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A Population-Based Study of School Readiness Determinants in a Large Urban Public School District

Lawrence D. Reid[1] · Donna M. Strobino[1]

Abstract

Objectives We examined biologic and social determinants of school readiness in an urban population and whether child-care altered these associations. *Methods* A retrospective cohort study was conducted using school readiness data linked to birth certificates of first-time kindergarten students (n = 39,463) in a large, urban public-school district during 2002–2012. Multivariate linear regression models compared mean readiness scores (MRS) for students born low birthweight (LBW) or preterm (PTB) and by childcare type, adjusting for other student and parent risk factors. *Results* MRSs for moderately LBW (1000–2499 g), extremely LBW (< 1000 g), moderately PTB (28–36 weeks), early-term (37–38 weeks) and post-term (42 + weeks) students were significantly lower than scores for their normal weight or full-term peers, adjusting for childcare type and other student and parent characteristics. Childcare was an important predictor of MRSs. MRSs were highest for district prekindergarten (PK) students and for students of mothers with greater years of education. *Conclusions for Practice* Social and biologic differences in MRSs for children entering school in a large urban public-school district suggest the need for greater attention to family and child health backgrounds. Increased enrollment in formal childcare may improve school readiness in these settings.

Keywords School readiness · Low birthweight · Preterm birth · Population-based · Childcare

Significance

Prior research has shown children born low birthweight or preterm have greater developmental delays than their normal birthweight and term counterparts. Important risk factors contributing to this association often point to lower socioeconomic status, however population-based studies are rarely conducted within these settings to better understand these associations.

This study seeks to fill this knowledge gap by examining the association between low birthweight, preterm birth and school readiness in a predominantly low-income, urban school district and to identify how childcare influences this association.

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Introduction

A major predictor of adolescent and young adult health and academic success is how prepared children are when they begin school in kindergarten (Duncan et al. 2007; LaParo and Pianta 2000). School preparedness, or school readiness, represents a complex multifaceted measure of how well children's first five years of life have prepared them to enter formal schooling. Students who enter school with greater preparedness are more likely to achieve higher levels of education and employment as adults (Rouse et al. 2005). Conversely, children who enter school less prepared often struggle to maintain their grades and attendance and often drop out of school (Hertzman and Wiens 1996). School dropouts are more likely to engage in illegal behaviors, become teen parents and depend on public assistance programs (Shonkoff and Philips 2000), ultimately costing society and the child exponentially more than the cost to help ensure children enter school ready to learn (Sum et al. 2009).

Although there is no definitive measure of school readiness, the estimated prevalence of school readiness has increased based on proxy indicators. Nationally, the

percentage of prekindergarten (PK) children with the ability to recognize all letters, count to at least 20 or write their name increased 31%, 16%, and 81%, respectively, from 1992 to 2012 (O'Donnell 2008; Chandler et al. 1999). These data further suggest the school readiness gap by poverty status increased from 1992 to 2007. Recent estimates indicate approximately 25% of children live in poverty in the United States (US) (Short 2012) suggesting continued negative impacts on school readiness for a significant number of US children.

Adverse birth outcomes like low birthweight (LBW, < 2500 g) or preterm birth (PTB, < 37 weeks gestation) occur more often in areas with greater socioeconomic disadvantage (Blumenshine et al. 2010) and compound the damaging effects of poverty on child development. Cognitive impairments are the most common and severe disabilities experienced by PTB children (Arpino et al. 2010), independent of birth weight (Anderson and Doyle 2003; Shankaran et al. 2004) and other potential confounders like maternal education and socioeconomic factors (Breslau et al. 2001). Children born PTB or LBW are also more likely to need special academic assistance in formal education settings (Taylor et al. 2011). Nationally representative studies in the US and Australia observed lower probabilities of school readiness for students born LBW (Isaacs and Magnuson 2011) and "significantly lower performance on cognitive skills underlying school readiness" for students born LBW, PTB, or small for gestational age (SGA) (Chen et al. 2014). Thus, the link between LBW, PTB and development delay is well documented.

The type of childcare a child receives before entering school also plays an important role in the successful development of LBW or PTB children (Hill et al. 2003; McCarton et al. 1997). Studies examining the unique impact of early childhood intervention services on school readiness show significant improvements in early academic abilities for children receiving care in quality programs (Barnett 1995; Burchinal et al. 1997). Studies also suggest evidence of effective interventions that improve developmental outcomes of children born LBW or PTB who experience greater levels of developmental delays (Hill et al. 2003; McCarton et al. 1997).

