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The Role of Pre-Primary Classes on School-Age Cognition in Rural Nepal

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ABSTRACT

Objectives In rural Nepal, we assessed the factors associated with pre-primary school attendance and its relationship to cognitive testing and school progress.

Study design Sociodemographic, household and schooling data were collected among 1,466 children age 7-9 years from Sarlahi, Nepal. We performed the Universal Non-verbal Intelligence Test (UNIT), backward digit span, go/no-go test, Movement Assessment Battery for Children (MABC), finger-tapping test, and Stroop numbers test. We conducted adjusted regression analyses to determine the association of pre-primary school attendance with test results and school progress.

Results We found that pre-primary class enrollment was lower among children of with female sex, Madheshi ethnicity, and low socioeconomic status. In adjusted analyses, pre-primary school enrollment was associated with beneficial scores on all cognitive tests. In addition, children who attended pre-primary school were less likely to repeat grade 1 (Prevalence ratio (PR) 0.15, 95% CI 0.08-0.30, $p < 0.001$) or ever fail a grade (PR 0.48, 95% CI 0.26-0.90, $p = 0.02$).

Conclusions In rural Nepal, there continue to be disparities in pre-primary school attendance; however, independent of these factors, pre-primary school attendance was associated with benefits in multiple cognitive domains and early school performance.

An estimated 200 million children under 5 years of age do not attain their cognitive developmental potential due to disparities including poverty and undernutrition (1). Interventions such as early childhood education may be able to prevent further deficits (2, 3). To address this, the 2000 Dakar Framework for Action called for Education for All, to expand Early Childhood Care and Education (4).

An important goal of early education is to promote a child's school readiness, defined as the appropriate cognitive, motor, social and emotional development to be prepared for the learning environment (5). This represents a shift from early understandings of school readiness in terms of test achievement, with a greater emphasis on the neurobiological changes during this critical period of development (6). Specifically, studies in the United States have shown that early education programs promote executive and motor skills that mediate benefits in school readiness (7-9)

Studies in resource-limited settings are sparse, but have also shown advantages. For East and South Asia, preschool education has been associated with increased intelligence, development quotient, and school achievement (10-12). In Nepal, early childhood education enrollment has increased dramatically (13, 14), and 56% of children have had exposure to early childhood education program services (15). Assessments from the Research Centre for Educational Innovation and Development (CERID) in Nepal have shown benefits in grade 1 scores, and better adjustment and sociability (16). However, findings were not adjusted for confounders including undernutrition and low socioeconomic status,

which are negatively associated with childhood cognition (17, 18). At the same time, there is evidence that children from disadvantaged backgrounds have greater gains from early education, because they receive less educational stimulation in deprived home environments (2, 19). In South Asia, there are few studies that have formally assessed cognition and the independent role of early education programs on cognitive development and school readiness.

Thus, in the rural Sarlahi District of Nepal, we assessed what factors predicted pre-primary class (PPC) enrollment, and whether pre-primary class enrollment was an independent determinant of cognitive test scores and school progress in children 7-9 years old.

METHODS

The Sarlahi District is located in the southeastern plains area of Nepal. The 2011 census found a population of 769,729, of which 86,846 are under the age of 5 years (20). The literacy rate is 46%, and is primarily an agrarian economy. There is a high rate of malnutrition, with a 41% prevalence of stunting among children under 5 (21). In the Terai eco-belt that contains Sarlahi, there were an estimated 14,213 early childhood development (ECD) or pre-primary schools (14). Early childhood education is divided into community-based ECD centers and school-based pre-primary classes (PPC). PPC have three sections of nursery, lower kindergarten and upper kindergarten (14).

Our group has an established research site in a selected area comprising 30 Village Development Committees in this rural southeastern district of Nepal where we have conducted several trials testing nutrition and health interventions.

In 1999-2001 and from 2001-2005 (22-25), two large cluster-randomized controlled trials of prenatal and preschool-age micronutrient supplementation were conducted to assess infant and child health and survival outcomes.

