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Community-Level Determinants of Child Growth

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Community-Level Determinants of Child Growth

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Abstract

Objectives: The paper presents the results of an ecological-economic approach to identifying community-level factors that influence the physical growth of young children.
Design: A cross-sectional design was used to obtain both the anthropometry and the ecological-economic data.
Setting: The sites were 24 communities located in a tea plantation near Bandung, West Java, Indonesia.
Subjects: 415 children between the ages of 6 and 18 months living in the 24 communities.
Methods: Epidemiological and ethnographic methods were used to measure community infrastructure and services related to child growth. Anthropometry was used to measure child growth. Econometric methods, including probit and ordinary least squares regression, were used to analyze the effect of community-level factors on child growth.
Results: Community vaccination programs, child care services, environmental sanitation and latrines were associated with better child growth. We concluded that community-level goods and services substantially contributed to health in early childhood.

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INTRODUCTION

Children are highly responsive to conditions in their environments, particularly during the early stages of physical development. Numerous studies have sought to identify biological and sociocultural determinants of child growth, hoping to inform policy and childrearing practices. Still, despite the many studies of child nutrition in rural areas of lower income countries, little is known about the contributions of community-level services and infrastructure to growth in early childhood. This study analyzes the relationship between the physical growth of young children and the quality of the communities they live in. In 24 Indonesian plantation communities, we measured child weight and height together with a comprehensive set of community-level factors to determine if the latter have an impact on child growth.

Nutrition studies have focused on family or household-level determinants under the presumption that factors in a child's immediate environment are likely to have the greatest impact on growth. Behrman (1995), for example, states that, "it can fairly be said that the household probably plays the major proximate role in determining the preschool child's health and nutrition." While we generally agree, we hypothesize that community-level factors such as infrastructure and services are an integral part of the environment in which children are raised and therefore also affect physical growth. Indeed, the community is the natural social unit through which investments in child health can be made (Oakley, 1989, and Morgan, 1993).

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A few studies have identified the contribution of community factors to child development. Using macro-level data sets, Edmonston and Andes (1983) analyzed national Peruvian Fertility Survey data and found statistical associations between infant mortality and female education, medical facilities and altitude. Holian (1988) conducted similar analyses using Mexican Fertility Survey data and found that infant mortality was associated with community population size, percentages of labor force in agriculture, distance to markets, urban areas, and medical facilities, percentages of electrification, piped water and sewers. In a localized study, de Meer, Bergman, Kusner and Voorhoeve (1993) compared five rural highland communities in Peru and found that children living in communities with more croplands and higher percentages of protected wells grew better. Andes (1989) ethnographically compared two Peruvian villages with different infant mortality rates and identified differences in community-level factors in the local economy, occupational make up, social service programs, water and sanitation. Wibowo and Tisdell (1993) used communities as the unit of analysis to predict morbidity in Central Java and found sanitation to be a stronger correlate than safe water supply.

Clinical nutritionists have long recognized that nutritional status is determined by disease as well as food consumption (Scrimshaw, et al., 1968; and Martonell, 1980). Several economic studies have analyzed the effect of disease on child growth (Thomas, et al., 1991; and Strauss, 1990). Most of these studies have also emphasized the important role of the community in mitigating childhood infections. For example, Alderman and Garcia (1993) found that the prevalence of infectious disease was a more important determinant of child health than household income in rural Pakistan and argues that community services are critical in the control of disease.

Previous studies (Alderman and Garcia, 1993, Cebu Study Team, 1991; Adair et al, 1993; Ricci and Becker, 1996) have relied on household-level data to determine the effects of community-level infrastructure and services. For example, Alderman and Garcia (1993) measured the effects of community infrastructure and services indirectly in a two stage process. They first used regression analysis to instrument variables such as "the average number days of diarrhea in past two weeks experienced by children in a particular community," where the outcome, diarrhea, is related to community factors such as "the average number of residents having access to a clean and potable tab water supply." The instrumented variables are then included as right hand side variables in a second-stage regression determining nutritional status. If the instrumented variables are significant,

they are interpreted as representing differences across communities insofar as the probability of diarrhea is explained only by community factors. The main disadvantage of using (aggregated) household data to characterize community factors, however, is that one generally cannot determine the quality of the infrastructure and services used. Thus, in the regression analysis it is impossible to relate the quality of community factors to child growth.

