motor integration.

KEYWORDS: Low birthweight, developmental outcomes, cognitive ability, academic achievement, African-American

Low Birthweight and Psychoeducational Outcomes: Investigation of an African-American Birth Cohort

Children born with low birth weight (LBW) are placed at immediate developmental disadvantage right from the start of life. The societal cost of intervention services for these children is high (i.e., $26.2 billion in 2005; Institute of Medicine (US) Committee on Understanding Premature Birth and Assuring Healthy Outcomes, 2007) with one study revealing that cost of premature birth/low birth weight rivals that of alcoholism (Lewit, Baker, Corman & Shiono, 1995). Despite the consistent yearly pattern of greater than a two-fold increase of low birthweight babies in African-American populations (14.2%) compared to their European-American counterparts (7%), research investigating specific African-American LBW outcomes is conspicuously absent (Aarnoudse-Moens, Weisglas-Kuperus, van Goudoever, & Oosterlaan, 2009; Dombrowski & Martin, 2007; Martin & Dombrowski, 2008; Mohamed et al., 2014; Ratnasiri et al., 2018; Wen, Smith, Yang & Walker, 2004). The broader research suggests that LBW babies are at increased risk for reduced cognitive/academic performance, learning disorders, special education placement, speech-language delays, and disorders of motor coordination, including fine motor skills (Alyward, 2014; Buck, Msall, Schisterman, Lyon, and Rogers, 2000; Gu et al., 2019; Ichord, 1993; Msall, 2012; McCormick, Gortmaker, & Sobol, 1990; McCormick, Brooks-Gunn, Workman-Daniels, Turner & Peckham, 1992; McNicholas et al., 2014; Squarza et al., 2016; Twilhaar, Wade, de Kieviet, van Goudoever, van Elburg, & Oosterlaan, 2018). Much of the available research has focused on the lowest birth weight babies. Less is available on the heavier, LBW category (i.e., >2000 grams), despite encompassing greater than 70% of the LBW births. There is a dearth of outcome research on African-American

samples, despite the doubling of the risk of low birthweight[1] in this group (Ratnasiri et al., 2018). This lacuna deserves greater research (and public) attention as it represents yet another factor that places African-American youth at disadvantage right from the very start of life.

The primary purpose of this study is to investigate a prospectively[2] designed African-American birth cohort and examine LBW in relation to cognitive, academic, visual-motor, and speech-language-auditory processing outcomes at ages 7 and 8. This study will help better elucidate the relationship between birthweight and various psychoeducational outcomes. It is hypothesized that children with low birthweight will be at increased risk of adverse psychoeducational outcomes compared to their normal birthweight counterparts, with the lowest birthweight category experiencing the most risk for adverse outcomes.

Methods and Materials

The participants for this study were part of the Pathways to Adulthood study, a randomly selected subsample from the population in the Johns Hopkins Collaborative Perinatal Study (JHCPS), itself a component of the Collaborative Perinatal Project of the National Institute of Neurologic and Communicative Disease and Stroke (see Hardy & Shapiro, 1999 for further details). The cohort mothers who enrolled in the study lived in east Baltimore, mostly within a 10-block radius of the Johns Hopkins University hospital. Of the original JHCPS children, a sample (n=1884) of African-American children had complete data involving maternal characteristics such as age, parity, poverty level, and educational level, children's gestational age

[1] Low birthweight data is often used in research studies instead of prematurity data because LBW is more readily available and considered more accurate as the precise date of conception may not be known. The two variables are highly correlated at approximately .80 (Martin & Dombrowski, 2008).

[2] A prospectively designed birth cohort study is one where the study (and its variables) were established before children were even born. Birth cohort studies are rarely available as they are complex and extremely costly. In this case, the JHCPS study was planned before the youth under study were born and participant data were collected at predetermined time periods in a systematic fashion.

and birth weight, and complete 7 or 8-year JHCPS cognitive, academic, visual-motor, and speech-language-hearing performance assessment.

