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Infant Morbidity and School Performance in Late Childhood in Cebu, Philippines

Tita Lorna Perez, Marilyn Cinco
and
Linda Adair

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Tita Lorna Perez *University of San Carlos Office of Population Studies Foundation*
Marilyn Cinco *University of San Carlos Office of Population Studies Foundation*
Linda Adair *University of North Carolina at Chapel Hill, NC*

Abstract

Diarrhea and respiratory infections continue to be the leading causes of childhood mortality and morbidity in the Philippines. These illnesses may also have long-term effects on surviving children's later health and development, but few studies have examined the effects of early child morbidity on school performance. Using the Cebu Longitudinal Health and Nutrition Study in the Philippines, we examine the associations and independent effects of diarrhea and respiratory diseases in the first 2 years of life on school absenteeism and English and Mathematics achievement tests scores at 10-12 years old. We also explore the simultaneous effects of diarrhea and respiratory illnesses on the same education-related indicators. Linear regression analysis reveals that diarrhea and respiratory infections during infancy are associated with lower achievement test scores at ages 10-12. Multinomial regression shows that with reference to those who were never absent, diarrhea and respiratory infections at younger ages elevates the risk of absenteeism due to health reasons at older ages (10-12). The long-term consequences of infant morbidity emphasize the importance of early interventions to improve child health.

Key Words: achievement tests infectious diseases morbidity school performance Philippines

Introduction

Critical brain and cognitive development occurs before the age of seven, particularly during the first three years of life. The process of development is influenced by a child's nutritional and health status during the first years when the brain pathways for lifelong capabilities are established (ECD Group).

Having good health during childhood results in better-educated and more productive adults. Cost-benefit studies have established that health has an impact on education and yields high economic returns (Belli et al., 2005). A study conducted in the United Kingdom by Case et al (2003) found that children with poor health performed less well in school, completed fewer years of education, and had significantly poorer health, as well as lower earnings as adults. A review of cost-benefit studies conducted by Behrman (Belli et al., 2005) established that chronic malnutrition occurring on the first two years of life permanently impaired cognitive ability, height and visual acuity, which adversely affect productivity and earning potential throughout life.

Education has long been viewed as an important factor in human capital development. Economists and international development agencies agree that education is a key ingredient for economic growth (Wisniewski, 2006) Almost all studies link educational attainment to development indicators of significance. Levinger (1996), says that "at the very heart of efforts to assist the world's most impoverished people in their struggle to obtain the essentials of life, food, shelter, livelihood, and a secure future, lies education".

Several studies have explored the relationship between child health and education. Some education-related indicators examined are grade level, age at school enrollment, absenteeism, grade repetition, IQ, and achievement tests. Stunting, protein-energy malnutrition, micronutrient deficiency, and morbidity experience have been used as indicators of a child's poor health (Soemantri et al., 1985; Torres et al., 2000; Mukudi, 2003; Jamison, 1986). A study by Glewwe and King (2001) on the impact of child health and nutrition on education outcomes in the Philippines showed that malnourished children in the Philippines are more likely to enroll late, to repeat grades, and to learn less per year of schooling. Stunted children are also found to have significantly lower mean cognitive test scores and tended to start school later than non-stunted children (Mendez and Adair, 1999) and they have significantly lower scores in arithmetic, spelling, word reading and reading comprehension than the non-stunted children (Chang, 2002).

Most of the early studies conducted on child's health and education have focused on the effects of nutrition on school performance (Mukudi, 2003; Glewwe et al., 1995; Alderman et al., 2001; Tarleton et al., 2006). Very few studies examine the impact of a child's morbidity experience early in life, specifically diarrhea and respiratory illnesses, on school performance. Diarrhea and respiratory infections are the most common illnesses suffered by children worldwide and the world's leading causes of mortality. These illnesses may also have potential long-term effects by limiting growth, physical development and cognitive performance.