Previous research of early childhood development has often relied on intensive studies in small samples of children or less intense analyses among large nationally representative samples; they all, nevertheless, suggest the common finding that low-income and urban minority children, and particularly those born LBW or PTB, have worse developmental outcomes. Despite an abundance of prior research showing that children from vulnerable settings are less likely to possess school readiness attributes at school entry, there is a paucity of population-based studies focused on children from low-income families and neighborhoods (Magnuson

et al. 2007) or the extent to which childcare may mitigate this risk.

The objective of this population-based study was to address this knowledge gap and examine whether LBW and PTB were related to school readiness among children in a predominantly low-income, minority, urban school district. We further assessed whether the type of childcare received prior to entering kindergarten altered the relation between LBW and PTB and school readiness.

Methods

Data

Our retrospective cohort study was based on a sample of children born in a large urban Northeast city and enrolled as kindergarten students in the local school district during 2002–2012. Approximately 68,000 kindergarten students were enrolled during this period and a total of 62,822 (92.3%) first-time kindergarten students had school readiness assessments completed. Eighty percent (n = 50,158) of these students were matched to birth certificates based on an exact match of their first and last name and date of birth. Analysts at the state health department completed the data linkage of kindergarten and birth certificate data and an anonymous dataset was shared with the authors. The study was deemed exempt by the authors' Institutional Review Board. The lack of identifiable data for study participants did not qualify as human subjects research, as defined by the United States Department of Health and Human Services regulations 45 CFR 46.102.

Eighty-three percent of students with linked data (n = 41,808) were identified with a maternal residence within the school district city limits listed on the birth certificate. Several records (2345; 5.6%) were excluded due to inconsistent gender codes between school records and birth certificates (n = 586); implausible (< 500 g or > 6000 g) or missing birthweights (n = 15); missing gestational age data that could not be imputed (n = 840); or incomplete school readiness (< 28 completed items) assessments (n = 981).

Hot deck imputation methods (Andridge and Little 2010) were used to impute readiness scores for 2.5% of the remaining 39,463 students who were missing one (n = 790) or two (n = 186) items on the readiness assessment. Students with a missing item were randomly assigned the value for the item of a student with similar characteristics at school entry. Mean readiness scores (MRSs) in the sample of 38,486 students with complete data (MRS = 73.1, 95% confidence interval (CI): 73.0, 73.3) were slightly higher than scores for the complete sample of 39,463 students (MRS = 72.9, 95% CI 72.8, 73.1) with imputed values (p = 0.0283).

The final sample of 39,463 students represents 63% of the children for whom readiness scores were available; most students were excluded from the sample because they did not have a birth certificate in the same state as the school district, or their mothers did not reside within the city limits. Mean readiness scores were slightly, but significantly, higher in the final sample than in the study population. Students excluded from the final sample were more likely to be Hispanic and have received no formal childcare in the year before entering kindergarten, but they were less likely to be free and reduced meal plan status (FARMS).

Measures

School readiness was measured by kindergarten teacher assessment of their students. The assessment was adapted from the work sampling system (WSS), a curriculum-embedded instructional assessment program that trains teachers to collect and evaluate student progress throughout the school year. Readiness scores reflect the sum of each student's fall assessment score for 30 items (3 response levels) covering seven developmental domains: personal and social, language and literacy, mathematical thinking, scientific thinking, social studies, the arts, and physical development.

Main independent variables were LBW, PTB, and childcare type as outlined in Table 1; LBW was also categorized as extremely and very LBW and PTB as extremely and very preterm. Birthweight and gestational age were obtained from

birth certificates. Covariates describing maternal and newborn morbidity, Apgar scores, selected pregnancy-related medical risk factors, abnormal conditions of the newborn, and complications of labor and delivery, were also obtained from birth certificates. Maternal and paternal race, ethnicity, age and education, marital status, maternal tobacco use, and number of siblings were obtained from birth certificates as well, for students' family and home environment at birth. An indicator was created for lack of paternal involvement at the time of the student's birth by identifying birth certificates with missing paternal age, education and place of birth. Student covariates included FARMS—a proxy for family income, student academic disability status (SWD), English language learner status (ELL), race/ethnicity, and age as of September 1 of school entry year.