Table 1 provides important obstetric and sociodemographic data on maternal characteristics including age, parity, poverty level, and education level. Twenty five percent of African American mothers were less than 20 years old when their children were born. Educational attainment among mothers was generally low; only 28.6% of cohort mothers had completed high school. At birth, 50% of cohort children lived in families at or below the poverty level and only approximately 10% had an income greater than twice that level.

*****INSERT TABLE 1 ABOUT HERE****

Academic achievement, cognitive ability, visual-motor coordination, and speech, language, auditory processing, and hearing assessment data were obtained when cohort children were 7 and 8 years of age. Children were assessed on the Wide Range Achievement Test (WRAT), Wechsler Intelligence Scale for Children (WISC), and Bender-Gestalt Test of Visual Motor Development (Bender). Speech, language, auditory processing, and hearing development were evaluated by a speech pathologist and audiologist when the cohort child was 8 years of age across four areas: language (comprehension, and expression), hearing, speech (mechanism and production), and auditory processing.

A series of multivariate logit models were used to investigate whether a relationship exists between birth weight and the various psychoeducational outcomes. Multivariate logit analysis is a statistical tool commonly used in the medical field not only to determine statistical significance, but also to better understand practical consequences of an adverse outcome. One

available metric produced by this analysis is an odds ratio (OR; Tolles & Meurer, 2016). An OR provides a measure of association between an exposure and an outcome, and reflects the odds that an outcome will occur given a particular risk factor, compared to the odds of the outcome occurring in the absence of that risk factor (Szumilas, 2010). Because of the potentially confounding effects of gender, parity, poverty level, maternal educational level, and maternal age, these variables in all analyses were controlled for statistically. All dependent variables (i.e., cognitive ability, academic achievement, visual-motor integration) were dichotomized. Cognitive ability scores were dichotomized into scores less than 70 or greater than/equal to 70. Academic achievement scores were dichotomized as average/above average or below average. The remaining dependent variables were rated as normal or abnormal based on the clinical judgment of the evaluator. The variables controlled for in the analyses were continuous (poverty index, maternal age), dichotomous (parity), or categorical (maternal education level). The two birthweight categories (i.e., LBW and VLBW) were dichotomized such that LBW included participants weighing 2000 to 2500 grams at birth while VLBW included participants weighing less than 2000 grams.

Results and Discussion

Multivariate logit analyses revealed that children born with moderately low birth weight were at increased risk of below average performance on the WRAT in the domain of spelling (OR[3] 1.55, 95% CI 1.03-2.35; see Table 2). Performance on measures of reading and mathematics among moderately low birth weight children was not statistically different from the

[3] An odds ratio is used to determine the strength of association between a risk factor (low birthweight) and an outcome (academic achievement) (Norton, Dowd, & Maciejewski, 2018). In this case, there is a 55% increased risk of below average performance on the WRAT Spelling subtest. In the case of VLBW there is nearly a threefold increased risk (OR=2.81) of below average performance on the WRAT Spelling subtest. Odds ratios include a confidence interval (e.g., 95%). Confidence intervals that bracket 1.0 are not significant (i.e., see LBW WRAT Math in Table 2 for an example of a non-significant odds ratio).

performance of average birth weight children. However, children born weighing less than 2000 grams were at elevated risk of below average performance on measures of spelling (OR 2.81, 95% CI 1.72-4.60), reading (OR 2.89, 95% CI 1.75-4.76), and mathematics (OR 2.73, 95% CI 1.66-4.48). It is noteworthy that VLBW reflected a nearly three-fold increase in the risk of below average academic performance across all domains.

Logit analyses revealed that children born with VLBW were at increased risk of scoring in the intellectual disability range (i.e., full scale intelligence quotient score <70) on the WISC (OR 3.58, 95% CI 2.29-5.59). Children born with moderately LBW were not at greater risk of performance in the intellectual disability range. Logit analyses revealed that children born with moderately LBW were at increased risk of abnormal performance on the Bender (OR 1.54, 95% CI 1.12-2.20). Children born with VLBW were at even greater risk of abnormal performance (OR 2.11, 95% CI 1.35-3.30).