A prospective study of Bangladeshi children found a significant negative association between the total number of days when diarrhea occurred and annual weight gain. (Torres et al., 2000). Hadi et al (1999) examined the role of respiratory infections and diarrhea in modifying the growth response to vitamin A supplementation and found that vitamin A supplementation improves the linear growth of children who have a low intake of vitamin A but the impact is muted with increasing levels of respiratory infections. In a study of Brazilian children, Niehaus et al (2002) reported that early childhood diarrhea is correlated with reduced cognitive functions 4 to 7 years later as measured by intelligence tests. Another study from the same survey found that early childhood diarrhea predicts the age at starting schooling and appropriateness of child's age for grade (Lorntz et al., 2006). Chronic infection or even mild infections associated with common childhood illnesses such as upper respiratory infections and gastroenteritis can lower hemoglobin concentration even when the diet is adequate in iron (Ryan, 1997). Moore (2001) also found out that children with diarrhea burdens at 0-2 years tended to be of smaller stature at ages 2 through 7 years. Although the strength of the correlation of early childhood diarrhea with nutritional status diminished slightly as children grew older, a significant amount of the variation in HAZ at age 6 was still explained by early childhood diarrhea. There are other studies, however, which did not find associations between early childhood diarrhea and respiratory illnesses and cognitive functioning or later physical growth (Tarleton et al., 2006; Berkman et al., 2002; Moy et al., 1994).

In the Philippines, respiratory illness and diarrhea are the two most common causes of child death and morbidity. Results of the National Demographic and Health Survey (NDHS) in 2003 show a morbidity rate of 15 and 12 percent from diarrhea and respiratory illnesses respectively among children under age two. Although studies have

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To the extent that time in school affects test scores, we may have underestimated the effects of early morbidity: Those with the highest levels of morbidity may be the least likely to be in school at the time we assessed school outcomes. An alternative strategy would be to jointly estimate the likelihood of being in school with school outcomes that may depend on time in school.

A main strength of the study is the availability of detailed data from the first 2 years of life, followed by important outcomes measured later. Few studies of school achievement have such detailed information on early childhood.

The findings imply that infant morbidity has long-term effects which extends ten years later and affects a child's performance in school. Therefore, early intervention to promote better health at infancy and prevent the negative effects of infant morbidity is very important and should be undertaken.

Diarrhea and respiratory infections are transmitted diseases, that is, via fecal, oral or person-to-person routes. Hence, efforts to prevent the transmission of diarrhea and respiratory infections and treatment programs with the integration of improving childhood nutritional status are needed.

Diarrhea and respiratory infections continue to be the leading cause of morbidity and mortality in developing countries including the Philippines. The Philippine government has developed an early childhood development program (ECD) for the purpose of improving the health conditions of the Filipino children. Included in the program are the controls of diarrheal diseases and respiratory infections as well as the integrated management of childhood illness (IMCI). The success of the Philippine ECD program hopefully will reduce the negative impacts of early child health on subsequent school performance and the child's quality of life in later adulthood.

Safeguarding health during childhood is more important than at any other age because poor health during children's early years is likely to permanently impair their health over the course of their life (Belli et al, 2005).

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been conducted on the association of malnutrition with cognitive development in the country, no studies have been conducted yet on the long-term association of diarrhea and respiratory infections with children's later health and cognitive development. This study examines the independent and combined effects of diarrhea and respiratory illnesses (in the first 2 years of life) on schooling performance measured as absenteeism and achievement test results at ages 10 to 12 years. Building on the findings of other studies, we posit that the experience of diseases like diarrhea and respiratory illnesses early in life, which may precede, follow or occur simultaneously with nutritional deficiencies, have consequences detrimental to a child's development. More specifically, children who experienced a high frequency of these illnesses during the first two years of life will exhibit greater tendencies of absenteeism and will have lesser proficiency in English and Math subjects.

Methods

This study uses data from the Cebu Longitudinal Health and Nutrition Survey (CLHNS). The CLHNS is a community-based study conducted in metropolitan Cebu, Philippines, the second most populous and most rapidly growing metropolis in the country.

Data and Sample

The children sampled were drawn from 33 barangays (smallest administrative unit) – 17 urban, 16 rural – using a stratified, single stage-sampling procedure. Baseline information was collected on all pregnant women who were due to give birth between May 1, 1983 and April 30, 1984. These pregnancies resulted in 3080 single live births. Mother-children pairs were visited at 19 different points in time - during pregnancy, immediately after birth, then at bimonthly intervals for a period of two years. Subsequent follow-ups were done in 1991, 1994, 1998, 2002 and in 2005. The same set of socio-demographic, environmental, health and nutrition data were gathered in each round. Each survey also included questions relevant to the children's age group.

We use data from the 1994 survey when all participants were of an age when children are normally attending primary school. There were missing data at each survey, attributed to deaths, migration, temporary absence and refusals. The present analysis sample includes 1,760 children (926 males, 834 females) who were singleton births, had complete longitudinal information from age 0 to 24 months, and who were enrolled in school and had test scores from English and Mathematics tests during the 1994 follow-up survey.