From 2007-2009, ~1900 children, ages 7-9 y, a subgroup of offspring born in the prenatal trial and who participated in the preschool trial were enrolled in a follow-up study to examine the role of the nutritional supplementation in early life on school age cognition (26-28).

Data for the present analysis were derived from this follow-up study. Detailed procedures have been described previously, but briefly, field workers visited the households of participating children to obtain information on demographics, schooling history, child diet and morbidity, socioeconomic status, the home environment, and to assess iodine content of household salt. The home visit was followed by a clinic visit where four master's level graduates in psychology conducted the UNIT and the MABC tests as described below. Trained interviewers and anthropometrists conducted the tests of executive function, performed anthropometry, and drew finger stick blood for testing hemoglobin levels. The study received ethical approval from the institutional review boards of Johns Hopkins Bloomberg School of Public Health, The Pennsylvania State University, and the Institute of Medicine, Tribhuvan University. Parents provided oral consent and children provided assent to participate in the study.

Demographic information included age, sex, ethnicity, religion and birth history. Field workers obtained parental report of schooling history, and asked whether the child failed, repeated or passed a given grade. PPC enrollment was defined as attendance at either nursery, lower or upper kindergarten.

Community-based ECD centers can vary widely in type and quality and were unable to be assessed. To evaluate environmental stimulation in the home, the Middle Childhood Home Observation for the Measurement of the Environment (HOME) inventory was administered (29). Socioeconomic status (SES) was determined from durable assets, and principal components analysis was used to determine an overall SES score (30).

Trained staff collected height (cm) at the clinic visit using standard procedures. Height-for-age z scores were calculated using the international WHO reference standard (WHO 2006), and stunting was defined as z score < -2. Iodine was measured in household salt via a semiquantitative kit (MBI Kits, Madras, India), and it was stratified as less than 15 ppm or greater than or equal to 15 ppm. Anemia was defined as hemoglobin < 11.5 g/dL. Hemoglobin was measured with a finger stick and use of a β -Hemoglobin Analyzer (HemoCue, Lake Forest, California).

Four trained psychometrists evaluated cognitive domains of general intelligence, motor function, and executive function. General intelligence was assessed with the Universal Non-verbal Intelligence Test (UNIT), and scaled according to T-scores based on the child's age (31). Motor function was determined via the Movement Assessment Battery for Children (MABC) and

finger-tapping test (32). MABC is scored from 0-40, with higher score indicating worse performance. The finger tapping test measures the mean number of finger taps in each hand over a set period of time. Executive function was examined with the go/no-go test, backward digit span, and Stroop numbers test (33, 34). The go/no-go test was evaluated by percent correct in the no-go trials, backward digit span as the number of digits remembered, and Stroop numbers test as failure on two trials. Maternal cognition was also assessed using the Raven's Coloured Progressive Matrices (35). These tests were all performed in the original parent trial, and have been performed in a number of studies in children from the region (26, 36-40). UNIT subscales were evaluated with exploratory and confirmatory factor analyses; α was calculated for each scales raw score, and reliabilities ranged from 0.76 to 0.88 (26, 27). The UNIT was chosen purposefully because it was a non-verbal test; we excluded the analogic subscale of the UNIT because it involved pictures of objects not usually seen by Nepalese children. Other cultural considerations in the data collection included conduction of tests in Nepali, and use of local terms in surveys and the HOME questionnaire.

The psychometrists underwent standardized training and were certified after accurate full administration of the tests. In addition, test sessions were video recorded and 20% were selected at random and assessed for accurate administration and scoring by Pennsylvania State University psychology graduate students supervised by the co-investigators.

Statistical Analyses

The primary exposure was enrollment in PPC among children who had ever attended school, and the main outcomes were cognitive test scores. We reported participant characteristics as frequency (percentage) if categorical, and as median (interquartile range) if continuous, compared by PPC attendance via Chi-squared or Wilcoxon rank sum test, respectively.