In this study, we have taken a direct approach to measuring community-level factors. We measured both the availability and quality of community infrastructure and services and included these measures in regressions to determine whether differences in such factors across communities influence the observed pattern of child growth. For example, we calculated annual child immunization rates in each community and used this measure as an indicator of program quality rather than making inferences from household data. Similarly, we measured day care center quality using multifactoral scales rather than relying on household reporting to note the presence of a community day care center. Despite the outward appearance of homogeneous conditions in the 24 communities studied, we have identified marked differences in community infrastructure and services, and demonstrate that these factors contribute significantly to explaining observed differences across communities in the patterns of early childhood growth.

SUBJECTS AND METHODS

Research location

All data collection procedures used in this study were reviewed by the Committee for Human Research at the University of California, Davis and the National Research Council of Indonesia. We conducted this study in 24 communities located within an Indonesian state-owned tea plantation due south of Pengalengan, West Java. Researchers from the Early Supplementary Feeding Study (ESFS) selected these communities to study child growth because three previous studies indicated that children living in this plantation were nutritionally at risk (Soewondo, Husaina and Pollitt, 1989; Husaina, et al, 1991; and Idjradinata, Watkins and Pollitt, 1994).

The communities were physically and administratively situated within six plantations on one estate. Based on outward appearances, the ESFS team believed that living conditions were homogeneous throughout the plantation and that child growth did not vary significantly between the communities. However, analysis of

anthropometric data collected in a pilot survey revealed striking differences between communities in the prevalence of sub-optimal growth. This analysis generated a new hypothesis to be tested: was growth in early childhood associated with community level factors?

To analyze potential associations between child growth and community-level factors, we first identified distinct communities for study, measured children, and then selected a set of community-level variables theoretically related to child growth that were measurable in each community. For the purposes of this study, the communities were selected using three criteria: 1) the community was locally recognized as such within a social network, 2) the community occupied a distinct, contiguous geographic space, 3) the community had sufficient numbers of children ages 6 to 18 months old permanently residing therein to statistically analyze potential associations between environmental factors and child growth. A sample of 24 out of 34 possible plantation communities was included in the study. Ten communities were not included because they each had less than 10 children within the specified age range.

These plantation communities offered an unusual setting within which to study community-level factors because the communities were geographically and socially distinct yet located within the same socioeconomic and environmental context. Anthropological interviews and observation methods were used to develop sociocultural and historical profiles of the communities. Demographic methods were used to compile quantitative socioeconomic data from plantation records. Because we were fortunate to have access to plantation records, we were able to focus more energy on the logistical challenges of transporting personnel and equipment between communities scattered throughout the rugged, rain-soaked terrain of a fertile volcanic range.

Community life and historical context

These tea plantation communities were established in the late 1800s and administered by Dutch colonials. In the late 1950s, Indonesian government nationalized the 12,800 hectare plantation, and control of the villages, *emplasemen* as the Dutch called them, was transferred to a state-owned tea corporation. The villages were located amidst a carpet of tea bushes on slopes and ravines from elevations of 1,800 meters to 1,400 meters. The colonial administrators established the *emplacemen* 15-20 km apart to distribute labor throughout the plantation.

All villages were neatly laid out on grids and housed plantation workers and their families in whitewashed bamboo and wooden structures. At the time of this study, the plantation employed approximately 9,500 workers. Unlike most communities on the island of Java, these 34 villages were geographically distinct and small with populations ranging from 272 to 2,399 inhabitants, averaging 1,047.

Permission to reside in the communities was regulated by the plantation administration, just as residency was regulated by local authorities throughout Indonesia. Most households were made up of nuclear families averaging 4.2 residents and seldom with more than two children; although extended family resided in some households.

Ethnically and culturally, these communities were homogeneous. Nearly all community members were ethnic Sundanese who adhered to traditional Sundanese customs and Moslem rituals. Plantation records showed that these plantation communities experienced little in-migration though some younger residents moved to cities in pursuit of schooling or employment. Our observations of plantation life and daily communal activities of work, volunteerism, and recreation, showed that each community was bound together as a social unit through strong economic and kinship bonds.

The plantation owned and maintained all physical structures and provided many basic social services. Housing and access to plantation-operated social services were guaranteed through a social contract with workers along with wages and other benefits. Housing and community facilities such as stores, schools, day care centers, health clinics, mosques and recreation halls were provided to workers and their dependents, as were electricity, water, public toilets and bathing facilities.