Description of Key Variables for the Analysis

<u>School performance in late childhood</u>**.** School performance is represented by absenteeism and by the achievement test scores in English (reading comprehension) and Mathematics when the sample children were between 10 to 12 years old.

The Cebu Longitudinal Health and Nutrition Survey is a collaborative research project involving the Office of Population Studies, University of San Carlos, Cebu, Philippines and the Carolina Population Center, University of North Carolina at Chapel Hill, USA. Follow-up surveys were supported by grants from the World Bank and the Asian Development Bank.

Absenteeism is constructed from questions, asked of mothers, on whether their child ever missed school within the month prior to the survey and if they did, for what reasons were they absent. Reasons for missing school are grouped into health-related and non-health related absences. As such, our first outcome variable (absenteeism) is classified into three categories: no absence, any absence due to health reasons, and any absence due to non-health reasons. Non-health reasons typically included factors such as family or domestic problems, economic reasons, children's attitudes and natural calamities.

Our second outcome uses a continuous variable, the standardized scores (Z-scores) on English and Mathematics achievement tests. The Z-scores were calculated for all who took the examination, regardless of their inclusion in the final analysis sample. These tests were developed for the CLHNS based on the official primary school curriculum in the Philippines. Each test consist of sixty items. Trained field staff administered these to sample children during non-school days in schools where these children were enrolled during the survey period. Filipino children typically enter school at age 6. Thus, at a mean age of 11, children are expected to be in grade 4 or 5. Performance on achievement tests is likely to be strongly influenced by time in school, but the analysis sample all children who were in school regardless of their grade level (37 children were in grade 1, 29 of whom were grade 1 repeaters) so as not to underestimate the role of early morbidity of children who entered school late or are repeating grades.

Morbidity experience is our main exposure variable. Morbidity information was collected during bimonthly visits from birth until the age of two years based on the mother's report of her child's symptoms in the week preceding each survey. Morbidity experience includes the frequency of occurrence of diarrhea and respiratory illness during the first two years of life. While these reports therefore do not provide a measure of total morbidity experienced by the child, they provide a good representation of the likelihood of each child experiencing illness.

We define the number of episodes of diarrhea and respiratory illnesses as the number of longitudinal surveys (out of 12) when the infant was reported having diarrhea and respiratory infections Diarrhea episodes ranged from 0 to 9, while respiratory illness ranged from 0 to 12 (only one child was reported to have no cough experience in any of the 12 longitudinal visits). Due to the very skewed distribution of both illnesses, we categorized the variables based on the average number of episodes of the illness. Diarrhea episodes are grouped into three: never had diarrhea, diarrhea one to three times, and diarrhea more than three times. We have two categories for respiratory illness: cough eight times or less, and cough more than eight times.

Simultaneous occurrence of both diarrhea and cough in the seven days before each survey is also assessed. This morbidity variable is constructed by determining the number of longitudinal surveys in which both illnesses simultaneously occurred. The frequency ranged from 0 (not simultaneous occurring) to a maximum of nine episodes, and is represented as 1, 2, and 3 or more simultaneous occurrences.

Discussion

The findings of this study support previous study results that diarrhea and respiratory infections are associated with later cognitive development or school performance. This study found that children who experienced diarrhea and respiratory infections in the first 2 years of life perform poorly in school: they are absent more often because of ill health and they have lower scores in Math and English achievement tests. The results of this study indicate that experience of early childhood diarrhea and respiratory infections are important risk factors for poorer school performance.

Several factors might explain the observed strong association of early child infectious morbidity and later school outcomes. Later childhood morbidity that might cause a child to miss school days at age 11 may share common underlying social and ecological risk factors. Our adjusted models included a number of important household socioeconomic and environmental factors that typically predict child morbidity (e.g. maternal education, household hygiene, crowding, income and assets). It is notable that their inclusion in the models did not markedly attenuate our estimates of the effects of morbidity. However, we cannot rule out the possibility that common underlying factors, which we did not measure or did not include in our models, influenced both early childhood and school aged morbidity.