Statistical Analysis

Demographic characteristics and readiness scores of kindergarten students with and without linked birth certificate data were compared using chi-squared tests for categorical variables and two-tailed t tests for continuous variables. Pearson correlation matrices were assessed to reduce collinearity in regression models. Preliminary analyses revealed student readiness scores were clustered within kindergarten cohort years and entry schools. On average, annual MRSs increased 1.4 points each year, but a significant six-point increase occurred between fall 2005 and fall 2006 ($p < 0.0001$),

Table 1 Main independent covariate descriptions

Covariate	Type	Description
Low birthweight (LBW)	Normal birthweight (NBW)	Reference group. ≥ 2500 g
	Moderately LBW (MLBW)	1000–2499 g
	Extremely LBW (ELBW)	500–1000 g
Preterm birth (PTB)	Full-term (FT)	Reference group. 39–41 weeks gestation
	Post-term (PT)	42–43 weeks gestation
	Early-term (ET)	37–38 weeks gestation
	Moderately PTB (MPTB)	28–36 weeks gestation
	Extremely PTB (EPTB)	22–27 weeks gestation
Childcare type	District pre-kindergarten (PK)	Reference group. School districts' PK education for 4-year old children, administered by local boards of education and regulated by the Maryland State Department of Education (MSDE)
	Head start	The federal pre-school program for 2–5 year olds from low-income families funded by the US Department of Health and Human Services
	Child care center	MSDE-regulated care provided in a facility, usually non-residential, for part or all of the day that provides care to children in the absence of the parent
	Private/other PK	Pre-school programs with an education focus for 3 and 4 year old children, approved or exempted by MSDE, usually part-day, 9 months a year. Includes students with a parent report of PK enrollment that was not linked to prior student enrollment in a district PK program as determined by school district staff
	No formal care	MSDE-regulated care given to a child younger than 13-years old in place of parental care for < 24 h a day in a residence other than the child's residence and for which the provider is paid or care provided by parent(s), guardian, or a relative

largely due to a 50% increase in available PK seats in the school district in the fall 2006 school year. Given these findings, all regression models included random intercepts for school entry year and entry school. A linear spline term was also included in the models for indicating school entry in fall 2005 and earlier compared to entry during fall 2006 and fall 2012.

Multilevel linear regression models examined the biologic and social risk factors associated with school readiness accounting for both school and cohort year clusters. Model 1 included unadjusted regression estimates separately for each covariate except for LBW and PTB measures which were included together. Model 2 added other student and parent covariates to Model 1. The final Model 3 added childcare type to evaluate whether it attenuated the relation of LBW and PTB with school readiness adjusted for student and parent characteristics. Tests of statistically significant interactions between PTB, LBW and childcare categories initially revealed statistically significant interactions for MLBW and EPTB students who attended Head Start programs and MLBW students who attended childcare centers (p < 0.05), but further investigation showed no notable differences in adjusted MRSs; accordingly, interaction terms were not added to the models. Domain specific readiness data were also examined but results are not included here due to high inter-correlation across domains and insufficient ability to detect meaningful domain specific differences in readiness scores. Of note, however, students born EPTB had significantly lower mean standardized readiness scores in the physical development and health domain.

Model fit was evaluated with covariance parameter estimates and Akaike Information Criterion (AIC) values. The amount of variance in student readiness scores explained by each model (R^2) was assessed. All analyses were conducted using SAS 9.3 (SAS Institute, Cary, NC). Requests for supplemental information can be submitted to the corresponding author.

Results

The MRS was 72.9 (standard deviation: 13.6) among study children; nearly three points higher than the suggested 70-point cut-off indicating a child as 'fully ready' (FR) for school. The overall percentage of students rated FR was 33.0% in 2002; it more than doubled to 78.2% in 2012. During this period, however, the school readiness gap by FARMS status increased sixfold. Fifteen percent of students had readiness scores < 60 and 4.9% scored less than the 50-point cut-off indicating a student is still 'developing' readiness. Table 2 shows the characteristics of the study population and the percentage of children by childcare site for these characteristics. LBW and PTB prevalence was 13.7%

and 14.6%, respectively, slightly higher than rates observed for city residents during the study period. One-quarter (25.5%) of students received no formal childcare and half (49.9%) attended a district PK prior to entering kindergarten; 7.8%, 12.3% and 4.6% attended a private PK, Head Start or Childcare Center program, respectively. More than 80% of students were non-Hispanic (NH) Black (86.6%) or FARMS (83.4%), similar proportions to those of the school district population. Eight percent of students were SWD and 91.9% were age 5 at school entry. Eighteen percent of parents were married, and more than a quarter (27.8%) of students had missing paternal information on their birth certificate.

A greater percentage of students with no formal childcare were LBW or PTB compared to other students. One-quarter (24.1%) of students who attended a private/other PK program were NH White students and less than two-thirds (59.8%) were FARMS. On average, students' mothers had fewer than 12 years of education and mothers of students who received no formal childcare had the lowest education levels. More than 60% of private PK students had married parents. Maternal tobacco use was present among 13% of students and highest among those who received no formal care (18.3%). MRSs varied significantly by gestational age across all childcare types, but the highest scores observed were for children who attended a district funded PK program (Table 3). Scores varied by birthweight for each childcare type except for students from Childcare Centers.