In order to evaluate factors associated with PPC enrollment, we conducted stepwise multivariable logistic regression, with an exit p-value of 0.1, robust variance and adjustment for clustering. We assumed a binomial distribution with logit link. To assess the association between PPC enrollment and cognitive test scores, multivariable generalized estimating equations with robust variance were used (41). We assumed a Gaussian distribution with identity link for UNIT, backward digit span, go/no-go, MABC, and finger-tapping. For failure on the Stroop numbers test, we estimated the prevalence ratio (PR) using a robust poisson distribution with a log link (42). To assess school performance, we performed similar adjusted analyses to evaluate preschool attendance on ever failing a grade, and having to repeat first grade. We adjusted for age, number of years after PPC passed, and for factors that were found to be significantly different between those who did and did not attend PPC. Children with missing data on these variables were not included in the model. Significance was defined as a p-value < 0.05 by Wald testing. Analyses were conducted using STATA version 12 (StataCorp, College Station, TX).

RESULTS

Of children in the original cohort, 1,466 children (79.9%) had ever attended school. Of this group, 624 (42.6%) had attended PPC (Table I). The minority of PPC attendees went to a government school (n=52, 8.3%). The median age of starting PPC was 5 years old, whereas the median age of starting school for children who did not attend PPC was 6 years old. The median age at assessment was 8.5 years (IQR 7.9-8.9), and was similar between groups.

On multivariable testing, factors related to sex, nutrition, household and community were significantly associated with PPC enrollment (Table II). Being female was associated with a 56% reduction in likelihood of attending PPC (OR 0.44, 95% CI 0.34 to 0.57, $p < 0.001$), while stunting was associated with a 36% reduced likelihood of PPC enrollment (OR 0.64, 95% CI 0.50 to 0.83, $p = 0.001$). Other significant factors associated with PPC attendance included maternal schooling, younger maternal age, a greater HOME score, and being a member of the Pahadi ethnic group. Higher socioeconomic status was strongly associated with PPC enrollment, with those from the highest class six times more likely to attend PPC (OR 6.10, 95% CI 3.96 to 9.30, $p < 0.001$).

Pre-primary Classes and Cognitive Test Scores

Univariate analyses suggested that PPC was associated with better scores in all administered tests (Table III). In adjusted analyses, PPC attendance continued to be associated with benefits related to general intelligence, executive function, and motor function. The largest association was found with general intelligence,

with PPC related to an increase in 4.59 standardized *T*-scores on the UNIT (95% CI 3.44 to 5.72, $p < 0.001$).

Pre-primary classes on School Progress

To assess school progress, we asked parents if their child had passed, repeated or failed a given year of school (Data not shown). In adjusted analyses (Table III), we found that children who attended pre-primary school were significantly less likely to repeat grade 1 (PR 0.15, 95% CI 0.08 to 0.30, $p < 0.001$) or ever fail a grade (PR 0.48, 95% CI 0.26 to 0.90, $p = 0.02$).

DISCUSSION

In a cohort of school-age children in rural Nepal, we found several disparities in PPC enrollment, including greater attendance among males, certain ethnic groups, and higher socioeconomic status. However, we also demonstrated that enrolling in PPC was associated with benefits in general intelligence, executive function and motor function, independent of age, sex, schooling, household, community or nutritional factors. Furthermore, those who attended PPC were less likely to repeat the first grade and were less likely to have ever failed a class. These results support the role of early childhood education on promoting cognitive development and its impact on school readiness in low resource settings.

We found several disparities among children who did and did not attend PPC. We found that female children were 56% less likely to attend PPC compared with male children. A multivariable analysis in Nepal found that males

were seven times more likely to go to school than females (43). Ethnographic research in Nepal has noted barriers to female inclusion such as female labor needs in the home, traditions of early marriage, prioritization of male education given more male employment opportunities, and schools that do not have female teachers as role models (44-46). We also found that the Pahadi ethnic group was more likely to attend PPC than Madheshis. Barriers to schooling among minority groups in Nepal have included geographic distance, parental awareness, cost of education, use of mother tongue, social discrimination and labor needs (45). Other factors associated with PPC enrollment, including nutritional status, maternal education and age, and household stimulation, likely relate to socioeconomic status. A 2006 report found that only 12% of the poorest families utilized ECD services (47). In rural communities such as Sarlahi, economic burdens can de-prioritize schooling as children are able to provide an additional labor source (48). Past reports have shown that girls and disadvantaged groups in Nepal who utilize early childhood education services are more likely to progress in their education with improvements in academic achievement (16, 45). Thus, improved access to early education has the opportunity to greatly improve the cognitive potential of children from underrepresented groups.