The association of early child morbidity with achievement test scores at age 11 may be similarly explained by common underlying factors that affected both exposure and outcome. Inclusion of household environment and SES variables attenuated the association of morbidity and test scores, but significant associations of meaningful magnitude remained in adjusted models. This suggests that there are effects of early morbidity independent of parental and household characteristics. Moreover, the effects of morbidity remained after controlling for stunting at age 2, which is a good overall indicator of child health. It is possible that micronutrient deficiencies or losses related to frequent morbidity influenced child cognitive development. At the same time, recent studies have recognized the synergistic relationship between malnutrition and diarrhea. A bidirectional causal relationship is postulated wherein malnutrition predisposes the host to infection, and conversely, infection exerts a negative impact on nutrition (Chen, 1983). Both as a result and cause of malnutrition, young children are also very susceptible to infections. Their immature immune systems fail to protect them adequately from contaminated foods and liquids, at the same time, as a result of poor diets and frequent infections, young children are malnourished. While recognizing the interactive relation between these two factors, the fact remains that diarrhea and respiratory infections are important risk factors for poor school performance and must be given attention.

The study has a number of important strengths and weaknesses: We have restricted our analysis sample to those children who were attending school at the time of the 1994 survey. It is likely that children not in school are the most disadvantaged children and who would likely have had high morbidity in early childhood. There is a potential for such exclusions to bias our estimates but sensitivity analysis on all the kids who have a test score (whether in school or not) showed no change in the morbidity coefficients.

Table 5. Association between Morbidity[1] in the First Two Years of Life and Mean Z-scores in English and Math Achievement Test at Ages 10-11y, Unadjusted and Adjusted coefficients (N=1753)

Variable	*Unadjusted*[2]				Adjusted[3]			
	Model 1				Model 2			
	Coef	*SE*	*P>z*	*95% CI*	*Coef*	*SE*	*P>z*	*95% CI*
English z_scores								
Diarrhea (1 to 3 episodes)	-0.12	0.064	0.072	-0.24, 0.01	-0.61	0.057	0.285	-0.17, 0.05
Diarrhea (>3 episodes)	-0.33	0.076	0.000	-0.48, -0.18	-0.16	0.067	0.015	-0.30, -0.03
Cough (>8 times)	-0.16	0.047	0.000	-0.26, -0.07	-0.08	0.041	0.060	-0.16, 0.00
Simultaneous occurrence (1-2x)	-0.04	0.058	0.481	-0.15, 0.07	0.01	0.051	0.846	-0.11, 0.09
Simultaneous occurrence (3x)	-0.29	0.064	0.000	-0.42, -0.16	-0.16	0.057	0.006	-0.27, -0.46
Math z_scores								
Diarrhea (1 to 3 episodes)	-0.09	0.066	0.181	-0.22, 0.04	-0.05	0.061	0.442	-0.17, 0.07
Diarrhea (>3 episodes)	-0.33	0.077	0.000	-0.48, -0.17	-0.20	0.072	0.006	-0.34, -0.57
Cough (>8 times)	-0.21	0.047	0.000	-0.30, -0.11	-0.14	0.044	0.002	-0.22, -0.05
Simultaneous occurrence (1-2x)	-0.11	0.059	0.057	-0.22, 0.00	-0.09	0.055	0.113	-0.19, 0.02
Simultaneous occurrence (3x)	-0.31	0.065	0.000	-0.43, -0.18	-0.20	0.061	0.001	-0.32, -0.08

[1]Children with a history of diarrhea versus with no reported diarrhea (referent); with respiratory infections >8x versus those having experienced eight times or less (referent); diarrhea and cough occurring simultaneously occurring versus not (referent); high morbidity versus low (referent)
[2]Estimated from linear regression not adjusted for any potential confounder
[3]Adjusted for gender of child, residence location, household's socio-economic status, mother's education, household crowding and environmental cleanliness

Effect of Covariates. Male children showed increased risks of absenteeism due to both health and non-health reasons relative to those who are not absent, but the relative risk is almost twice for those absent due to non-health reasons. Mother's education showed similar contrasting effects as in the case of diarrhea and cough – significantly higher risks of absenteeism due to health reasons for children with mothers who have finished elementary school, and significantly lower risks of absenteeism due to non-health reasons for children with mothers who have college education. Urban residence was associated with reduced non-health related absences.

The coefficients in the adjusted test score models, apparently shown to be more attenuated is in all likelihood due to the contribution of other covariates. Mean Z-scores in English and Mathematics significantly reduced for male children across all morbidity categories. Urban residence and very sanitary environment in the adjusted models was associated with better performance in English, but their association with the performance in Math is not striking (significant only at the ten percent level). Consistent with other studies, maternal education strongly influenced the attenuation of the crude results. Children of college educated mothers scored one standard deviation higher in English compared to children with less educated mothers.