In the unadjusted model (Model 1), the relation of each covariate was modeled separately, except for birthweight and gestational age which were included together in the model. MRSs were significantly lower for LBW or PTB students than for their NBW or full-term (FT, 39–41 weeks) counterparts (Table 4). The MRS for students born moderately LBW (MLBW) and extremely LBW (ELBW) was 1.61 and 6.81 points lower than MRS for NBW students, respectively (p < 0.001), adjusted for gestational age. MRSs of children born moderately PTB (MPTB) and extremely (EPTB) were 1.65 points and 6.47 points lower than students born full-term, respectively (p < 0.001), adjusting for birthweight. Together, birthweight and gestational age explained 0.5% of the variation in readiness scores. Students who attended a district PK program had the highest unadjusted MRSs (77.3 points) while those with no formal childcare had MRS 6.58 points lower than district PK students (p < 0.001).

When parent and other student characteristics were added (Model 2), PTB effects were attenuated with the largest changes among MPTB and EPTB students. The relation of birthweight with MRS was also attenuated but less so than for PTB. Childcare type had a modest effect on the adjusted differences in MRSs by LBW and PTB categories in Model 3. MRS differences between MPTB and EPTB were further reduced when adjustment was also made for childcare type in Model 3 although students born early-term [ET (p < 0.01)]

Table 2 Characteristics of kindergarten sample, by childcare type

	All students (n=39,463) n (%)	District PK (n=19,693) n (%)	Private/other PK (n=3066) n (%)	Head start (n=4839) n (%)	Child care center (n=1810) n (%)	No formal care (n=10,055) n (%)	p-value
Birthweight							
Normal (> 2500 g)	34,067 (86.3)	17,099 (86.8)	2718 (88.6)	4129 (85.3)	1595 (88.1)	8526 (84.8)	<.0001
MLBW (1000–2499 g)	5028 (12.7)	2435 (12.4)	320 (10.4)	650 (13.4)	205 (11.3)	1418 (14.1)	
ELBW (< 1000 g)	368 (0.9)	159 (0.8)	28 (0.9)	60 (1.2)	10 (0.6)	111 (1.1)	
Gestational age							
Full-term (39–41 weeks)	22,424 (56.8)	11,237 (57.1)	1881 (61.4)	2721 (56.2)	1056 (58.3)	5529 (55.0)	<.0001
Early-term (37–38 weeks)	10,964 (27.8)	5539 (28.1)	802 (26.2)	1334 (27.6)	488 (27.0)	2801 (27.9)	
Post-term (42 + weeks)	333 (0.8)	148 (0.8)	34 (1.1)	39 (0.8)	17 (0.9)	95 (0.9)	
MPTB (28–36 weeks)	5382 (13.6)	2620 (13.3)	325 (10.6)	686 (14.2)	241 (13.3)	1510 (15.0)	
EPTB (< 28 weeks)	360 (0.9)	149 (0.8)	24 (0.8)	59 (1.2)	8 (0.4)	120 (1.2)	
Other student characteristics							
Student's race/ethnicity							
Black NH	34,179 (86.6)	17,273 (87.7)	2242 (73.1)	4455 (92.1)	1569 (86.7)	8640 (85.9)	<.0001