Insert table 2 about here *******

A speech-language pathologist along with an audiologist evaluated children when they were eight years old. Logit analyses revealed no significant difference on measures of hearing at either of the birth weight levels (moderately LBW or VLBW). On a measure of auditory processing, the analysis indicated a significant finding for children born with moderately LBW (OR 1.75, 95% CI 1.12-2.71) and VLBW (OR 1.69 95% CI 1.23-2.32). A language assessment revealed that VLBW children were at elevated risk for language related difficulties (OR 2.19, 95% CI 1.25-3.85); however, moderately LBW children (OR 1.35 95% CI .95 -1.90) were not significant.

The result of our investigation of an African-American prospectively designed birth cohort provided evidence for an approximate 3.5 increased risk of performance in the intellectual disability range and a threefold increased risk of reduced academic achievement, in the areas of spelling, reading, and mathematics among babies born with VLBW (<2000 grams). The results for moderately LBW babies were non-significant for reading, mathematics, and cognitive ability, but significant for spelling. The available research on the relationship with visual-motor skills reports a fairly strong relationship (Geldof et al., 2012; Halsey, Collin, & Anderson, 1993; Mansson & Stjernqvist, 2014; Ornstein, Ohlsson, Edmonds, & Asztalos, 1991). Our analysis of the Bender was consistent with this literature. Both moderately low and VLBW babies reported increased risk of abnormal performance (54% and 111%, respectively). In addition, the results of our study suggest that being born VLBW increased the relative risk of delays in auditory processing, language, and speech. These findings, too, are consistent with prior research, which indicates a linkage with LBW/premature birth and later speech-language outcomes. The effects are somewhat less severe in the moderately LBW sample.

The findings of adverse cognitive, academic, visual-motor, and speech, language, auditory processing outcomes are plausible from a neurodevelopmental perspective (Dombrowski & Martin, 2007; Kinney & Volpe, 2012). LBW and premature birth are highly correlated at approximately .80 (Martin & Dombrowski, 2008). Accordingly, being born too early or with LBW suggests a less than optimal intrauterine environment, which has been thought to contribute to later cortical and neuronal abnormalities (Taylor, Minich, Bangert, Filipek & Hack, 2004) including smaller volumes of the sensorimotor cortex and the surrounding cortex, corpus callosum, amygdala, hippocampus, and basal ganglia (Bhutta & Anand, 2001). Furthermore, neonatal ultrasound has shown that LBW infants are prone to germinal matrix and

intraventricular hemorrhages, hydrocephalus, and infarction of the periventricular region and cerebral cortex (Panaeth, Rudelli, Kazam & Monte, 1994; Twilhaar et al., 2018). Volpe (2009) coined the term encephalopathy of prematurity for this complex amalgam of disruptive and destructive brain damage that occurs when a baby is born at the more extreme lower birthweight range.

The biological bases of the psychoeducational deficits in LBW children above the extreme low end (>2000 grams) of the birth weight distribution are less clear. For some of the variables, but not all, there appears to be a pattern akin to a dose-response relationship between birth weight and developmental outcomes, such that the lower the birth weight the more deleterious the impact. This was most noticeable on tasks (e.g., spelling; Bender) that required visual-motor integration. For the remaining variables (e.g., cognitive ability, speech, hearing, reading, math) there was no evidence of an adverse impact at the moderately LBW range (i.e., 2000 to 2500 grams). This may well suggest that babies born above the 2000 gram weight limit may escape some of the adverse outcomes experienced by babies with even lower birthweight.

