

Associations between Cognitive Function, Blood Lead Concentration, and Nutrition among Children in the Central Philippines

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Objective Because little is known about its effects on cognitive function among children in less-developed countries, we determined the impact of lead exposure from other nutritional determinants of cognitive ability.

Study design Data were from a cross-sectional population-based stratified random sample of 877 children (age 6 months-5 years) participating in the Quality Improvement Demonstration Study we are conducting in the Philippines. With data from validated psychometric instruments, venous blood samples, and comprehensive survey instruments, we developed multi-stage models to account for endogenous determinants of blood lead levels (BLLs) and exogenous confounders of the association between BLLs and cognitive function.

Results A 1 $\mu\text{g}/\text{dL}$ increase in BLL was associated with a 3.32 point decline in cognitive functioning in children aged 6 months to 3 years and a 2.47 point decline in children aged 3 to 5 years olds. BLL was inversely associated with hemoglobin and folate levels. Higher folate levels mitigated the negative association between BLL and cognitive function.

Conclusions These population-based data suggest greater lead toxicity on cognitive function than previously reported. Our findings also suggest that folate and iron deficient children are more susceptible to the negative cognitive effects of lead. Folate supplementation may offer some protective effects against lead exposure. (*J Pediatr* 2008;152:237-43)

Lead is a potent developmental neurotoxicant that can impact multiple neurochemical pathways, interfering with blood-brain-barrier capillary integrity, synaptogenesis, myelination, and catecholamine metabolism in the central nervous system.¹ Our understanding of the neurobehavioral and cognitive consequences of childhood lead exposure comes from observational research conducted mostly in developed nations where environmental exposure is more readily detected and containment and prevention policies are well enforced.²

Children in less developed countries are both more vulnerable to neurodevelopmental delays (because of endemic disease, caloric and micronutrient deficiencies, and limited resources for early intervention) and less likely to be examined for toxic exposures, including lead.^{3,4} However, there is accumulating evidence that lead exposure in urban areas of developing nations is among the highest in the world.⁵⁻⁸ Recently, we reported on results from a large population-based study in the Philippines showing that a high prevalence of elevated blood lead levels (BLLs) also exists in rural areas.⁹

There is a paucity of information about the consequences of lead exposure on cognitive development in children in less developed countries. The few published studies available show a wide discrepancy in the strength of the association between lead and cognitive ability. A report from Shanghai demonstrated that a 0.91 point decrease in full scale IQ (95% CI, 0.68-1.1) was linked to a 1 $\mu\text{g}/\text{dL}$ increase in BLL in school-age

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BLL	Blood lead level	NIH	US National Institutes of Health
BSID-II	Bayley Scales of Infant Development, second edition	PDI	Psychomotor development index
FDA	US Food and Drug Administration	PIQ	Performance intelligence quotient
HOME	Home observation for measurement of the environment	PP	Philippine pesos
MDI	Mental development index	QIDS	Quality improvement demonstration study
NHANES	National Health and Nutrition Examination Survey	VIQ	Verbal intelligence quotient
		WPPSI-III	Wechsler Preschool and Primary Scales of Intelligence, third edition

children.¹⁰ In contrast, a study in San Jose, Costa Rica, could not demonstrate a statistically significant association between BLL and IQ in children.¹¹

The substantial variation in reports is not surprising because of the challenge of conducting these studies in less developed countries.¹² Optimally, studies should identify the known determinants of cognitive performance and account for the unique deprivation associated with poverty in developing settings.¹³ Four substantive problems arise when trying to accomplish this. First, obtaining a representative population is challenging. Second, variations in sample collection and measurement error must also be taken into account. Similarly, accounting for the variation in the local home environment—one of the most significant determinants of intellectual development—is critical.¹⁴ A third challenge is accounting for the impact of severe nutritional deficiencies (common in the Philippines and other developing countries) on cognitive function.¹⁵ Finally, any inferences need to take into consideration that the same factors that predispose to elevated BLL, such as lack of education, are also associated with lower intelligence.^{16,17}

These problems, if left unaccounted for, lead to overestimation or underestimation of the impact of lead on IQ. We attempted to disentangle lead exposure from nutritional and other biologic and sociologic determinants of cognitive ability by using a population-based sample.