White NH	3703 (9.4)	1515 (7.7)	740 (24.1)	192 (4.0)	206 (11.4)	1050 (10.4)	
Hispanic	1295 (3.3)	755 (3.8)	62 (2.0)	164 (3.4)	20 (1.1)	294 (2.9)	
API	155 (0.4)	81 (0.4)	14 (0.5)	13 (0.3)	10 (0.6)	37 (0.4)	
Other	131 (0.4)	49 (0.2)	3 (0.1)	13 (0.3)	5 (0.3)	29 (0.3)	
FARMS	32,927 (83.4)	17,067 (86.7)	1835 (59.8)	4224 (87.3)	1305 (72.1)	8496 (84.5)	<.0001
SWD	3063 (7.8)	1775 (9.0)	217 (7.1)	442 (9.1)	74 (4.1)	555 (5.5)	<.0001
Age 5 at school entry	36,270 (91.9)	18,478 (93.8)	2776 (90.5)	4520 (93.4)	1646 (90.9)	8850 (88.0)	<.0001
School entry fall 2005 and earlier	10,924 (27.7)	4199 (21.3)	889 (29.0)	1216 (25.1)	564 (31.2)	4056 (40.3)	<.0001
Neonate characteristics							
Female	19,529 (49.5)	9844 (50.0)	1534 (50.0)	2413 (49.9)	886 (49.0)	4852 (48.3)	0.0628
First born	15,225 (38.6)	7239 (36.8)	1389 (45.3)	2105 (43.5)	840 (46.4)	3652 (36.3)	<.0001
Multiple birth	1357 (3.4)	636 (3.2)	105 (3.4)	204 (4.2)	70 (3.9)	342 (3.4)	0.0144
Low 1-min. Apgar score	3961 (10.0)	1925 (9.8)	304 (9.9)	507 (10.5)	203 (11.2)	1022 (10.2)	0.2354
Low 5-min. Apgar score	579 (1.5)	277 (1.4)	52 (1.7)	74 (1.5)	27 (1.5)	149 (1.5)	0.7794
Fetal distress	1472 (3.7)	702 (3.6)	131 (4.3)	173 (3.6)	90 (5.0)	376 (3.7)	0.0165
Assisted ventilation	383 (1.0)	161 (0.8)	37 (1.2)	48 (1.0)	15 (0.8)	122 (1.2)	0.0106
Parent characteristics							
Maternal education, mean (SD)	11.8 (2.20)	11.7 (2.14)	13.0 (2.67)	11.8 (1.93)	12.6 (2.37)	11.4 (2.11)	<.0001
Married	7159 (18.1)	3437 (17.5)	1079 (35.2)	655 (13.5)	430 (23.8)	1558 (15.5)	<.0001
Maternal tobacco use	5317 (13.5)	2378 (12.1)	314 (10.2)	593 (12.3)	189 (10.4)	1843 (18.3)	<.0001
Maternal race							
Black NH	33,636 (85.2)	17,062 (86.6)	2169 (70.7)	4423 (91.4)	1546 (85.4)	8436 (83.9)	<.0001
White NH	4368 (11.1)	1805 (9.2)	796 (26.0)	250 (5.2)	235 (13.0)	1282 (12.7)	
Hispanic	1092 (2.8)	635 (3.2)	53 (1.7)	139 (2.9)	14 (0.8)	251 (2.5)	
API	29 (0.1)	15 (0.1)	5 (0.2)	1 (0.0)	6 (0.3)	2 (0.0)	
Other	320 (0.9)	166 (0.8)	43 (1.4)	23 (0.5)	9 (0.5)	79 (0.8)	
Missing	15 (0.0)	10 (0.1)	0 (0.0)	3 (0.1)	0 (0.0)	5 (0.0)	
Maternal age, mean (SD)	24.3 (6.25)	24.1 (6.02)	26.3 (7.04)	23.9 (6.12)	25.2 (6.62)	24.0 (6.29)	<.0001
Paternal race							
Black NH	21,408 (54.2)	10,298 (52.3)	1552 (50.6)	2808 (58.0)	1041 (57.5)	5709 (56.8)	<.0001
White NH	3102 (7.9)	1259 (6.4)	709 (23.1)	134 (2.8)	191 (10.6)	809 (8.0)	
Hispanic	14,143 (35.8)	7714 (39.2)	752 (24.5)	1815 (37.5)	544 (30.1)	3318 (33.0)	
API	20 (0.1)	11 (0.1)	1 (0.0)	2 (0.0)	3 (0.2)	3 (0.0)	
Other	289 (0.8)	154 (0.8)	28 (0.9)	20 (0.4)	14 (0.8)	73 (0.7)	
Missing	501 (1.3)	257 (1.3)	24 (0.8)	60 (1.2)	17 (0.9)	143 (1.4)	
No paternal information	10,968 (27.8)	5766 (29.3)	576 (18.8)	1340 (27.7)	450 (24.9)	2836 (28.2)	<.0001