Data Analysis

The initial CLHNS sample represents a one-year birth cohort of 3,080 singletons. Exclusion from the analysis sample occurs because of child deaths, migration from the study area, missing one or more of the 12 longitudinal surveys while still remaining in the sample, not being enrolled in 1994, and refusal to take the achievement tests. We have not separately analyzed factors related to these different reasons for exclusion, but have compared the baseline sociodemographic characteristics of children included versus those who were excluded from the analysis sample using basic descriptives (means or percentages). In addition, we used logistic regression to identify those characteristics that significantly differentiate the 2 groups.

Bivariate tests are likewise performed to assess associations between exposure and outcome variables. We use chi-square tests to assess relationships between absenteeism and the different morbidity categories, and T-tests and Anova to test the association of standardized Z-scores in English and Mathematics proficiency with morbidity.

Since absenteeism is categorized into 3 groups, we use multinomial logistic regression to estimate the likelihood of being one of the 2 absentee categories (health or non-health reasons) with no absenteeism as the referent category. The estimates are presented as relative risk ratios. The multinomial logistic regression model is the result of fitting the independent contribution of each morbidity variable to absenteeism and the joint contribution of other covariates and confounders.

The prediction model for our first school performance outcome is:

$$Y = B1\ [\text{morbidity experience}] + B2\ [\text{covariates}] + BC$$

Where Y is the relative risk of absenteeism (that is, rr1=P (y=1)/P (reference category); rr2=P (y=2)/P (reference category), B1 is a coefficient (that is, the relative risk ratio) of the morbidity variables; B2 (coefficients of morbidity covariates); C represents confounding variables viewed to be related with morbidity but not causally and may also be influencing school performance independent of morbidity.

For our continuous outcome (standardized Z-scores in English and Mathematics) linear regression coefficients are calculated along with 95% confidence intervals and p-values. The model for this outcome is as follows:

$$Y = a + B1\ [\text{morbidity experience}] + B2\ [\text{covariates}] + BC$$

Where Y is the standardized Z-scores in either English or Math, a is a constant, B1 is a coefficient for the morbidity variables; B2 (coefficients of morbidity covariate); C represents confounding variables.

We first estimate unadjusted models to examine the crude association of morbidity with schooling outcomes, and estimate models adjusted for theoretically relevant factors perceived to be potential confounders or effect modifiers. These include child's gender, place of residence during the first two years of life (urban-rural), socioeconomic status of the child's household, and maternal education. Morbidity covariates which include household crowding measured as the number of persons per room in the household and a hygiene index to measure environmental cleanliness are also adjusted for in the second model.

Results

Profile of the Sample

Children included in the analysis differ significantly from those excluded in several important characteristics (Table 1). Bivariate comparisons reveal that children in the analysis sample have mothers who are older, less educated and with higher parity. Their fathers also have less education, but are not different in age than those excluded from the analysis. Included children were less likely to live in urban communities but their families were more likely to own a house and to be in highest income group. Considering all of these variables in a logistic regression predicting whether the child was in or out of the sample, residential location and house ownership remained significant. Urban dwellers have lesser propensity to stay in the sample (p=0.016), while those who own their dwellings have twice the odds of remaining in the sample (p=0.000). Despite these differences, Heckman Selectivity Models indicate no selectivity bias in the estimates of the effects of morbidity.

Table 1. Socio-Demographic Characteristics of CLHNS cohorts (N=3080)

Characteristics	**Lost to follow-up (n=1320)**	**In the sample (n=1760)**	***P*-value[1]**
	Mean / SD	***Mean / SD***	
Birth weight, *g* [3]	2959.67 ± 459.19	3011.41 ± 419.94	0.0013
Birth length, *cm*[4]	48.99 ± 2.12	49.12 ± 2.04	0.0934
Maternal age, *y*	25.78 ± 5.94	26.28 ± 6.02	0.0210
Maternal education, *y*	7.24 ± 3.34	7.00 ± 3.28	0.0415
Paternal age, *y*	29.16 ± 6.44	29.36 ± 6.61	0.4056
Paternal education, *y*	7.52 ± 3.48	7.21 ± 3.33	0.0129
Parity	2.11 ± 2.08	2.4 ± 2.31	0.0005
	n (%)	***n (%)***	***P*-value[2]**
Belong to the upper third of income & assets	460 (34.85)	686 (38.98)	0.019
Urban Location	1070 (81.06)	1285 (73.01)	0.000
Owns house	714 (54.09)	1313 (74.60)	0.000

[1] Values of *P* based on one-way ANOVA overall F-test statistic
[2] Values of *P* based on Pearson's chi-square test
[3] Values of n=3039 (1296 lost to follow-up, 1733 in the sample)
[4] Values of n=3050 (1292 lost to follow-up, 1758 in the sample)

Similarly, we observed a 58% increase in the likelihood of health-related absences associated with having more than 8 episodes of cough. More frequent simultaneous occurrence of diarrhea and cough episodes was also significantly associated with a higher likelihood of school absences, but these analyses are not more revealing than those which consider each type of morbidity separately. Early childhood morbidity was not consistently associated with non-health related school absences.