A past assessment of preschool enrollment in Nepal had been associated with 20% greater enrollment in grade 1, and improvement in pass rates in grade 1 and 2 (46). In the same study, interviews with teachers also found that children who had PPC had greater readiness for grade 1, better attendance, and improved parental engagement (46). Another evaluation further showed that

children who used PPC services repeated fewer grades, participated more, and were better adjusted and sociable (16). While these reports highlighted the potential effectiveness of early childhood education in the country, they have been largely descriptive or qualitative. Moreover, because factors associated with not attending pre-primary school, such as undernutrition, may promote further cognitive deficits, it is difficult to assess if pre-primary school in these settings has an independent association with cognition and school outcomes.

After adjusting for these possible confounders, we continued to find significant benefits in general intelligence, executive function and motor function, while demonstrating a lower proportion of children who had ever failed a grade or needed to repeat grade one. Taken together with studies in other countries, early childhood education has overall shown benefits in cognitive testing, primary school readiness, and achievement (49-52). Further evaluation is required to assess whether duration of preschool modifies this effect and if these benefits will continue into adolescence and adulthood.

Our study had several advantages. We had a large cohort of children in a rural setting of Nepal at high risk of cognitive deficits. They had been evaluated both at birth and in school age, with comprehensive information available on sociodemographics and schooling history. In addition, we implemented cognitive tests by trained psychometrists with quality assurance measures. A limitation of the study was that nutritional and household stimulation factors during PPC attendance were not assessed and could perhaps have further elucidated the relationship. Data was not collected on attendance in informal schools or early

childhood development centers, which may have shown further benefits for cognition. Within PPC, we did not assess quality of the school, which may reduce the impact of early education programs. While we attempted to control for confounding factors, due to the observational nature of the study, residual confounding limits causality. While the cognitive tests have been utilized in similar settings, validation studies have not been conducted in Nepal.

Since the 2000 Dakar Framework for Action, there have been strong efforts to increase early childhood education and care and Education for All (4). In Nepal, there is an established National Early Childhood Development council that coordinates local and national programs in early childhood development and pre-primary classes (14). This study further supports early intervention programs such as pre-primary schooling in order to reduce disparities in cognitive potential in low and middle-income countries.

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ABBREVIATIONS

ECD: Early Childhood Education

IQR: Interquartile range

HOME: Middle Childhood Home Observation for the Measurement of the Environment inventory

MABC: Movement Assessment Battery for Children

PPC: Pre-primary classes

PR: Prevalence Ratio

SES: Socioeconomic status

UNIT: Universal Non-verbal Intelligence Test

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Table 1. Child Characteristics by Pre-primary enrollment in rural Nepal