Data shown are numbers with percentages in parenthesis unless otherwise stated

SD standard deviation, *FARMS* free and reduced meal plan status, *SWD* student with a disability, *NH* non-Hispanic, *API* Asian/Pacific Islander, *MLBW* moderately LBW, *ELBW* extremely LBW, *MPTB* moderately PTB, *EPTB* extremely PTB

Table 3 Mean school readiness scores and standard deviations by birthweight, gestational age, and childcare type

	All students Mean (SD)	District PK Mean (SD)	Private/other PK Mean (SD)	Head start Mean (SD)	Child care center Mean (SD)	No formal care Mean (SD)	*p*-value
Birthweight							
Normal (> 2500 g)	73.2 (13.4)	76.1 (12.7)	74.5 (13.0)	72.5 (12.8)	71.9 (13.0)	67.6 (13.7)	< 0.0001
MLBW (1000–2499 g)	71.4 (14.1)	74.4 (13.6)	71.2 (15.0)	71.8 (12.9)	72.0 (13.3)	66.1 (13.9)	< 0.0001
ELBW (< 1000 g)	65.3 (15.1)	69.0 (15.1)	67.3 (13.1)	65.9 (12.9)	63.3 (8.3)	59.4 (15.5)	0.0032
p-value	< 0.0001	< 0.0001	< 0.0001	0.0003	0.6274	< 0.0001	
Gestational age							
Full-term (39–41 weeks)	73.4 (13.4)	76.3 (12.6)	74.5 (13.1)	72.6 (12.9)	72.6 (12.7)	67.8 (13.6)	< 0.0001
Early-term (37–38 weeks)	72.9 (13.5)	75.7 (12.8)	73.9 (13.0)	72.7 (12.7)	71.0 (13.6)	67.6 (13.9)	< 0.0001
Post-term (42 + weeks)	70.1 (13.6)	73.1 (12.8)	71.8 (14.5)	68.3 (12.6)	69.6 (13.7)	65.8 (13.8)	0.0071
MPTB (28–36 weeks)	71.4 (14.0)	74.7 (13.4)	72.3 (14.3)	71.0 (12.9)	70.8 (13.1)	65.8 (13.6)	< 0.0001
EPTB (< 28 weeks)	66.1 (15.6)	70.1 (15.3)	67.6 (14.0)	67.2 (13.4)	61.9 (9.8)	60.6 (16.1)	0.0033
p-value	< 0.0001	< 0.0001	0.0222	0.0099	0.0069	< 0.0001	

Data shown are means with standard deviations in parenthesis

SD standard deviation, *g* grams, *PK* prekindergarten, *MLBW* moderately LBW, *ELBW* extremely LBW, *MPTB* moderately PTB, *EPTB* extremely PTB

and post-term (PT) had significantly lower MRSs than term born students (p < 0.05). Adjusted differences in MRSs between private/other PK and district PK students increased by 35% in Model 3. Adjusting for all covariates in Model 3 explained nearly 12% of the variation in readiness scores.

MRS differences associated with maternal education < 12 years (− 3.04 points) was nearly three times greater than differences related to low income (FARMS, − 0.88 points) (p < 0.001) in the fully adjusted model (Model 3). Furthermore, students with missing paternal information and whose mothers used tobacco during pregnancy had MRSs more than half a point lower than their counterparts. Lower adjusted MRS were also observed for students with low 1-min Apgar scores (< 7) and those who experienced fetal distress during delivery. Assisted ventilation as a neonate was associated with higher adjusted MRS. Differences in MRS were greatest between students with and without a disability (− 8.35 points). Sensitivity analyses (not shown) suggests factors that best explained variation in student readiness scores were childcare type (4.8%), disability status (4.2%), gender (1.2%), maternal education (0.7%), student age at school entry (0.3%), and birthweight (0.1%), adjusting for other covariates.

Discussion

We studied the relation between biologic and social risk factors at birth, current student characteristics and school readiness in a predominantly low-income, minority urban sample of first-time kindergarten students during the 2002–2012 school years. Despite limited variation in teacher

assessed school readiness scores, our analysis of readiness scores measured as a continuous variable provided a unique investigation of various risk factors and the level of school readiness in this large population-based sample. Research on developmental outcomes of PTB and LBW children rarely examine composite school readiness measures in large populations. Rather, studies often focus on one or two cognitive or behavioral scales to assess child development (Keller-Margulis et al. 2011) in select samples, making it difficult to compare the current findings with prior studies.

Students born LBW or PTB had lower school readiness, consistent with prior research (Isaacs and Magnuson 2011; Aarnoudse-Moens et al. 2009). Unlike prior studies, however, we documented school readiness differences within LBW and gestational age categories, adjusted for each variable. Students born ELBW had lower readiness scores than students born MLBW or NBW. Students born ET and PT also had lower school readiness than students born FT, although the effects of gestational age were attenuated in the fully adjusted model. These findings suggest LBW (< 2500 g) should not be treated as a uniform group when examining early childhood development. ELBW children had markedly lower MRSs than NBW students that persisted after adjustment for other student and family characteristics and childcare type. Birthweight also had a greater impact on readiness scores than gestational age based both on the magnitude of differences in scores across groups and the amount of variation explained by birthweight in adjusted models. This finding may underscore the impact of intrauterine growth restriction on developmental outcomes like school readiness, particularly in the urban setting from which our sample was drawn.