Table 4. Morbidity[1] During the First Two Years of Life and School Absenteeism at Ages 10-11y, Unadjusted and Adjusted Risk Ratios, Calculated from multinomial logistic regressions, comparing health and non-health related absences to no school absences (N=1760)

Variables	**Unadjusted Risk Ratios[2]**				**Adjusted Risk Ratios[3]**			
	Model 1				Model 2			
	RRR	*SE*	*P>Z*	*95 % CI*	*RRR*	*SE*	*P>Z*	*95 % CI*
***Absence due to health reasons** (referent=no absence)*								
Diarrhea (1 to 3 episodes)	1.69	0.299	0.003	1.19, 2.39	1.66	0.296	0.005	1.17, 2.35
Diarrhea (>3 episodes)	1.92	0.386	0.001	1.29, 2.84	1.74	0.355	0.007	1.16, 2.60
Cough (>8 times)	1.64	0.193	0.000	1.30, 2.07	1.52	0.150	0.000	1.20, 1.93
Simultaneously occurring (1 to 2 x)	1.24	0.183	0.149	0.93, 1.65	1.21	0.180	0.201	0.90, 1.62
Simultaneously occurring (3x or >)	1.49	0.242	0.014	1.08, 2.04	1.35	0.222	0.068	0.98, 1.86
***Absence due to non-health reasons** (referent=no absence)*								
Diarrhea (1 to 3 episodes)	0.98	0.180	0.949	0.69, 1.41	0.93	0.174	0.694	0.64, 1.34
Diarrhea (>3 episodes)	1.32	0.278	0.190	0.87, 1.99	1.05	0.228	0.818	0.69, 1.61
Cough (>8 times)	1.43	0.194	0.008	1.09, 1.86	1.28	0.179	0.076	0.97, 1.68
Simultaneously occurring (1 to 2 x)	0.95	0.161	0.767	0.68, 1.33	0.91	0.158	0.598	0.65, 1.28
Simultaneously occurring (3x or >)	1.45	0.261	0.040	1.02, 2.06	1.20	0.224	0.316	0.84, 1.73

[1] Children with a history of diarrhea versus with no reported diarrhea (referent); with respiratory infections >8x versus those having experienced eight times or less (referent); diarrhea and cough occurring simultaneously occurring versus not (referent); high morbidity versus low (referent)
[2] Estimated from multinomial logistic regression not adjusted for any potential confounder
[3] Adjusted for gender of child, residence location, household's socio-economic status, mother's education, household crowding and environmental cleanliness

Achievement test scores. Table 5 presents coefficients from crude and adjusted linear regression models of English and Mathematics achievement test scores. Based on unadjusted estimates, better performance on both test scores was significantly associated with nearly all categories of illness occurrence. The estimates of the effects of illness were of the same order of magnitude for the 2 different tests. However, compared to the results for absenteeism, there was more attenuation of the estimated effects of morbidity when potential confounders were taken into account.

In the adjusted models, children with more than 3 reported episodes of diarrhea or more than 3 simultaneous diarrhea and cough episodes had English and Math test scores that were about one fifth of a standard deviation (SD) lower than those without diarrhea, but there was no significant association with less frequent diarrhea. Having more than 8 reported episodes of cough was associated with a 0.14 SD reduction in Math score, but not with the English score.

