



# Gestational Age and Kindergarten School Readiness in a National Sample of Preterm Infants

Prachi E. Shah, MD, MS<sup>1,2</sup>, Niko Kaciroti, PhD<sup>3,4</sup>, Blair Richards, MS<sup>2</sup>, and Julie C. Lumeng, MD<sup>1,2,4</sup>

**Objective** To examine the association of gestational age with school readiness in kindergarten reading and math skills. We hypothesized that compared with infants born at 39-41 weeks, infants born at lower gestational ages would have poorer school readiness.

**Study design** The study sample comprised 5250 children from the Early Childhood Longitudinal Study, Birth Cohort, assessed with specialized reading and math assessments at kindergarten. Poor school readiness was characterized by reading and math theta scores  $\geq 1.5$  SD below the sample mean. The aOR and 95% CI of poor school readiness were estimated using multivariate logistic regression, examining gestational age continuously and categorically (very preterm [VPT], moderate/late preterm [M/LPT], early term [ET], and term). Pairwise comparisons were performed to test for differences by gestational age category.

**Results** There was an association between gestational age and poor school readiness for reading and math, with the suggestion of a threshold effect in children born at  $\geq 32$  weeks gestation. In adjusted models, in VPT infants, the aORs of poor school readiness in reading and math were 2.58 (95% CI, 1.29-5.15) and 3.38 (95% CI, 1.66-6.91), respectively. For infants born M/LPT and ET, the odds of poor school readiness in reading did not differ from those of children born full-term, however.

**Conclusions** Compared with term infants, the highest odds of poor school readiness in reading and math were seen in VPT infants, with lower odds of poor school readiness in children born at  $\geq 32$  weeks gestation. Ongoing developmental surveillance before kindergarten is indicated for VPT infants. (*J Pediatr* 2016;178:61-7).

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In 1990, The US National Education Goals Panel articulated a vision that all children in America will start kindergarten “ready to learn.”<sup>1</sup> This led the American Academy of Pediatrics to define a set of competencies in the young child known as “school readiness,”<sup>2</sup> characterized partially by foundational skills in reading and math.<sup>2-4</sup> Poor school readiness is predictive of lesser future academic achievement,<sup>4,5</sup> educational attainment,<sup>6</sup> and economic success,<sup>7</sup> but it can be remediated with interventions.<sup>8,9</sup> Identifying children at risk for poor school readiness may help target some for intervention.

Preterm birth, defined as birth before 37 weeks gestation,<sup>10</sup> has been considered a potential risk factor for poor school readiness; however, we have identified only a handful of studies that focused on school readiness in preterm infants,<sup>11-19</sup> and each of these studies has some limitations. Several studies focused on infants classified as born extremely preterm,<sup>11,12</sup> very preterm,<sup>13,14</sup> or late preterm<sup>15</sup> without examining school readiness across the full range of gestational age. Three studies examined school readiness in non-US preterm samples,<sup>16-18</sup> thereby limiting generalizability to the US population, and one study<sup>19</sup> combined prematurity with low birth weight status, thereby limiting interpretation of the role of prematurity in school readiness.

In the US, neonatal follow-up care is typically provided only to infants born extremely preterm,<sup>20</sup> with most preterm infants not receiving any specialized developmental care before school entry. Identifying the risks for poor school readiness in preterm infants can help individualize preeducational strategies for children across the full spectrum of prematurity. Using

AGA	Appropriate for gestational age
ECLS-B	Early Childhood Longitudinal Study, Birth Cohort
ET	Early term
LGA	Large for gestational age
M/LPT	Moderate/late preterm
NCES	National Center for Education Statistics
SES	Socioeconomic status
SGA	Small for gestational age
VPT	Very preterm

From the <sup>1</sup>Division of Developmental Behavioral Pediatrics, Department of Pediatrics, Medical School, University of Michigan, Ann Arbor, MI; <sup>2</sup>Center for Human Growth and Development, University of Michigan, Ann Arbor, MI; <sup>3</sup>Department of Biostatistics, School of Public Health, University of Michigan, Ann Arbor, MI; and <sup>4</sup>Department of Nutritional Sciences, School of Public Health, University of Michigan, Ann Arbor, MI

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a nationally representative, population-based US sample, in the present study we examined the odds of poor school readiness in preterm infants. We hypothesized that there would be a dose-response association between gestational age and school readiness skills in kindergarten literacy and mathematics.

