Iron Sufficiency in Early Childhood and Preschool Cognitive Development in the Philippines

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Introduction

Iron is an essential mineral needed for the production of hemoglobin (the protein in blood cells that delivers oxygen in support of metabolism throughout the body), and several enzymes necessary for proper functioning of muscle, brain and the immune system.

Anemia is a condition in which the hemoglobin concentration in the blood falls below 11.0g/dL, which is associated with impaired function. Although anemia can be influenced by factors like heredity and infections, about half of all cases can be attributed to iron deficiency (WHO, 2001).

Anemia is associated with weakness or fatigue, general malaise, poor concentration dyspnea, lower immunity to infections and pregnancy complications. Iron deficiency anemia has also been linked to impaired cognitive development, particularly when experienced during infancy and early childhood when brain growth is rapid (Hurtado et al., 1999, Batra and Sood, 2005, McCann and Ames, 2007, Black, 2003). Studies find an increased likelihood of mild or moderate mental retardation in school-age children who had anemia in early childhood.

Most studies have focused on the relationship of anemia and cognitive development using cross-sectional data. When longitudinal data are available, studies find that children anemic in infancy continue to have poorer cognition, school achievement and more behavioral problems in middle childhood (Grantham-McGregor and Ani, 2001; Hurtado et al. 1999; Watkins and Pollitt, 1996). Some factors found to be associated with poor cognitive development in addition to anemia are age, gender, socioeconomic status, low birth weight, maternal or parental education, duration of breastfeeding, and attendance in nursery school (Halterman et al. 2001; Ryan, 1997).

Findings in the longitudinal studies underscore the potential social and economic impact of iron deficiency in developing nations, where iron deficiency remains common. The World Health Organization (2001) reports that more than 30% (2 billion people) of the world's population are anemic, and with South East Asia having among the highest prevalence in the world, at 57%. The Philippines typifies this global pattern: among Filipino children aged 6 months to 5 years of age, three out of every 10 children are anemic, and more than half of one year old children are anemic (FNRI, 2003). Despite policy efforts, the problem has not subsided: for instance, prevalence of anemia among children increased from 28.9% in 1993 to 32.4% in 2003. To date, no study has evaluated the potential impact of this widespread problem on cognitive development in the Philippines.

To address this problem, our study aims to determine whether iron status at 6 to 24 months is associated with the child's cognitive development at preschool age (5-6 years) in a large sample in the Philippines. Most previous studies on anemia and cognition have had small sample sizes using trial or intervention technique. McGregor and Ani (2001) in their review of studies revealed that the association of anemia and delayed development varies in different populations. Our study uses a much larger data set from the Study of the Effects of Early Childhood Interventions on Children's Physiological, Cognitive and Social Development (ECD), a Philippine-based survey with about 7000 children, ages 0-4 years old.

Data and methods

Study Design. The Study of the Effects of Early Childhood Interventions on Children's Physiological, Cognitive and Social Developments was conducted by the Office of Population Studies of the University of San Carlos on behalf of the Philippine Early Childhood Development Project (ECD). It is a longitudinal evaluation study undertaken to assess the impact of specific local government interventions on the quantity and quality of ECD service delivery, child-rearing practices of parents, and children's physical, language, cognitive and social development (ECD 2002 report). The study began in 2001 with the enrollment of over 7,000 children aged 0-4 years old who were recruited from 95 municipalities from 3 regions of the Central Philippines. A stratified two-stage sampling design was employed in the selection of sample children with barangays (neighborhoods) as the primary sampling units and households as the secondary sampling unit. The study was biased towards poorer, depressed and rural households since they are the recipients of the ECD project of the Philippine Government. Follow-up surveys were conducted in 2002, 2003 and 2005. Approximately 88% of the baseline participants were interviewed in 2005 and outmigration was the major reason for attrition.

This study uses data from the baseline survey in 2001 and the follow up survey in 2005. The baseline survey included 2,433 children aged 6 to 24 months of which 2,149 were interviewed in 2005. However, there were 319 children excluded because they did not qualify for the age requirement, i.e., 5 years of age in 2005 to be given the Philippine Nonverbal Intelligence Test and the School Readiness Assessment Test. The present analysis sample includes 1639 children aged 6 to 24 months at baseline with complete information on hemoglobin, non-verbal IQ scores (IQ) and cognitive development scores on School Readiness Assessment tool (SRA).