Characteristic ¹	Total (N = 1466)	Did Not Attend Preschool (n = 842, 57.4%)	Attended Preschool (n=624, 42.6%)	p-value
Age (yrs)	8.5 (7.9-8.9)	8.4 (7.9-8.9)	8.5 (8.0-8.9)	0.26
Age Started School (yrs)	5 (5-6)	6 (5-6)	5 (4-5)	<0.001
Female n (%)	696 (47.5)	433 (51.4)	263 (42.2)	<0.001
Anemia (Hemoglobin < 11.5 g/dL) n (%)	501 (34.4)	323 (38.5)	178 (28.8)	<0.001
Stunted (Height for age Z < -2) n (%)	596 (40.9)	399 (47.5)	197 (31.9)	<0.001
Birth Outcomes				
Low Birth Weight (< 2.5 kg) n (%)	529 (36.1)	332 (39.4)	197 (31.6)	0.002
Preterm (< 37 weeks) n (%)	287 (19.6)	175 (20.8)	112 (18.0)	0.17
Household				
Mother Primary Caretaker n (%)	1390 (94.8)	801 (95.1)	589 (94.39)	0.3
Maternal Age n (%)	30 (27-34)	31 (27-36)	29 (26-32)	<0.001
Maternal Literacy n (%)	378 (26.0)	91 (10.9)	287 (46.2)	<0.001
Mother ever attended school n (%)	342 (23.5)	70 (8.4)	272 (43.8)	<0.001
Maternal Raven's Score	15 (13-20)	15 (12-19)	18 (14-23)	<0.001
Salt Iodine < 15 ppm n (%)	400 (27.3)	276 (32.8)	124 (19.9)	<0.001
HOME Score	25 (21-29)	23 (20-27)	27 (23-31)	<0.001
Community				
Brahmin Caste of Hindu n (%)	129 (8.9)	23 (2.8)	106 (17.1)	<0.001
Pahadi Ethnic Group ² n (%)	957 (65.8)	196 (23.5)	301 (48.5)	<0.001
SES Quintile n (%)				<0.001
Level 1	198 (13.6)	170 (20.3)	28 (4.6)	
Level 2	269 (18.5)	206 (24.6)	63 (10.2)	
Level 3	307 (21.1)	192 (22.9)	115 (18.7)	

Level 4	328 (22.6)	178 (22.9)	150 (24.4)
Level 5	350 (24.1)	91 (10.9)	259 (42.1)

1. Categorical variables given as n (%) and continuous variables as median (IQR)

2. Pahadi are people from the hills, whereas Madheshi people are from India who settled in the plains of Nepal.

Table 2. Multivariable regression of factors associated with pre-primary school enrollment in rural Nepal

Characteristic	OR	95% CI	p-value
Female	0.44	0.34, 0.57	<0.001
Anemia (Hemoglobin < 11.5 g/dL)	0.71	0.53, 0.95	0.02
Stunted	0.64	0.50, 0.83	0.001
Maternal age	0.93	0.90, 0.95	<0.001
Mother did not attend school	0.31	0.21, 0.45	<0.001
HOME score	1.05	1.02, 1.08	0.001
Pahadi vs. Madheshi ethnic group	1.92	1.37, 2.69	<0.001
SES Quintile ¹			
Level 3	2.10	1.41, 3.12	<0.001
Level 4	2.27	1.51, 3.41	<0.001
Level 5	6.10	3.96, 9.30	<0.001

1. Compared to the lowest socioeconomic quintile

Table 3. Multivariable analysis of the effects of preschool enrollment on cognitive testing and school progress in rural Nepal

Test	Unadjusted			Adjusted		
	Mean Difference	95% CI	p value	Mean Difference	95% CI	p value
UNIT	6.87	5.92, 7.82	<0.001	4.59	3.44, 5.72	<0.001
Backward Digit Span	0.84	0.72, 0.97	<0.001	0.48	0.34, 0.62	<0.001
No-Go % correct	4.37	2.42, 6.32	<0.001	4.07	1.66, 6.47	0.001
MABC	-2.22	-2.80, -1.63	<0.001	-1.62	-2.30, -0.95	<0.001
Finger Tapping	1.96	1.39, 2.53	<0.001	1.15	0.55, 1.75	<0.001
	<u>Prevalence Ratio</u>	<u>95% CI</u>	<u>p value</u>	<u>Prevalence Ratio</u>	<u>95% CI</u>	<u>p value</u>
Stroop Test Failure	0.31	0.23, 0.43	<0.001	0.47	0.35, 0.65	<0.001
Repeat first grade	0.15	0.09, 0.26	<0.001	0.15	0.08, 0.30	<0.001
Ever fail a grade	0.42	0.23, 0.75	0.003	0.48	0.26, 0.90	0.02