METHODS

The study was conducted in the Visayas, the central region of the Philippines covering approximately a third of the country. Data were collected between December 2003 and September 2004.

Database Description and Sampling Design

This analysis was performed as part of the Philippine Child Health and Policy Experiment, Quality Improvement Demonstration Study (QIDS), a National Institutes of Health/National Institutes of Child Health and Human Development (NIH/NICHHD; R-01 # HD042117) and Philippine Health Insurance Corporation-supported project assessing ongoing national health sector reforms.

Our initial baseline analysis revealed that the mean BLL was 7.1 $\mu\text{g}/\text{dL}$ and that 22% of children had a BLL considered elevated by current World Health Organization and US Centers for Disease Control guidelines.⁹ This unanticipated finding provided a unique opportunity to assess the association between BLL and cognitive function in a highly exposed and understudied population.

We drew a population-based, stratified random sample from 30 health districts located in the Visayas region. All children living in these districts between the ages of 6 and 59 months were eligible for enrollment into QIDS. Approximately 50 children were chosen randomly from each district by household by using the National Statistics Office census frame. We selected the youngest child in each selected household meeting study eligibility criteria. Children were excluded

when they had a known cognitive disability, congenital neurologic condition, or both. Parents or guardians of all children provided written informed consent before enrollment, and all study participation was voluntary. The project received institutional review board approval from the Committee on Human Research at the University of California, San Francisco, and the UPEcon Foundation at the University of the Philippines, both of which have federal-wide assurance numbers.

Blood Testing

Lead, hemoglobin, and folate tests were performed from blood samples drawn by a trained technician during a home visit using standard venipuncture. Lead was measured by using the LeadCare Analyzer, a US Food and Drug Administration (FDA)-approved device that has been used successfully in other studies in remote areas of developing nations, in a central laboratory in Manila, where refrigerated pre-prepared samples were flown in twice weekly.¹⁸ Hemoglobin levels were tested by using the Hemocue Blood Hemoglobin Photometer on the day the sample was obtained, with a standardized, controlled procedure in the laboratory of the local provincial hospital. Red blood cell folate was measured by using the Architect system by Abbott Laboratories; specimens were frozen on the day of collection and shipped to a central lab in Singapore for testing.

Assessment of Cognitive Function

We evaluated cognitive development with age-appropriate, translated and validated psychometric instruments that were administered by bachelors- or masters-level psychologists fluent in English and local dialects. All psychologists received study-specific training by a nationally recognized expert in child development, and active field monitoring was performed with re-training as needed.

We administered the Bayley Scales of Infant Development, second edition (BSID-II) to infants and children from 6 to 35 months of age.¹⁹ The age-adjusted BSID consists of 2 indices: the mental developmental index (MDI) and the psychomotor developmental index (PDI). In infants, the MDI, as opposed to the PDI, is considered most strongly correlated with later intellectual achievement and language abilities partly because of continuity in underlying cognitive functions.¹⁹ The Wechsler Preschool and Primary Scales of Intelligence, third edition (WPPSI-III) was administered to children aged 36 to 59 months.²⁰ WPPSI includes a verbal IQ score (VIQ) for verbal-related skills and a performance IQ score (PIQ) for non-verbal aspects of intelligence. The correlation between the WPPSI-III VIQ and BSID-II MDI is $r = .8$.¹⁹ Because of the nature of test items, there is no direct comparison between the WPPSI-III PIQ and the BSID-II PDI. Although both involve fine motor skills to some degree, the BSID also includes gross motor abilities, and the WPPSI-III contains non-verbal cognitive items.