## Methods

Data were drawn from the Early Childhood Longitudinal Study, Birth Cohort (ECLS-B), a nationally representative, population-based longitudinal study sponsored by the US Department of Education's National Center for Education Statistics (NCES) in the Institute for Education Science. The ECLS-B is based on a nationally representative probability sample of children born in the US in 2001 (inclusive). Data were collected from more than 10 000 children and their parents at 9 months, with subsequent assessments at 24-month, preschool, and kindergarten time points, with >77% of the sample included at the kindergarten 2006 time point. Data collection consisted of home visits with parent interviews and direct child assessments, and included information on the children's development across multiple settings.<sup>21</sup>

Because in most states, children must be age 5 years to be eligible to enter kindergarten,<sup>22,23</sup> for this study we defined "kindergarten eligible" as age  $\geq 60$  months at the kindergarten time point. Thus, our sample was restricted to children aged  $\geq 60$  months at the kindergarten time point, excluded children with congenital and chromosomal abnormalities, and including children born at 22-41 weeks gestation inclusive and using data from 5 time points (birth, 9 months, 24 months, preschool, and kindergarten). This study was considered exempt by the Institutional Review Board because the research involved the use of a publicly available dataset, in which the participants were deidentified, and data could not be linked to the participants.

## Outcomes

**Kindergarten School Readiness.** Children were directly assessed at kindergarten age during a home visit by trained NCES staff using a specialized battery of tests developed for the ECLS-B to assess early reading and math skills. The reading assessment was formulated from existing instruments including the Peabody Picture Vocabulary Test, Third Edition, and the Preschool Comprehensive Test of Phonological and Print Processing and measured markers of early literacy, including basic reading skills (letter and word recognition, understanding letter-sound relationships, phonological awareness, sight word recognition, and understanding words in the context of simple sentences). The reliability of the early reading assessment is described by the item response theory reliability coefficient, reported as 0.92 at kindergarten age. Scores provide ability estimates in a particular domain and were reported as normally distributed theta scores, which demonstrated a range of -2.11 to 3.09 (mean  $\pm$  SD, 0.33  $\pm$  0.86) at kindergarten age.<sup>22</sup>

The ECLS-B mathematics assessment incorporated items to test the following content areas: number sense, geometry, counting numerical operations, and pattern recognition. The item

response theory reliability coefficient for the early mathematics assessment was also 0.92 at kindergarten age. The mathematics theta scores demonstrated a range of -2.42 to 3.12 (mean  $\pm$  SD, 0.38  $\pm$  0.80) at kindergarten age.<sup>22</sup> Because a performance of 1 or 1.5 SD below the mean for age on standardized, norm-referenced tests in a specific area of development has been used previously as a threshold to identify children in need of educational services,<sup>24,25</sup> we defined "poor school readiness" by kindergarten reading and math theta scores falling  $\geq 1.5$  SD below the mean.

**Predictor.** Gestational age was ascertained from birth certificate data from the ECLS-B restricted-use dataset.<sup>26</sup> We examined the association between gestational age and poor school readiness using gestational age as a continuous variable, and also by gestational age categories as defined by clinical convention.<sup>27-29</sup> We created a 4-group gestational age category, with infants characterized as being very preterm (VPT; <32 weeks), moderate/late preterm (M/LPT; 32-36 weeks), early term (ET; 37-38 weeks), or full-term (39-41 weeks), following gestational age category definitions described previously.<sup>29</sup>

**Covariates.** Maternal and infant characteristics associated with suboptimal development<sup>30-33</sup> were chosen a priori as covariates after a review of the literature. The following maternal characteristics were ascertained from the restricted ECLS-B birth certificate data: maternal age, race/ethnicity, marital status (married/unmarried), history of prenatal smoking, duration of breastfeeding, and plurality (singleton, twin, multiple gestation). Included also were measures of maternal education (<high school; high school graduate; >high school) and poverty (<185% federal poverty level;  $\geq 185\%$  federal poverty level), which were incorporated into a single composite measure of household socioeconomic status (SES) created by the ECLS-B at age 9 months.<sup>34</sup>

Because the ECLS-B did not contain a composite measure of neonatal morbidity, we included the following neonatal risks ascertained from birth certificate data as indicators of infant medical risk: birth weight; fetal growth, characterized as small for gestational age (SGA; <10%), appropriate for gestational age (AGA; 10%-90%), or large for gestational age (LGA; >90%); 5-minute Apgar score (dichotomized as  $\leq 7$  vs  $>7$ ); and duration of hospitalization (0-1 days, 2-7 days, 8-14 days, 15-30 days, >30 days).

At the kindergarten assessment, even though all children were kindergarten-eligible, a notable percentage of the children were identified as attending preschool at the kindergarten time point. We accounted for this variability in kindergarten experience by including a 4-category variable indicating grade level and month of school at time of kindergarten assessment (preschool; kindergarten: August-October, kindergarten: November-January, and kindergarten: February-June), and we adjusted for the age of the child at kindergarten assessment.

Enrollment in early intervention, determined from 9- and 24-month parent questionnaires, Head Start, or any preschool program at preschool age, as well as child's sex were also included as covariates.

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