Sample and growth measures

We chose to study the growth performance of children ages 6 to 18 months because pediatric nutrition studies have demonstrated that the "weaning period" is perhaps the most critical phase of physical growth (Brown, Dewey and Pollitt, 1993). These upper and lower age limits were defined by the study inclusion

criteria of the ESFS. In the first week of January 1993, trained field staff working in the ESFS conducted anthropometric surveys in 24 plantation communities. Parents were asked to bring their children to the monthly growth monitoring program operated by the government-sponsored community services organization, the *posyandu* (the facility in which the *posyandu* staff work is also known as the *posyandu).* Based on comparisons with *posyandu* participation rates prior to these surveys, we estimate that at least 80% of the 6- to 18-month-olds in each community were measured. Trained field staff followed standard anthropometric procedures to measure the weight and recumbent length of each child (Jelliffe, 1966).

A total of 415 children participated from the 24 communities, 208 boys and 207 girls. The frequency distribution of age by month in the sample was generally even, although the 18 month-old cohort contained about 20% fewer children than the others. Anthropometric observations were standardized (converted to Z scores) using EpiInfo v.5 (World Health Organization [WHO]/National Center for Health Statistics [NCHS] growth reference curves) to generate growth indexes for length-for-age (LAZ) and weight-for-length (WLZ). Cross-sectional length-for-age data have been shown to represent "long-term" linear growth performance in skeletal development that may be associated with environmental factors (Waterlow, 1988 and 1994). In contrast, cross-sectional weight-for-length data represent "short-term or current" growth performance given that weight is known to fluctuate according to recent diet, illness and recovery (Gorstein et al., 1994). These measures therefore indicated two different growth processes.

Conceptual model of child growth in a community context

Our conceptual model to studying community effects builds on the ecological foundations of Odum (1963) and Bronfenbrenner (1979 and 1989) and the social epidemiology of Syme (1992). Syme argues, "Although one can distinguish between the man-made environment, the natural environment, and the social and cultural environment, none of these aspects exists independently of the others: the environment is the result of the continuing interaction between natural and human-made components, social processes, and the relationships between individuals and groups. In spite of these interconnections, it often is useful to closely examine specific components of the whole." Bronfenbrenner (1989) proposes a similar orientation to studying associations between human development and the environment in his person-context model.

Our model considers humans as integral to their social, economic and environmental habitats. For young children, the environment is the local community within which the household exists. In terms of outcome, the model shown in conceptually departs from those proposed by Syme (1992) and Mosley and Chen (1994) by reversing the orientation from the determinants of disease and malnutrition. The model specifies community-level factors that promote growth. Limiting factors (Odom, 1963) are defined as those aspects of the community which are defective, deficient, or altogether absent.

The socio-ecological framework of child growth begins with seven basic needs (nurturing, cleaning, clean water, medico-spirit care, food, clothing and shelter) that, when met, allow children to grow at or near their genetic potential. The context responds to these child needs. At the household level, parents and other family members provide sustenance through their own material and cognitive resources. Simultaneously, the community responds collectively to child needs, often in ways that are infeasible or inefficient for individual households. Community activities are therefore either complementary or supplementary to household responses.

The model identifies high-quality day care as a cross-cutting response to all seven child needs. Sanitary public baths and latrines allow families to attend to children's needs to be cleaned and in doing so support the interactive process of nurturing. Community water treatment aids the cleaning process and supplies uncontaminated drinking water, reducing the risk of diarrhea. Effective sanitation facilities abate biological disease vectors. Health services and practitioners who provide Western medical care, traditional healing or a combination thereof respond to child medico-spirit needs with preventative interventions and attention to bouts of illness. Families work in, and benefit from, the aggregate private and cooperative agricultural and animal husbandry activities in the community. These activities respond to basic child needs by producing food and medicinal substances (e.g., herbs). Similarly, the local economy responds to children's needs for food, clothing and shelter by providing a context for exchange of goods and services that benefit households. These six factors are buttressed by the broader community-level factors of education, local knowledge and communication, which in turn exist within the broader sociocultural milieu, political-economy and natural environment.

Community-level factors

Ethnographic observation and interviews produced data which allowed us to identify community-level factors that were potentially associated with child growth. We trained four field staff from the region to assist in data collection. The staff participated in the process of refining the measures. The measures were pretested and inter-rater reliability was assessed to achieve a > 90% level of agreement.

Community-level variables were measured and coded on either continuous or rank order scales. Variables with one observation per community, i.e., elevation and immunization rates, were measured using a single value or score for the entire community. We measured variables requiring multiple observations, such as the quality of community water sources, by either sampling or by rating all items and using the community mean. Variable definitions and measurement techniques are described below for those variables which produced coefficients of variation above 10% and/or represented factors which ethnographic analysis and intuition suggested were most likely to predict growth.