Socioeconomic Environmental and Other Biologic Health Determinants

We used a comprehensive household survey to obtain detailed information about socioeconomic status, including educational attainment, smoking, age, sex, history of breastfeeding, and total income. Household characteristics such as sources of water and roofing material—known factors associated with lead exposure—were also measured.⁹

To assess the developmental environment in the home, trained psychologists administered the Home Observation for Measurement of the Environment (HOME) Survey, third edition. The HOME instrument measures directly experienced process-oriented factors including parental responsiveness, acceptance of the child, organization of the environment, play materials, parental involvement, and variety of stimulation. This allowed for better quantification of day-to-day environmental influences and parsing of aspects of environmental stimulation that would be obscured with broader status measures alone (eg, socioeconomic status).²¹

Weight and height were measured in each child twice during the home visit, and the mean values for each measure were used to calculate body mass index (kg/m²). The difference between measures was within ± 3 cm or 0.2 kg for all children. All survey data collection methods were monitored by project leaders to ensure quality and uniformity.

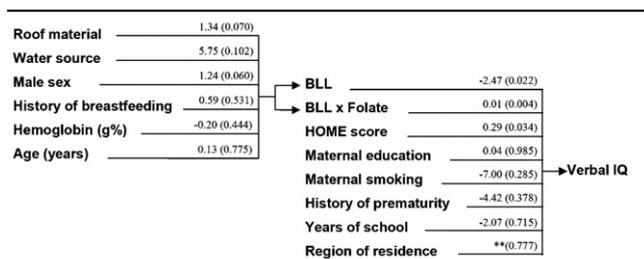
Assembly of Analysis Population

Of the 1496 subjects aged 6 to 59 months in the QIDS study, 1192 had a measured BLL, cognitive assessment, and folate level. Six hundred twenty-five of those subjects were administered the BSID, and the remaining 567 were given the WPPSI. Overall, complete blood and cognitive data were available for 501 subjects (80%) in the BSID group and 376 subjects (66%) in the WPPSI group. There were 191 incomplete records in the WPPSI and 124 in the BSID group. The HOME score was the missing co-variate in 106 of the 191 (55%) in the WPPSI group and 21 of 124 (17%) in the BSID group (Figure 1; available at www.jpeds.com). We compared subjects with complete data and subjects excluded because of incomplete data; overall the populations were similar and there were no systematic or clinical differences.

Statistical Analysis

Separate models were fit for 4 cognitive outcomes: BSID-II PDI and MDI and WPPSI-III VIQ and PIQ. We used 2-stage least squares regression models to assess the association between cognitive function and BLL. Two-stage least squares models estimate the factors of non-recursive paths as shown in Figure 2. Moreover, the models estimated here are concerned with multi-stage causal influences on a single dependent variable in contrast to the classic path analysis that deals with correlations among multiple dependent variables.

The first stage addresses the endogeneity of BLL levels on the basis of our earlier findings that rainwater, roofing



* Values presented here are for each covariate, the corresponding regression coefficient and (p-value) for the WPPSI Verbal IQ
 **Coefficient not given for categorical variable, p-value derived from partial F-statistic. The F-statistic and R-squared for the first-stage model are 1.80 and 0.019, respectively.

Figure 2. Path diagram for modeling IQ.

material, and region were associated with higher environmental exposure in the home.⁹ We also modeled a folate-lead interaction that was codetermined by the same exogenous factors as lead alone in the first stage. Path analysis technique confirmed the fit of the first stage model. An example path diagram for the model with WPPSI verbal IQ as the dependent variable is provided in Figure 2. Roof material, water source, sex, and history of breastfeeding were used to instrument BLL with a coefficient of determination (R-squared) of 0.019 and F-stat 1.8. The same exogenous variables were used for all models.

In the second stage, we modeled the determinants of cognitive outcomes as measured with the BSID and the WPPSI indices. Earlier studies of the relationship between cognitive ability and pediatric lead exposure have established an *a priori* set of co-variates that predict intellectual outcome in children in developed countries.²²⁻²⁷ These variables typically included the child's sex, prematurity, mother's IQ or education, years of education, maternal tobacco use during pregnancy, and yearly household income. We did not include race, because all subjects were Filipino. Income was subsequently dropped because of the high correlation with the HOME measures. Dummy variables for local and regional locations were introduced to account for unobserved community level effects and conditions. Endogenous co-variates were included when they were significantly associated with the cognitive function index being modeled. We performed usual testing for outliers and heteroscedasticity and for multi-collinearity of the variables before running the models.