Key variables. For this study, the hemoglobin level of children at ages 6 to 24 months (at baseline) is the main exposure variable. These specific ages are chosen in view of the studies conducted in developing countries where a higher prevalence of anemia is reported among this age group compared to older children (Villalpando et al., 2003, FNRI, 2003, Black, 2003). Children less than six months of age are not included because hemoglobin is often transiently elevated during the first 6 months of life due to transfer from the mothers during pregnancy and lactation (NIH fact sheet). Because this is the case, our data collection did not gather information of hemoglobin concentration on children below 6 months old.

During the survey, each child's hemoglobin level was assessed in a *c*apillary blood sample on a hematology analyzer (Photoelectric Colorimeter). The cyanmethemoglobin technique was used in determining hemoglobin readings (ECD, 2002). The amount of hemoglobin is strongly related to the amount of iron that is circulating in the blood. Classification, whether anemic or normal, was based on the cut-off level set by World Health Organization (WHO) in 1972 which is 11.0 g/dL for children 6-72 months old. In this study iron deficiency is equated with anemia and so the two terms are used interchangeably.

The outcome variables are IQ test score and SRA cognitive score in the 2005 survey. The intellectual level of the sample was measured with the Philippine Non-Verbal Intelligence Test, a 100-item test developed and standardized in the Philippines (Guthrie, Tayag, and Jacobs, 1977). The test measures concept recognition and abstract thinking. The subject is presented a card with five drawings and is asked which one is different, i.e., which one does not belong with the others. The items move from easy (e.g. four squares and a circle) to more difficult items (e.g. four animals can be categorized so as to exclude a fifth of a different type). There was no time limit for each item. The test shows good reliability and validity for children 5 to 14 years of age. The scores were normed based on the entire sample population. Children who were at least 5 years of age were given the IQ test.

The SRA was administered by the Department of Education to determine if the child is ready to enter Grade 1 (source, http://www.deped.gov.ph). Results of the SRA are used to guide Grade I teachers in providing appropriate instruction and assistance to address specific needs of the pupils. In 1995, with the integration of early childhood education into the existing school system, the official age of entry to Grade 1 was dropped from seven years of age to six. Children who were not yet enrolled in Grade 1 and who were at least 5 years of age were given the test. A clinical psychologist trained the persons who administered the SRA. There were five domains on the SRA: fine motor, receptive language, gross motor, cognitive and social-emotional. The child is asked to perform all the items in each domain and was given a check mark if he/she exhibits the skill. Our study utilizes the cognitive domain only (SRA z scores).

We also consider other variables as controls including: 1) maternal characteristics such as educational attainment and age, 2) child characteristics that include sex, age in months and child's attendance in preschool, 3) household socio-economic status measured by ownership of selected assets in 2001 (landholding and TV), and 4) the presence of electricity in the community.

We did not adjust for other measures of nutritional status, such as height-for-age z-score or body weight, as these could be downstream of iron status itself or factors that influence iron status.

Statistical analysis. All analyses were done using Stata version 8.0. We primarily used linear regression to estimate the association between iron status at infancy with subsequent IQ and SRA scores at preschool age. Model 1 adjusted for the basic demographic characteristics of child's sex and age in the 2005 survey. Model 2 then built from this model to consider potential environmental or socioeconomic confounders of the association between hemoglobin and later cognitive performance. Although we were interested in the associations of anemia with later cognition, slightly more than 70% of the sample was classified as anemic; as such, there was minimal variability in a dichotomous indicator of anemic status in the sample. But there may be much greater problems if a child was far below the cutoff for being anemic rather than slightly below it. We therefore considered baseline hemoglobin status as a continuous predictor of later cognition (primarily reflecting the severity of iron deficiency).

We explored how robust these results are to alternative specifications and approaches, including treating early-life hemoglobin as determined endogenously by variations in community-level conditions and family background characteristics. However, we did not get strong estimates in the first stage – our F statistics were below 10, a level often used as a "rule of thumb" in the literature.