The findings of this study must be viewed in light of the following limitations. We were not able to control for additional factors that have been definitively or hypothetically linked to LBW such as anoxia, maternal smoking, substance use, maternal pregnancy weight gain, parental size, and maternal infection (Alyward, 2014; Dombrowski, Martin & Huttunen, 2003; 2005; Kinney & Volpe, 2012; Martin, Dombrowski, Mullis, & Huttunen, 2005). Thus, the results of this study should be viewed as associative, not causative. Selected risk factors (e.g., smoking; anoxia, substance use; prenatal infection) not only contribute to adverse outcomes but also to the increased likelihood of LBW. LBW is one step in a series of adverse events that began earlier in pregnancy, which combine to disrupt the health and development of the fetus. This line of

thinking is consistent with the broader developmental child psychopathology research that does not support granting central etiological status to any single risk or causal factor (Hayden & Mash, 2014).

Despite these limitations, this investigation is among the first to use a prospectively designed, randomly sampled African-American birth cohort that was able to control for numerous confounding sociodemographic and maternal variables including maternal parity, age, education level, and poverty level. Future research that compares LBW outcomes across various racial/ethnic groups appears worthwhile to determine whether the findings are specific to this racial/ethnic group. This study suggests that being born within the lowest birthweight category produces additional developmental challenges for African-American children that deserves increased attention by the research, public health and educational communities.

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Table 1: Cohort Characteristics

	n	Percentage
Child Gender		
Male	943	50.05%
Female	941	49.95%
Total	1884	100.0%
Average WISC Scores		
Full Scale IQ	91.6	
Verbal IQ	91.5	
Performance IQ	93.3	
Maternal Parity		
Primimparous	531	28.2%
Multiparious	1353	71.8%
Total	1884	100.0%
Maternal Education level		
Less than 8th grade	258	13.7
Eighth grade	250	13.3
Some high school	832	44.2
High school graduate	423	22.4
Some college	109	5.8
Bachelors or higher	12	0.6
Total	1884	100%
Low Birthweight	223	11.8
Very Low Birthweight	110	5.8

	Mean	25%	75%	90%	S.D.

Maternal age	25.3	19.6	30.4	35.7	7.3
Poverty index level	1.14	.68	1.45	2.05	.71

Table 2: Relationship with Psychoeducational Outcomes

Assessment	Relative Risk of Below Average Performance Odds	95% CI		Significance
Visual-Motor Integration				
Bender				
LBW (2000 to 2500)	1.54	1.12	2.10	p <.01
VLBW (<2000)	2.11	1.35	3.30	p<.001
Academic Achievement				
WRAT				
Spelling				
LBW (2000 to 2500)	1.55	1.03	2.35	p<.05
VLBW (<2000)	2.81	1.72	4.60	p<.0001
Reading				
LBW (2000 to 2500)	1.39	.89	2.15	NS
VLBW (<2000)	2.89	1.75	4.76	p<.0001
Math				
LBW (2000 to 2500)	1.43	.94	2.19	NS
VLBW (<2000)	2.74	1.67	4.49	p<.0001
Cognitive Ability				
LBW (2000 to 2500)	1.38	.92	2.07	NS
VLBW (<2000)	3.58	2.29	5.59	p<.0001

Assessment	Relative Risk of Abnormal Performance Or Suspected Disability Odds	95% CI		Significance
Speech, Language, Hearing & Auditory Processing				
Speech				
LBW (2000 to 2500)	.89	.62	1.29	NS
VLBW (<2000)	1.80	1.14	2.84	p<.01
Language				
LBW (2000 to 2500)	1.35	.95	1.91	NS
VLBW (<2000)	2.19	1.25	3.85	p <.01
Hearing				
LBW (2000 to 2500)	1.06	.65	1.73	NS
VLBW (<2000)	1.65	.91	3.00	NS
Auditory Processing				
LBW (2000 to 2500)	1.75	1.12	2.71	p<.01
VLBW (<2000)	1.69	1.23	2.32	p<.001

NS=Non Significant; LBW=Low birthweight (2000-2500 grams)
VLBW=Very low birthweight (Less than 2000 grams)