RESULTS

Overall, the children in this population (n = 877) had a mean BLL of 7.1 $\mu\text{g}/\text{dL}$, an average hematocrit level of 11.8 g/dL, and a red cell folate concentration of 225 $\mu\text{g}/\text{mL}$ (Table I; available at www.jpeds.com). The children were poor, living in families that had an average annual family income of 59,801 Philippine pesos (PP; equivalent to US \$1067/year in 2004 dollars). Households had an average of 5.7 members. The children were also chronically malnourished (29% were stunted), anemic (24%), folate deficient (34%, defined as $<159 \mu\text{g}/\text{mL}$), but were born to mothers who were mostly high school graduates, had breast fed their children, and were unlikely to smoke. The average HOME environmental score

Table II. Full specification of the second-stage model: the effects of lead, folate-lead, and selected household characteristics on BSID MDI and PDI and WPPSI verbal and performance IQ

Independent variables	Dependent variables: IQ measures							
	BSID				WPPSI			
	MDI		PDI		Verbal IQ		Performance IQ	
	Coefficient	P value	Coefficient	P value	Coefficient	P value	Coefficient	P value
Biomarkers								
Lead	-3.32	<.01	-0.29	.71	-2.47	.02	-0.49	.65
Folate*Lead	0.01	<.01	<0.01	.59	0.01	<.01	0	.29
Household characteristics								
HOME	0.45	.01	0.28	.05	0.29	.03	0.33	.01
High school graduate mother	-2.27	.25	-0.76	.66	0.04	.99	3.21	.13
Smoker mother	3.01	.6	11	.03	-7	.29	-4.85	.46
Years of schooling of child	DROPPED		DROPPED		-2.07	.72	3.98	.48
Born pre-mature	8.35	.24	-3.33	.6	-4.42	.38	-7.79	.12
Regions								
Region 6	17.08	.04	16.6	.02	18.82	<.01	31.81	<.01
Region 7	10.61	.22	14.18	.06	9.08	.05	12.52	.01
Region 8	7.26	.41	10.37	.17	6.57	.2	7.93	.12
Constant	68.52	.01	74.46	<.01	74.26	<.01	68.24	<.01
Number	502		510		377		377	
F-stat	5.46	<.01	2.73	<.01	6.97	<.01	17.25	<.01

Instrumented: lead, folate*lead.

Instruments: sex, age of child, roof materials (light), water source (rain), breastfed for at least 4 months.

was 30.6 of a possible 100, suggesting low levels of environmental stimulation and experience.

In younger children (6 months-3 years old), the mean BSID-II MDI was 87.3, and in older children (3-5 years old) the mean WPPSI-III VIQ was 91.8. Non-verbal/motor scores were somewhat higher: BSID-II PDI scores averaged 96.8 (or 9.5 points higher than the MDI) and WPPSI-III PIQ scores averaged 97.5 (or 5.8 points higher than the VIQ).

We consistently found that the HOME score was predictive of cognitive function in both older and younger children. A 1 percentage point increase in the HOME score was associated with approximately a 0.28 to 0.45 increase in the BSID-II MDI score and a 0.29 to 0.33 increase in the WPPSI-III VIQ score. Maternal education, being born premature, whether the mother smoked, and (for the older children) years the child has been in school were not significantly associated with MDI or VIQ (although associations trended in the expected direction). Age was not included because all the cognitive measures are age-adjusted. (Complete specifications for the models are shown in Table II.)

Lead Impact on IQ

We identified significant associations between increasing BLL and decreasing cognitive function. A 1 µg/dL increase in BLL was associated with a 3.32 point decline in the BSID-II MDI in younger children ($P < .01$; 95% CI, -5.02-1.6) and a 2.47 point decline in WPPSI-III VIQ in older children ($P = .02$; 95% CI, -4.58-0.35). The association

between BLL and motor function (as measured with BSID-II PDI in younger children and WPPSI-III PIQ in older children) was not significant. These results are summarized in Table II.