Results

Profile of the sample

Children in the analysis sample and those who left did not differ much in their background characteristics except for few biological characteristics, e.g., hemoglobin concentrations. Mean hemoglobin level of the former was 10.25 g/dL compared to 10.42 g/dL of the latter, which means that they are still anemic since they fall below 11g/dL. As mentioned, the sampling design was biased towards disadvantaged children and prevalence of anemia is also high in this group.

Table 1 shows the characteristics of non-anemic children vs. children with anemia. About 70% of the sample population was classified as anemic on the basis of having a hemoglobin level of <11 g/dL, which is consistent with the country's report of low hemoglobin concentration among younger children. A slightly higher number of males (54%) than females (46%) are anemic.

Most of the mothers of the children with anemia have less education compared with the mothers of children who are not anemic. This confirms the common knowledge that maternal education is a determinant of the health of children.

Although breastfeeding is a crucial determinant of a child's nutritional health, the study shows that prolonged lactation is negatively associated with children's health. The majority of the children who were breastfed for 6 months or longer were anemic compared to those who were not breastfed. This may be attributed to the absence of micronutrient supplementation during the lactating period wherein children rely mainly on their mothers' milk for food.

Early child education is considered an important investment in developing children for the future. Although most of the sample children have attended preschool or day care, a bigger percentage of the children who were anemic, did not go to preschool. A World Bank study showed that children who do not attend preschool have a higher dropout rate compared with those who attend preschool (source: http://www.ecdgroup.com).

Children with anemia are from households with low economic status. They do not have landholdings and they do not own television sets. This is not surprising because ECD sample barangays are economically and socially disadvantaged segments of the Philippine population.

Moreover, children who suffer from anemia were younger, had lower HAZ scores, and they fared less well in both IQ and SRA tests.

Bivariate analysis

Results of the bivariate analysis are presented in Table 2. As shown, females had higher scores than males in both IQ and SRA tests.

Higher IQ and cognitive Z-scores are associated with the mother's level of education, child's demographic and biological characteristics, household's ownership of assets and community characteristics.

Children living in households with more assets and those whose mothers had higher education scored higher both in IQ and SRA tests. Children who have attended preschool or daycare classes fared much better in both tests than those who have not attended preschool.

Results from regression

Table 3 illustrates the relationships between right-side variables in the two models with IQ and SRA scores. Model I shows that a 1 g/dL increase in hemoglobin level is associated with increases in IQ by 2 points and SRA scores by 0.14 points. Being female is associated with increases in IQ and SRA test scores by 1.5 and 0.27 points respectively.

In model 2, iron status continues to have a highly significant positive association with later cognitive scores after controlling for the effects of child, maternal, household and community characteristics, although the magnitude of the association was attenuated slightly. A child whose mother had college education is associated with about 4.0 higher points in IQ scores and 0.38 higher points in cognitive Z scores. Rural electrification is associated with 6 more points in IQ and 0.26 more points in cognitive scores. Better socio-economic status is associated with higher cognition. Ownership of landholding increases by 2 and 0.10 higher points in IQ and cognitive scores respectively. Children who live in households with TV scored 4 points greater in IQ and 0.21 points in cognitive compared with children whose households own no TV. More importantly, preparing children for entry to Grade 1 is associated with an increase by 3.2 and 0.60 points in IQ and cognitive scores respectively.

To clarify whether it is hemoglobin status in early life that is associated with the cognitive development of the child, we added hemoglobin measured in the 2005 survey to the full model (estimates not shown). The results show that even when current iron status is taken into account, early iron status has a positive significant association on the child's cognition, and is a stronger predictor of cognition than is current iron status.

The results of this study, thus, shows that anemia in early childhood has an inverse association with children's later cognitive development.

Discussion

This study suggests the importance of recognizing anemia in early life and its consequences on the child's cognitive development at school age. Results reveal that lower hemoglobin concentration, whether unadjusted or adjusted for other factors, is associated with delaying cognitive development. Children who were anemic in the first two years of life have low scores in the IQ and SRA cognitive tests. This finding supports the results of several studies that iron deficiency anemia is associated with later cognitive development.