Table 4 Estimated differences in mean school readiness scores and standard errors

	Unadjusted Model 1	Adjusted Model 2	Adjusted Model 3
Intercept		77.24 (0.92)***	79.13 (0.81)***
Birthweight (ref: normal, ≥ 2500 g)			
MLBW (1000–2499 g)	− 1.61 (0.18)***	− 1.15 (0.23)***	− 1.09 (0.22)***
ELBW (< 1000 g)	− 6.81 (0.64)***	− 4.51 (1.01)***	− 4.59 (0.99)***
Gestational age (ref: full-term, 39–41 weeks)			
Early-term (37–38 weeks)	− 0.64 (0.14)***	− 0.44 (0.14)**	− 0.43 (0.14)**
Post-term (42 + weeks)	− 1.87 (0.68)**	− 1.54 (0.65)*	− 1.42 (0.64)*
MPTB (28–36 weeks)	− 1.65 (0.19)***	− 0.58 (0.23)**	− 0.49 (0.22)*
EPTB (< 28 weeks)	− 6.47 (0.65)***	− 1.21 (1.02)	− 0.70 (1.00)
Childcare type (ref: district PK)			
Private/other PK	− 1.54 (0.25)***		− 2.09 (0.24)***
Head Start	− 3.50 (0.20)***		− 3.31 (0.19)***
Child care center	− 3.73 (0.30)***		− 4.27 (0.29)***
No formal care	− 6.58 (0.16)***		− 6.44 (0.15)***
Other student characteristics			
Female	3.36 (0.12)***	2.98 (0.12)***	2.84 (0.12)***
Race/Ethnicity (ref: Black NH)			
White NH	0.87 (0.29)**	− 0.26 (0.46)	0.01 (0.45)
Hispanic	− 1.14 (0.39)**	− 1.10 (0.55)*	− 1.02 (0.53)
API	0.72 (1.00)	− 1.55 (1.11)	− 1.14 (1.09)
Other	0.00 (1.08)	− 0.39 (1.06)	− 0.49 (1.04)
Age at school entry (ref: five)			
< 5	− 1.93 (0.26)***	− 2.21 (0.25)***	− 2.05 (0.24)***
6+	− 5.13 (0.67)***	− 4.24 (0.65)***	− 1.88 (0.64)**
School entry fall 2005 and earlier	− 9.41 (1.43)***	− 9.29 (1.41)***	− 8.63 (1.21)***
Non-FARMS (ref: FARMS)	1.66 (0.18)***	0.71 (0.18)***	0.88 (0.18)***
SWD (ref: no disability)	− 8.65 (0.23)***	− 7.91 (0.23)***	− 8.34 (0.22)***
Number siblings (ref: none)			
One	− 0.17 (0.15)	− 0.33 (0.16)*	− 0.47 (0.15)**
Two or more	− 1.29 (0.15)***	− 1.17 (0.17)***	− 1.10 (0.17)***
Multiple birth (ref: singleton)	− 0.73 (0.34)*	0.75 (0.35)*	0.85 (0.34)*
Low 1-min Apgar score (ref: ≥7)	− 1.22 (0.21)***	− 0.49 (0.22)*	− 0.46 (0.21)*
Low 5-min Apgar score (ref: ≥7)	− 2.28 (0.51)***	− 0.25 (0.54)	− 0.31 (0.53)
Fetal distress (ref: no distress)	− 0.92 (0.33)**	− 0.67 (0.32)*	− 0.63 (0.31)*
Assisted ventilation (ref: no ventilation)	− 1.48 (0.63)*	1.38 (0.64)*	1.38 (0.63)*
Parent characteristics			
Maternal years of education (ref: 13 + years)			
12 years	− 2.22 (0.17)***	− 1.71 (0.18)***	− 1.56 (0.17)***
<12 years	− 4.11 (0.18)***	− 3.41 (0.20)***	− 3.04 (0.19)***
Married (ref: single)	1.50 (0.17)***	0.73 (0.19)***	0.59 (0.18)**
Maternal tobacco use (ref: none)	− 1.79 (0.18)***	− 0.90 (0.19)***	− 0.57 (0.18)**
Missing paternal information	− 1.21 (0.14)***	− 0.78 (0.20)***	− 0.64 (0.20)**
Maternal race (ref: Black NH)			
White NH	0.72 (0.27)**	0.42 (0.41)	0.85 (0.40)*
Hispanic	− 1.04 (0.43)*	− 0.29 (0.60)	− 0.24 (0.58)
API	4.62 (2.29)*	2.68 (3.13)	2.52 (3.06)
Other	1.02 (0.70)	0.96 (0.79)	1.08 (0.78)
Paternal race (ref: Black NH)			
White NH	1.18 (0.30)***	0.78 (0.41)	0.49 (0.40)
Hispanic	− 0.91 (0.14)***	0.26 (0.20)	0.22 (0.20)

Table 4 (continued)

	Unadjusted Model 1	Adjusted Model 2	Adjusted Model 3
API	4.87 (2.75)	2.55 (3.81)	2.83 (3.73)
Other	0.31 (0.73)	− 0.27 (0.82)	− 0.52 (0.80)
Maternal age (ref: 20–35)			
<20 years old	− 0.41 (0.14)**	− 0.14 (0.17)	− 0.07 (0.17)
36 + years old	− 0.09 (0.26)	0.07 (0.26)	0.09 (0.25)
Model R^2		7.5	11.9
AIC		307075.5	305279.1