Garbage: The quality of community garbage management was determined by rating common-use garbage heaps. We developed five-point scales by combining criteria regarding garbage treatment and the proximity of garbage heaps to water sources or buildings. The best quality garbage heaps were burnt and buried and located more than 10 meters from water or structures (score 5), and the worst heaps were exposed, untreated and piled less than 10 meters from water or buildings (score 1). Field staff rated all heaps in a community and scores were averaged to determine the overall community garbage score.

Day care centers: Each community had one plantation-sponsored day care center. Seventy-nine percent of the children in our sample attended these day care centers six days a week. The quality of each day care center was measured on nine factors: physical condition (humidity, sanitation, lighting, size of facility, and, crib condition) and quality of care (educational level, personal cleanliness, basic skills, and staff/child ratio). Field staff scored each element from 1 to 3. The overall score was calculated as the sum of the scores for the nine elements.

Community child health groups: *Posyandus* (facilities, staff and programs) were an integral part of Indonesian efforts to improve child health. *Posyandus* were staffed by community volunteers and served a range of

integrated functions: registration of child births and deaths, growth monitoring, pre-and post-natal counseling, family planning, child immunization, and mother-child health and nutrition education. Data were extracted from child weighing/immunization cards and *posyandu* registers. The variable used to determine participation rates was the percentage of one-year-olds immunized in the 12 months prior to the anthropometric survey.

Community primary care clinics and health posts: Clinics and health posts provided Western primary care. Prior to this study, the plantation administration had closed a number of clinics and posts and cut back staffing in others due to financial pressures, making clinics a sensitive political issue. The only available measures of clinic quality were plantation reports on staff educational levels and years of employment. Staff education data were averaged and communities that had no clinic were coded with a zero for this variable, though residents were seen at clinics in neighboring communities.

Community latrines: Nearly all residents used public latrines. Latrine quality ranged from a clean, sealed toilet, connected to a septic tank, to a squatting-place over a hole. All latrines were counted and the ratio of facilities to residents was calculated using population figures from community records.

Community water quality: Nearly all residents relied on community water sources for drinking water. These sources ranged from a steel pipe coming from a protected concrete structure to bamboo or plastic waterspouts draining surface water from a dirt bank. Community water quality was measured by sampling three equidistant public water sources that residents confirmed were used for drinking water. Specimens were collected, handled and analyzed according to the WHO protocol for water quality assessment. Community water quality was determined by counting the number of specimens that had coliform counts under 50 coli/100 ml, the WHO standard for acceptable drinking water; a community with three acceptable water sources received a score of 3.

Overall water quality at homes: The quality of water can change dramatically after collection depending on household handling and treatment practices. We collected drinking water specimens from cups and glasses at seven houses in each community. Each community was divided into seven clusters of houses within which houses were sampled randomly. Specimens were handled and rated as described above; a community in which all 7 sampled households possessed acceptable water received a score of 7.

Community class composition: Community class composition was measured by calculating the proportion of salaried administrative personnel among all plantation employees in the community. Within the plantation, social status and political influence are closely related to occupation and gender where male workers in

managerial positions hold significant sway. The vast majority of tea pickers are women. The plantation kept records of all employees using three main occupational categories: 1) administrative personnel earning monthly salaries, 2) factory and service workers earning daily wages and 3) tea pickers earning piece rate incomes.

Plantation wages earnings: Plantation records were used to estimate average monthly wages earned in a community over the previous year. For each community, average monthly wages were calculated by multiplying the number of employees in each wage category by their respective wages and taking the average. To account for seasonal variation, this index was averaged for high, medium, and low months of tea production.

Community educational levels: Formal education data were obtained from plantation records for the educational level of each worker e.g., primary, secondary; high school, and in a few cases college. Because nearly all workers have some primary schooling, average educational levels for a community were measured by calculating the percentage of plantation workers that had received some education beyond the primary level.

Agriculture and livestock: Activities other than plantation employment, including cropping and animal husbandry, provided a source of food and income in many communities. The area in crop production within a 0.5 km radius around a community was estimated and multiplied by average gross income per hectare for the region. This figure was adjusted on a per capita basis using population data. Livestock income was estimated for each community by counting goats, sheep and cows. The economic contribution of these animals was valued using local prices and adjusted to a per capita basis using community population figures.