Table 3b_1. Distribution of Mean Z-scores on Achievement Test by Morbidity Experience in the First Two Years of Life and Other Categorical Covariates (N=1753)

Morbidity variables and other covariates		Achievement Test Mean z-scores					
		English			Math		
	N	*Mean*	*SD*	*F-stat*	*Mean*	*SD*	*F-stat*
Diarrhea				10.84*			11.00*
No diarrhea	281	0.17	1.03		0.15	1.03	
Diarrhea (1 to 3 episodes)	1091	0.05	0.97		0.07	1.00	
Diarrhea (3+ episodes)	381	-0.17	0.91		-0.17	0.89	
Respiratory				12.22*			19.48*
Cough (8 times or less)	757	0.12	1.02		0.15	1.01	
Cough (>8 times)	996	-0.05	0.93		-0.06	0.97	
Simultaneous Occurrence (Diarrhea & Respiratory)				13.35*			11.64*
Not occurring simultaneously	414	0.12	1.03		0.17	1.01	
Simultaneously occurring (1 to 2 times)	840	0.08	0.97		0.06	1.02	
Simultaneously occurring (3 times or more)	499	-0.16	0.90		-0.14	0.89	
Combined morbidity experience (diarrhea+ cough)				22.36*			18.20*
Low frequency (11 times or less)	982	0.12	1.00		0.12	1.01	
High frequency (>11 times)	771	-0.10	0.92		-0.09	0.96	
Gender				80.18*			32.19*
Males	920	-0.17	0.93		-0.10	0.93	
Females	833	0.24	0.97		0.17	1.03	
Household crowding (persons/room)				29.00*			15.13*
Less crowded	897	0.14	1.01		0.12	1.02	
More crowded	856	-0.10	0.92		-0.07	0.94	

Values of *P* based on one-way ANOVA overall F-test statistic, significant at the 5 percent level

Table 3b_2. Correlation of Mean Z-scores on Achievement in English and Mathematics with Other Continuous Covariates (N=1753)

Covariates	Achievement Test Mean Z-scores	
	English	Math
Residence location (urbanic83 & urbanic86)	0.1230 ***	0.0606 ***
Household's socio-economic status (assets83 & assets86)	0.3067 ***	0.2824 ***
Mothers' education	0.4109 ***	0.3247 ***
Environmental Cleanliness (hygiene83 & hygiene86)	0.2610 ***	0.2038 ***

*** Significant at the 5 percent level

Multivariate Analysis

Absenteeism. Table 4 presents unadjusted and adjusted relative risk ratios associated with the different types and frequencies of illness. Results are presented separately for health related and non-health related absences, which in each case, are compared to no absences.

Results are quite consistent across the types of illness. The likelihood of health-related absences was significantly increased among children who experienced a greater frequency of illness in the first 2 years of life. Results were generally stronger for diarrhea than for respiratory illnesses. There was very little attenuation of the associations when a wide range of potential confounders was taken into account. The crude and adjusted models demonstrate a dose response. Adjusting for confounders, there was a 61% increase in the likelihood of health-related school absences in those with 1-3 diarrhea episodes in early childhood, and a 74% increase in those with more than 3 episodes.

The characteristics of the selective sample children (n=1760) are shown in Table 2. There are more males in the sample than their female counterparts. Already in their pre-teens, the cohorts are 11 years old on average and majority of them are on the 4th and 5th elementary levels. School absenteeism in late childhood was more often attributed to health than to non-health reasons. Nearly twenty-five percent incurred absences for reasons that pertain to health.

Stunting is highly prevalent in the sample (six out of ten children had a length for age Z-score below -2 at 2 years of age). Only 16% of children had experienced no episodes of diarrhea in the weeks assessed by the survey. Cough was a common experience among the children, with nearly fifty-seven percent having cough at nearly all of the 12 bimonthly visits. Simultaneous occurrence of both diarrhea and cough is also observed.

Table 2. Selected Characteristics of the Sample Children in the Analysis

Characteristics	*N (%)*	*Mean / SD*
Mean age in years	-	11.01 ± 0.48
Gender		
Male	926 (52.61)	-
Female	834 (47.39)	-
Grade enrolled in 1994		
Grade 1	37 (2.10)	-
Grade 2	82 (4.66)	-
Grade 3	199 (11.31)	-
Grade 4	723 (41.08)	-
Grade 5	703 (39.94)	-
Grade 6	16 (0.91)	-
School attendance		
Never absent	1034 (58.75)	-
Absent due to health reasons	435 (24.72)	-
Absent due to non-health reasons	291 (16.53)	-
English proficiency z_scores[1]	-	0.2291 ± 0.973
Math proficiency z-scores[1]	-	0.2792 ± 0.989
Birth weight, *g* [2]	-	3011.41 ± 419.94
Birth length, *cm* [3]	-	49.12 ± 2.03
Stunted at 24 months old (based on WHO definition)	1093 (62.10)	-
Diarrhea		
No reported diarrhea	281 (15.97)	-
Diarrhea (1 to 3 episodes)	1094 (62.16)	-
Diarrhea (>3 episodes)	385 (21.88)	-
Respiratory		
Cough (8 times or <)	760 (43.18)	-
Cough (>8 times)	1000 (56.82)	-
Diarrhea & respiratory occurring simultaneously		
Not occurring simultaneously	415 (23.58)	-
Simultaneously occurring (1 to 2 times)	842 (47.84)	-
Simultaneously occurring (3 times or more)	503 (28.58)	-