Our adjusted model includes important risk factors that might explain the strong association of early anemia and later childhood outcomes (e.g. maternal education, household assets, child's attendance in preschool, and barangay electrification). The inclusion of these factors did not markedly attenuate the estimates of the associations of anemia during ages 6-24 months with test performance at age 5 years. It is possible that common underlying factors which we failed to include in our models influence anemia and later cognitive development. However, results from our first stage estimates were not good i.e., with an F statistics <10 considering some variables such as presence of barangay health center, prevailing prices of basic commodities, hygiene index of the neighborhood and geographical locations of barangays. Therefore we can say that child's cognitive development is strongly associated with early-life anemia but we must reserve judgment regarding the extent to which these associations reflects causal effects.

Although the analysis sample may not represent Filipino children in general because it tends to include children from low socio-economic status, rural residents and who are nutritionally deficient, the results still show that prevalence of anemia is high. This is an alarming situation that the Philippine government should take into account since human capital is at risk.

The main strength of the study is the availability of longitudinal data collected from years 2001 to 2005 of 7,000 0-4 year-old-children. Few studies on children's cognitive development have such detailed information on early childhood.

Some previous researches indicated that the damage inflicted by anemia is not always reversible (Batra and Sood, 2005). A study also found that children who were anemic when they were less than two years old have failed to catch up with non-anemic children even after iron supplementation (Watkins and Pollitt, 1996). Considering its grave consequences, infant anemia then should be given immediate attention. Interventions must be undertaken not only in early infancy but during conception as well in order to avoid its probable adverse effects in later childhood.

One of the objectives of the Philippine Early Childhood Program (ECD) is the reduction of the proportion of children under six with anemia from 49% to 35%. The success of this specific ECD objective hopefully will reduce the negative effects of early anemia on children's cognitive performance and quality of life.

More longitudinal studies are needed to evaluate the impact of early child anemia on children's cognition especially in developing countries like the Philippines where 3 out of 10 Filipino children 5 years old and below are anemic (FNRI, 2003).

Table 1. Characteristics of sample children by anemia status

Characteristics	n (%)	Anemia status in 2001	
		% Anemic	% Not anemic
Sex of child			
Male	863 (52.6)	54.4	48.5
Female	776 (47.4)	45.6	51.5
Maternal education			
Less than Grade 6	345 (21.1)	22.7	17.2
Grade 6	402 (24.5)	26.4	20.1
1-3 years of high school	303 (18.5)	19.8	15.3
High school graduate	310 (18.9)	18.8	19.2
With college	279 (17.0)	12.3	28.2
Household has no landholding	1,111 (67.8)	70.1	62.4
With landholding	528 (32.2)	29.9	37.6
No TV	1,266 (77.2)	82.5	64.8
With TV	373 (22.8)	17.5	35.2
Barangay has no electricity	198 (12.1)	12.4	11.2
With electricity	1,441 (87.9)	87.6	88.8
Has no health center	652 (39.8)	39.3	40.9
With health center	987 (60.2)	60.7	59.1
Child did not attend preschool	511 (31.2)	35.5	21.1
Had attended preschool/daycare	1,128 (68.8)	64.5	78.9
Child was not breastfed	96 (5.9)	5.2	7.4
Breastfed for <6 mos.	179 (10.9)	7.9	18.0
Breastfeed for 6 mos. or more	1364 (83.2)	86.9	74.6

	N	Anemic		Not anemic	
		Mean	*SD*	*Mean*	*SD*
Child's age in mos. in 2001	1639	16.17	4.72	17.46	4.69
HAZ score in 2001		-1.87	1.17	-1.56	1.19
Child's standardized IQ score		97.69	14.59	101.48	14.82
Child's cognitive Z-score		-0.09	0.97	0.27	0.98
Maternal age in years		30.39	6.94	30.73	6.52