Elevation: A community's natural environment is influenced by elevation which can determine agricultural activities and productivity. Elevation is also used as a proxy for mean temperature and relative humidity, two aspects of a community that make shelter and clothing particularly important in protecting children from exposure and risk of respiratory infection. Elevation was determined using US Army Service maps of the region.

Location: In observing what appeared to be a core-periphery dichotomy in the quality of general conditions such as roads and facility maintenance, we measured the distance by road between each community and the administrative offices for its subdistrict using maps.

RESULTS

Anthropometry

Analysis of the length-for-age data showed that children living in this plantation were quite short, though no shorter on average than other Asian populations (UNIFEC, 1995; Victoria, 1992; and Florentino and Pedro, 1992). However, Table 2 shows that 81% of the 415 children were, despite their young age, already at least slightly short for their ages when compared with the NCHS reference population (length-for-age ≤ - 1 SD). Weight-for-length data for this population showed that while few children were overly thin for their length, 26% were already slightly thin (WLZ ≤ -1 SD). The correlation between individual Z scores for the two anthropometric measures (LAZ and WLZ) is positive and significant ($r.= 0.127$, $p < 0.5$), but weak compared to those found in other studies in Asian children of roughly the same age range [(31)].

For each community, we calculated prevalence rates of ≤ -1 SD for length-for-age and ≤ -1 SD weight-for-length and found significant variations between the communities (Habicht and Pelletier, 1990). The prevalence for weight-for-length ≤ -1 SD was distributed across a range from 4% to 48%. Length was similarly distributed, but at lower prevalence rates. We could not attribute the bulk of the differences between communities to differences in the age distribution of children between communities because 21 of the 24 communities had mean ages clustered between 11.5 and 13.5 months. These results were similar to those obtained in a pilot survey and prompted us to explore the quality of social and environmental conditions in the communities.

Econometric models and results

We utilized regression analysis to determine whether community-level factors, including the provision of community-level infrastructure and services influenced child growth. Two types of dependent variables were used, 1) a dichotomous variable using Z score cutoffs to determine whether mild or more severe growth deficiency was responsive to community-level variables, 2) a continuous variable to determine if child growth was responsive across the full range of growth

outcomes. The results from the regressions using individual child measurements were then used to predict prevalence rates for each community.

Model 1: Dichotomous Outcome

Use of standardized measurements with cutoffs

In Model 1, we tested models using standardized weight-for-length and length-for-age measurements as dependent variables. These dependent variables were generated by using cutoffs to convert Z scores to dichotomous values. To explore the effect of different cutoffs on the results, we used several cutoffs, ranging from -1 SD to -3 SD. Less severe -1 cutoffs were tested because 6 to 18 months-old children are still in the early stages of development. We expected that a community's environment would exert a pervasive, but only moderate influence on child growth, particularly at this early stage of life, and therefore thought that a lower cutoff might better capture the effect of community infrastructure and service investments [(34)]. Although mild growth deficiency is unlikely to have severe consequences for an individual, mild growth deficiency in infancy often points toward a more pronounced deficiency in later years and thus ought to be of considerable concern.

Two sets of regressions were run using transformed data for 1) weight-for-length and 2) length-for-age for each child, with several different cutoffs. For example, each child was assigned a dichotomous outcome based on its Z score for weight-for-length, with adequate growth (e.g., a Z score ≥ -1 SD of the WHO/NCHS reference population) being defined as a value of 1 and deficient growth a value of 0. The probit model is an appropriate statistical technique to analyze such dichotomous outcomes (Greene, 1990). This regression model is constructed assuming that the dependent variable, y_i , has a value of 1 with probability p_i and a value of 0 with probability $(1-p_i)$, and where p_i is a function of independent variables, x_i, believed to influence the outcome. That is, $p_i = Pr(y_i = 1) = F(X'B)$, where X is a vector of the x_i and B is a vector of the respective regression coefficients, β_i. The probit model uses the standard normal cumulative density function to map $X'B$ into the (0,1) interval to ensure that $0 \leq p_i \leq 1$. The estimator is non-linear. The regressions were carried out using Econometric Views 1.1A.

The model shown in Equation 1 was specified such that each child's growth status was a function of the child's age and sex and a set of community-level variables chosen to represent the influence of community-level infrastructure, services, the community's physical site and other variables chosen to represent community-level

socio-economic conditions. The values for community-level variables were identical for all children who resided in the same community.