Micronutrients

We found a significant interaction effect between BLL and serum folate level for both older and younger children ($P < .01$ in both cases). Specifically, increasing folate levels appear to offset the effects of lead toxicity. For example, as red cell folate increases from 80 µg/mL to 155 µg/mL, the impact of lead on MDI declines by 0.82 IQ points (Figure 3). The robust determinants of the folate-lead effects on IQ for both the young and older children confirmed the significance of folate (Figure 3). The relationship with folate, however, is associated with BLL and is not an independent factor in our findings (Table III).

We also found an inverse relationship between iron (proxied for by anemia) and BLL in our model. When we took into account the endogeneity of lead and iron, we found that as hemoglobin increased from the 10th percentile to the 50th percentile, the associated BLL fell an average of 1.24 µg/dL per child (Table III). We performed additional modeling, but found no significant direct or indirect effects between BLL and stunting or wasting on IQ.

DISCUSSION

Today, children in less developed nations are more likely to be subject to environmental lead exposure, more

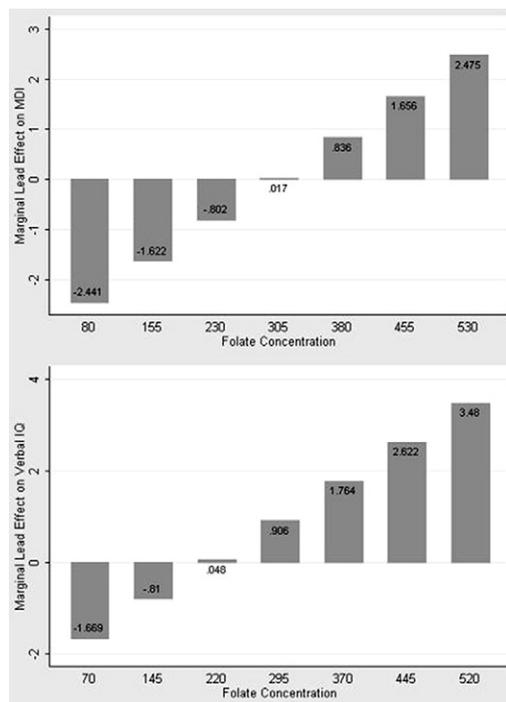


Figure 3. Marginal effect of lead on BSID-II MDI and WPPSI-III VIQ considering folate concentration levels.

Table III. Mean blood lead level at various levels of folate and hemoglobin concentration (n = 877)

	n	BLL (μg/dL)
Folate concentration		
100 μg/mL (10th percentile)	87	7.73
141 μg/mL (25th percentile)	220	7.64
195 μg/mL (50th percentile)	439	7.55
281 μg/mL (75th percentile)	658	7.22
Hemoglobin concentration		
9.4 g/dL (5th percentile)	51	8.88
10.1 g/dL (10th percentile)	85	8.76
11 g/dL (25 percentile)	234	7.58
12 g/dL (50 percentile)	476	7.52
12.8 g/dL (75 percentile)	653	7.16

likely to absorb lead through the gastrointestinal tract because of iron and other nutritional deficiencies, and may be more susceptible to the effects of blood-borne lead on the central nervous system because of poor nutrition.

Our data provide direct observational evidence of an inverse association between BLL and cognitive function in poor children in a developing country with a high prevalence of anemia and folate deficiency. Lead toxicity in this population had a greater impact on IQ than previously reported. Canfield et al reported a 0.32-point decrease in full IQ for each 1 μg/dL increase in concurrent BLL (SD, 0.15; 95% CI, -0.6--0.01) after adjustment for multiple covariates, an effect size consistent with earlier research in other cohorts in