Table 2. Distribution of IQ and cognitive SRA scores by selected characteristics

Characteristics	*n (%)*	Nonverbal IQ (standardized)			Cognitive Z-scores		
		Mean	*SD*	*P- value*	*Mean*	*SD*	*P- value*
Child							
Sex							
Male	863 (52.6)	97.90	14.52	0.008	-0.13	0.98	0.000
Female	776 (47.4)	99.84	14.97		0.18	0.97	
Anemia status							
Anemic	1150 (70.2)	97.69	14.82	0.000	-0.09	0.97	0.000
Not anemic	489 (29.8)	101.48	14.59		0.27	0.98	
Attendance in preschool/daycare							
No preschool/daycare	511 (31.2)	94.64	13.60	0.000	-0.59	0.88	0.000
Had preschool/daycare	1128 (68.8)	100.71	14.88		0.29	0.91	
	N	*Coefficient (CI)*		*P- value*	*Coefficient (CI)*		*P- value*
Hemoglobin (g/dl) in 2001		1.93 (1.36-2.49)		0.000	0.16 (0.13-0.20)		0.000
Age (mos.) in 2001 survey		-0.15 (-0.30- -0.00)		0.049	0.02 (0.01-0.03)		0.000
Age (mos.) in 2005 survey	1639	0.18 (0.03-0.33)		0.020	0.03 (0.02-0.04)		0.000
	n (%)	*Mean*	*SD*	*P- value*	*Mean*	*SD*	*P- value*
Maternal							
Education							
Less than Grade 6	345 (21.1)	94.84	14.74	0.000	-0.33	0.95	0.000
Grade 6	402 (24.5)	97.27	13.89		-0.20	0.96	
1-3 years of high school	303 (18.5)	97.86	14.26		0.01	0.95	
High school graduate	310 (18.9)	100.81	13.38		0.18	0.93	
With college	279 (17.0)	104.79	15.87		0.59	0.89	
	N	*Coefficient (CI)*		*P- value*	*Coefficient (CI)*		*P- value*
Age (yrs.) in 2001survey	1639	-0.12 (-0.22- -.01)		0.031	-0.02 (-0.03--0.01)		0.000
	n (%)	*Mean*	*SD*	*P- value*	*Mean*	*SD*	*P- value*
Household							
No landholding	1111 (67.8)	97.68	14.65	0.000	-0.06	0.99	0.000
With landholding	528 (32.2)	101.22	14.71		0.19	0.97	
No TV	1266 (77.20)	97.00	14.14	0.000	-0.12	0.97	0.000
With TV	373 (22.80)	105.00	15.15		0.47	0.91	
Community							
No electricity	198 (12.1)	91.28	12.02	0.000	-0.40	0.86	0.000
With electricity	1441 (87.9)	99.85	14.80		0.07	0.99	

Table 3. Results from linear regression

Variable	Nonverbal IQ - standardized		Cognitive Z-scores	
	Model 1	Model 2	Model 1	Model 2
	Coefficient (95% CI)	*Coefficient (95% CI)*	*Coefficient (95% CI)*	*Coefficient (95% CI)*
Child characteristics				
Hemoglobin reading in 2001 survey	1.82 (1.25-2.38)*	1.18 (0.62-1.74)*	0.14 (0.11-0.18)*	0.08 (0.04-0.11)*
Sex of child[1]	1.53 (0.11-2.95)*	1.22 (-0.14-2.59)	0.27 (0.18-0.36)*	0.22 (0.14-0.30)*
Age (in mos.) in 2005	0.12 (-0.04-0.27)	0.06 (-0.09-0.21)	0.02 (0.02-0.04)*	0.01 (-0.00-0.02)*
Maternal education[2]				
Grade 6		1.21 (-0.81-3.24)		0.02 (-0.10-0.14)
1-3 years of high school		0.98 (-1.23-3.18)		0.14 (0.00-0.27)*
High school graduate		2.42 (0.17-4.68)*		0.15 (0.01-0.29)*
With college education		3.73 (1.21-6.25)*		0.38 (0.23-0.54)*
Maternal age (in yrs.)		-0.07 (-0.17-0.03)		-0.01 (-0.02- -0.01)*
Household				
With landholding[3]		1.86 (0.38-3.34)*		0.10 (0.01-0.19)*
With TV[4]		4.11 (2.27-5.96)*		0.21 (0.10-0.32)*
Community characteristics				
With electricity[5]		6.41 (4.28-8.54)*		0.26 (0.13-0.39)*
Attendance in preschool/daycare[6]				
Had preschool/daycare		3.09 (1.50-4.69)*		0.63 (0.53-0.72)*
N		1639		1639

Referent:
[1]Male
[2]Less than Grade 6
[3]No landholding
[4]No TV
[5]No electricity
[6]Did not attend preschool/daycare

*significant at $P<0.05$

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