Model 1 fits each variable shown separately. All models include random intercepts for school entry year and students clustered in schools

FARMS free and reduced meal plan status, *SWD* student with a disability, *NH* non-Hispanic, *API* Asian/Pacific Islander, *MLBW* moderately LBW, *VLBW* very LBW, *ELBW* extremely LBW, *MPTB* moderately PTB, *VPTB* very PTB, *EPTB* extremely PTB

$*p < 0.05$ $**p < 0.01$ $***p < 0.001$

Our results showed significant variation in readiness by childcare type which had a modest effect on the readiness of LBW and PTB students. As documented in prior studies, childcare type and quality is an important determinant of healthy child development (Keys et al. 2013; Lee et al. 2014). In the current study, the type of childcare students received before school entry explained the greatest amount of variation in school readiness scores, independent of students' LBW or PTB status. Students who attended structured childcare settings like district PK or other center-based programs had markedly higher readiness scores than those who attended informal childcare settings. Nearly one-third of LBW and PTB students received no formal childcare and fewer than half attended a district PK program before entering kindergarten. Some studies group PK with other center-based care (Keys et al. 2013; Lee et al. 2014) but our findings suggest this approach may obscure significant differences in readiness, particularly in low-income urban settings.

Our study indicated several other observations worth noting. The intergenerational impact of education cannot be overstated as years of maternal education was one of the strongest and most consistent parent level predictors of children's school readiness. Years of maternal education alone explained nearly 2% of the variation in student readiness scores. This relation has been consistently documented in prior studies of school readiness in kindergarten students (Hillemeier et al. 2011; Isaacs and Magnuson 2011; Breslau et al. 2001). Students whose mothers had less than a high school education had MRSs three points lower on average than students of mothers with at least some post high school education, adjusted for birthweight, gestational age, family income and other characteristics. Children of lower educated women were also twice as likely to have received no formal childcare before entering kindergarten.

Results further suggest maternal tobacco use was significantly related to lower school readiness scores, independent of maternal education levels, and other variables. This finding replicates similar effects of maternal tobacco use on early childhood outcomes in other recent studies (Moore et al. 2014; Isaacs and Magnuson 2011). Maternal smoking may be a marker for other risk factors like poor nutrition, greater psychosocial stress, and substance abuse that are associated with adverse birth outcomes and poor child development (Erickson and Arbour 2012) but were not measured in our study.

Lack of paternal involvement in the child's life at birth, as assessed by missing paternal information on the birth certificate, was associated with lower school readiness scores. This finding supports previous research about fathers' role in fostering healthy child development, particularly in urban settings (Black et al. 1999). Using birth certificate data in this way to examine paternal involvement was found to be associated with greater fetal and infant morbidity (Alio et al. 2010), but the effect on school readiness is the first to the authors' knowledge. Reasons for missing paternal information on the birth certificate may be multifaceted and warrants further qualitative exploration to develop definitive conclusions and interpretations.

Additionally, unadjusted comparisons showed lower readiness scores for students who received assisted ventilation at birth, but the adjusted results suggested these students had significantly higher MRSs, adjusted for birth weight, gestational age. This finding may suggest the presence of an unmeasured confounder in the study sample—respiratory distress syndrome among premature infants (Patrianakos-Hoobler et al. 2009). This effect may also point to an unmet medical need among low-income minority neonates in this urban population and warrants further investigation to better understand the mechanisms at work.

Our study was not without limitations. First, our sample differed from the study population due to fewer Hispanic, non-FARMS, and students with informal care who had linked birth certificates. Second, childcare type was self-reported without verification, although school district staff attempted to verify parent reports of district PK enrollment by cross-checking official enrollment files. The quality, duration or level of engagement of students in childcare was also not available. Finally, we did not have measures of specific parenting behaviors and parent–child interactions which are critical components of child development and school readiness, particularly in low-income settings (Hill 2001).

In summary, our study adds to the extant literature by showing LBW and PTB students have significantly lower school readiness scores than their normal birthweight and full-term counterparts in a large urban school district population. Our findings draw attention, however, to the markedly lower readiness scores of students born ELBW. We further found that childcare type was one of the most important predictors of school readiness and that readiness scores were highest among children who had attended a district PK program. A greater percentage of LBW and PTB children, however, did not attend formal childcare in this low-income urban school district which suggests efforts to improve school readiness may be best directed toward increasing the availability of publicly funded PK programs. These programs may in turn increase maternal and paternal educational attainment, potentially breaking the intergenerational effects of low education on school readiness and academic achievement. Greater attention to the unique needs of ELBW students, although low in number, may also be important for improving the overall effectiveness of district PK programs on school readiness.

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