more developed settings.^{22-24,27} In another study, a 1-μg rise in red cell lead levels was associated with a drop of nearly 1 percentage point in IQ.¹⁰ However, we found that a 1 μg/dL increase in BLL was associated with a 2.47 to 3.32 point drop in cognitive function. There may be several reasons for this difference compared with earlier studies. First, we used age-adjusted instruments across a broader range of children, which may have given us greater sensitivity to the lead effects. Second, we used other nutritional markers and the HOME environmental assay, which is often not used in surveys done in developing countries.²⁸⁻³⁴ Third, our 2-stage model corrects for the inherent endogeneity of iron and lead, thereby significantly improving the precision of estimated marginal effects. Finally, there may exist actual differences in lead susceptibility in children living in less developed settings. Other studies have demonstrated that children with iron deficiency anemia are at increased risk for the subsequent development of lead toxicity. The inverse association between hemoglobin concentration and BLL may be causal, in theory related to parallel gastrointestinal uptake of iron and lead.^{35,36} An inverse relationship between calcium intake and BLL has been reported, something that might also be occurring in these children.³⁷ There have also been studies linking low thiamine levels and ascorbate levels to decreasing IQ.³⁸ Our findings support the notion that in addition to a heightened risk for increased blood lead burden, children who are poorly nourished are more susceptible to the negative cognitive effects of lead once it is present in their blood. Independent of their anthropometric status, the increased vulnerability of the younger children, when cognitive development is relatively more dynamic, may also reflect the importance of nutritional predisposition to the effects of lead.

We noted a lack of effect of lead on motor development/non-verbal intelligence. Although directionally there seemed to be some effect, there were no significant differences in either the BSID-II PDI results or the WPPSI-III PIQ results. This may reflect the greater cumulative influence of biologic risk (lead) and environmental risk (ie, lack of cognitive stimulation) on the MDI or VIQ compared with motor function or non-verbal IQ. Earlier sensorimotor behaviors, which are strongly canalized, are less susceptible to the negative (and perhaps subtle) effects of higher BLL.³⁹ We suspect that the consistent exposure to lead that results in modest verbal deficiencies in other settings is amplified by a lack of environmental stimulation in this survey population.

Nutritional factors clearly play a key role in neurological development, but there has been little investigation of nutritional factors and their relationship to lead toxicity.⁴⁰ Earlier studies have been confounded by the selection of children seeking care or already identified as having high BLLs.^{23,25-27} In this study, we had both a population-based sample and a high degree of accuracy from venous samples of lead, hemoglobin, and folate. However, the mechanism for the observed association between lead and anemia remains confounded because both lead poisoning and iron deficiency are associated with a variety of circumstances related to lower socioeconomic

status. We adjusted for socioeconomic endogeneity and found that iron deficiency was associated with higher lead levels and lower IQ. Undoubtedly, this relationship is complex, because chronic anemia also impairs neural development.⁴¹

Although folate is critical for *in utero* neural development, we did not observe a direct effect of folate on IQ in this population.⁴²⁻⁴⁴ However, when we modeled folate as moderating the neurotoxic effect of lead on IQ, we found that higher levels of folate have a protective effect. The impact was seen in all children, but was greatest in younger children with folate levels >304 $\mu\text{g}/\text{mL}$.

Although the protective effect of folate is compelling, it also raises the question of whether there is a treatment effect. Previous research from NHANES found a seemingly curious relationship among folate intake, folate levels, and lead levels. BLL is positively associated with folate intake, but negatively associated with serum folate levels; thus, folate intake may be associated with increased lead absorption, but serum folate is associated with increased excretion.³⁸ Our findings support these results and further suggest the possibility of folate treatment for lead toxicity. Nutritional supplementation, in addition to its many other health merits, may be protective against systemic absorption of lead and against blood-borne lead's ill effects on cognitive development. Because folate also affects nutritional anemia, it is also possible that there is a relationship between lead levels, in which 99% of lead in blood is bound to erythrocytes, and erythrocyte health.⁴⁵ Independent of the mechanism, in our analysis, nutrition played a more significant role than income, indicating that nutritional supplementation may, to some extent, offset the effect of poverty on cognitive development in this type of population. Future experimental designs will be needed to determine whether nutritional supplement intervention consisting of iron, folate, and perhaps other water soluble vitamins can reduce lead levels or mitigate the effects of lead on IQ.

We did not find an association between stunting or wasting and cognitive function. Wasting is not a consistent predictor of poor development.⁴⁶⁻⁵¹ We attribute this to our inability to find other measures of nutritional status and measures of economic and educational status that are highly correlated with stunting and already controlled for in our analysis.