Values of: [1]n=1753, [2]n=1733, [3]n=1758

Bivariate Analysis

Table 3a presents frequency of illness episodes and other child characteristics by categories of absenteeism. Children experiencing more than three diarrhea episodes, more frequent cough, and simultaneous occurrence of diarrhea and cough of three times or more during the first two years of life have greater propensity to be absent either due to health or non-health reasons.

Boys appear to have more absences than girls. School absenteeism is mostly health-related for both sexes but boys' absence due to non-health reasons is comparably higher than that of girls. Among girls, health-related absence is more predominant than absence due to non-health reasons. Rural children, children from low income families, and children exposed to more crowded households exhibit greater tendencies of absenteeism. More prominent reason for absent is health-related. However, children whose mothers have college education are observed to be absent less often.

Table 3a_1. Percent Distribution of Absenteeism by Morbidity in the First Two Years of Life and Other Categorical Covariates (N=1760)

Morbidity variables and other covariates	*Absenteeism* No Absence	Health-related absence	Non-health related absence	N
Diarrhea*				
No diarrhea	65.48	17.08	17.44	281
Diarrhea (1 to 3 episodes)	58.68	25.87	15.45	1094
Diarrhea (> 3 episodes)	54.03	27.01	18.96	385
Respiratory*				
Cough (8 times or less)	64.74	20.39	14.87	760
Cough (>8 times)	54.20	28.00	17.80	1000
Diarrhea & Respiratory occurring simultaneously*				
Not occurring simultaneously	62.65	21.20	16.14	415
Simultaneously occurring (1 to 2 times)	60.10	25.18	14.73	842
Simultaneously occurring (3 times or more)	53.28)	26.84	19.88	503
Gender*				
Males	54.10	25.81	20.09	926
Females	63.91	23.50	12.59	834
Household crowding (persons/room)*				
Less crowded	63.89	22.44	13.67	900
More crowded	53.37	27.09	19.53	860

* Significant associations at the 5 percent level

Table 3a_2. Mean (Standard Deviation) Distribution of Absenteeism by Continuous Covariates (N=1760)

Covariates	*Absenteeism* No Absence	Health-related absence	Non-health related absence
Residence location (urbanic83 & urbanic86)	27.97 (12.79)	29.8 (12.85)	27.99 (13.33)
Household's socio-economic status (assets83 & assets86)	2.74 (1.97)	2.54 (1.79)	2.32 (1.59)
Mothers' education	7.27 (3.47)	6.97 (3.00)	6.10 (2.86)
Environmental cleanliness (hygiene83 & hygiene86)	5.53 (1.91)	5.33 (1.77)	4.95 (1.81)
N	*1034*	*435*	*291*

Table 3b presents mean standardized scores on English and Math achievement tests according to levels of exposures and other covariates. Analysis of variance was used to determine whether there were trends across categories, and Bonferroni tests were used to further compare means when there are more than 2 categories of exposure. Children who had one to three episodes of diarrhea compared with no diarrhea, attained lower scores in English, but the magnitude of the association is not significant. Conversely, children afflicted with more than three diarrhea episodes compared to the two groups: children with no diarrhea and those with one to three episodes, significantly scored lower in English. Similarly, more frequent episodes of diarrhea yielded the same negative effects in the mean Z-scores in Math (Bonferroni p=0.000).

Children who experienced frequent respiratory illness (greater than eight times) had significantly lower mean Z-scores in both subjects compared with those who had fewer cough episodes. A higher frequency of simultaneous occurrence of diarrhea and cough, and a higher combined morbidity experience were both significantly associated with lower scores.

Table 3b also shows that males, and children who resided in more crowded households and in poorly sanitized environments scored significantly lower in both subjects. Urban children as well as those who belong to the upper third of income and assets scored better than their counterparts. Comparisons of the Z-scores among the different levels of maternal education show that children with mothers who obtained a high school education scored better than children whose mothers finished elementary. Most revealing are children with college-educated mothers. Their mean Z-scores in both English and Mathematics increased by more than one standard deviation (Bonferroni p=0.000) compared to those children with some elementary education.