In contrast, the consistently positive relationships between HOME scores and all measures of cognitive function suggest a strong impact of environment on cognitive function in this population. Interventions aimed at improving the home learning environment may also be an effective means of mitigating or mediating the impact of other factors that are associated with decreased cognitive function. There is still an effect of lead, despite the massive influence of the environment, which could be acting to suppress the lead effects.

There are several limitations to this study. First, the cross-sectional nature of this study is a source of some potential but addressable challenges. A single measure of BLL

may not provide an accurate measure of cumulative lead exposure in the study population. Earlier studies, however, show a strong correlation between concurrent BLLs and measures of cumulative lead exposure.²³ Second, although the LeadCare device used to measure BLL in this study was primarily developed for screening in the practice setting and has not been widely used in research, the device has undergone extensive clinical testing and approval. Performance data from the manufacturer's evaluation does not indicate differential error in comparison to the "gold standard" of atomic absorption spectrometry. However, caution is still warranted. Third, although we did not have a direct measure of iron level in this study, we used a highly accurate determination of hemoglobin level to proxy for iron. Other research has shown that the most common cause for anemia is iron deficiency.⁵² Fourth, the IQ measures used in this study were designed for and validated in the US population. However, these measures are now widely used internationally, including in the Philippines, and issues of construct validity have not been identified. Additionally, the association between these IQ measures and the expected determinants of cognitive function in this study provides evidence that the measures were suitable in the Philippines.

The macroeconomic benefits of mitigating lead toxicity could be staggering. It is estimated that each 1 point increase in IQ raises eventual worker productivity 1.76% to 2.38%; the economic benefit for a cohort of 3.8 million 2-year-old children would be between \$110 and \$319 billion dollars in the US.⁵³ In the Philippines and other developing countries where the cohorts are much larger and the marginal benefit seemingly much greater, the economic measurement would be even higher. With improved cognitive performance, school performance would improve and overall capabilities expand, all of which would push economic growth and poverty alleviation.

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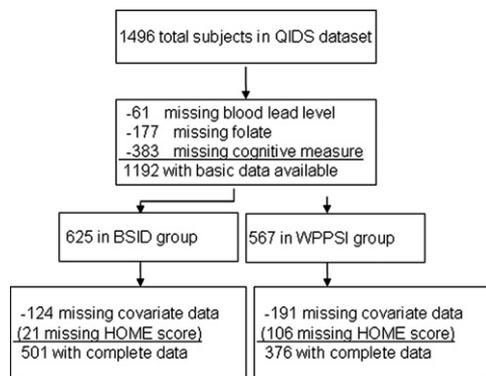


Figure 1. Assembly of analysis population from the QIDS data set.

Table 1. Characteristics of the study population

Characteristic	Complete data set (n = 877)	
	Mean	SD
Blood lead concentration ($\mu\text{g/dL}$)	7.1	7.7
Elevated lead (% with $>10 \mu\text{g/dL}$)	22.3	0.4
Hemoglobin concentration (g/dL)	11.8	1.5
Hemoglobin deficient (% with $<11 \text{ g/dL}$)	23.7	0.4
Folate concentration ($\mu\text{g/mL}$)	225	124.9
Folate deficient (% with $<159 \mu\text{g/mL}$)	34.4	0.5
Stunted (% with $<-2 \text{ SD height-for-age}$)	29.1	0.5
BSID (n = 501)		
Mental scale	87.3	16.4
Motor scale	96.8	18.7
WPPSI (n = 376)		
Verbal IQ	91.7	7.2
Performance IQ	97.5	1.1
HOME total score (%)	30.6	0.5
Age at testing (years)	2.2	0.1
Female sex (%)	51.1	0.3
Child's years of schooling (years)	0.01	0.2
Breastfeeding for at least 4 months (%)	88.3	0.5
Born premature (%)	3	0.5
Maternal education (% high-school graduate)	54.8	0.2
Smoker(s) in the house (%)	60	56.1
Smoker mother (%)	2.9	0.5
Household income (1000 Philippine Pesos)	59.8	0.5
Resides in region 6 (%)	31.1	0.5
Resides in region 7 (%)	31.6	0.2
Resides in region 8 (%)	34.2	0.5
Resides in region 10 (%)	3.1	0.2