(1) $Pr(y_{ij} = 1) = F(X'B)$, where

$y_i = 1$ if weight-for-length or length-for-age for child i is greater than the cutoff value; otherwise 0,

B = a vector of estimated coefficients, and

X = a vector of independent variables.

The effect of a one unit change in the jth regressor on the conditional mean (or equivalently on the probability that $y_i = 1$ is

$$\partial E[y_i | X_i] / \partial X_{ij} = f(X'\beta)\ \beta_j$$

where $f(z) = \partial F(z) / \partial z$. The estimated coefficients in different probit models are not directly comparable since $f(X'\beta)$ varies with different models. However, we expect different probit models to lead to roughly similar values of $\partial E[y_i | X_i] / \partial X_i$. Note that the effect of a unit change on the conditional mean of y_i is evaluated through the standard normal cumulative density function. Thus, the estimated coefficients, β_i, show the effects of a unit change in the respective variables on the "probability" that a child suffered from low growth, as defined by the cutoff used in that regression. The independent variables were defined so that a health-promoting change in a variable was reflected in a higher score, i.e., a positive sign was expected for the estimated coefficients on the community-level variables.

Probit using weight-for-length as the dependent variable

The results of the probit regressions are shown in Table 1. In Equations 1.1-1.4, the dependent variable is a dichotomous variable using successively more severe cutoffs, i.e., -1, -1.5, -2 and -3 SD of the WHO/NCHS reference population for weight-for-length. Equations 1.5-1.8 are the analogous equations for length-for-age. The independent variables are the same in each regression.

[See Table 1]

The probit results for weight-for-length clearly support the hypothesis that communities providing better quality community infrastructure and services have fewer children that are mildly thin, i.e., ≤ -1 SD of the

WHO/NCHS reference population mean (see Equation 1.1). The large, negative and highly significant coefficient on age indicates that a child was increasingly likely to become thin as it aged, regardless of the cutoff for weight-for-length. This result is consistent with many studies that show that child growth in developing areas often begins to lag the WHO/NCHS reference population in the first few months of life. The deficit usually increases steadily over 15-24 months, though the lag in growth is often sharpest in the few months after weaning because of the pathogens thereby introduced. However, if more pathogens are introduced in some environments than others, or if curative health services can reduce the effect of pathogens, the coefficient on age may also capture the cumulatively larger effects of community-level variables as children age. As children grew and interacted more broadly in the community environment, the continuous and progressive exposure to infection may have progressively reduced their size relative to that of their WHO/NCHS reference group. In turn, communities that provided improved infrastructure and services to diminish that threat, to cure illness, or to improve nutrition might have produced an effect that was cumulatively larger as a child aged. Given that we had no information on child birthweights, we could not identify the separate effect of community influence on birthweight and subsequent child growth. However, we believe that the independent effect of birthweight on size was small by age six months.

The estimated coefficients on the community infrastructure and service variables consistently had the expected positive sign, indicating that improved community performance led to better child growth. The estimated coefficients on CGARBAGE, CDAYCARE, and %IMMUNIZE were all significant at the 10 percent level or lower. The coefficient on HHWATER was also significant and had the expected sign, while the coefficient on COMWATER was significant with the unexpected sign. The coefficients on the community-level socio-economic variables generally had the expected sign, but only %ADMIN was marginally significant. Both of the coefficients on the variables that attempted to measure the per capita level of “independent” agricultural income also had the correct sign and the coefficient on animal income was significant at the 15 percent level.

The coefficient on household water quality was consistently positive whenever it was significant, indicating that children grew better in those communities in which households consumed better quality water. Most of the

household water samples collected were of acceptable quality. No community produced more than 2 of the 7 household water samples with unacceptable coliform counts.

The coefficient on the quality of community water sources was consistently negative and significant in the weight-for-length equations, unexpectedly indicating children who lived in communities with poor water quality had better weight-for-length scores. No community produced three clean specimens from community water sources, and 21 of 24 communities produced at least 2 contaminated water samples out of 3. Only 17 out of 72 samples had acceptable water quality and the coliform count of many samples was extremely high, e.g., from 1000 to 2,400 coli/100 ml when the WHO limit is 50.

The probit model retained considerable explanatory power when the weight-for-length cutoff was raised to -1.5 SD, but the model had no explanatory power when the cutoff was raised higher. No results could be obtained for a cutoff of -3 SD because only one child in the sample was so severely thin.

Probit using length-for-age as the dependent variable

When probit regression was used to analyze the influence of community-level factors on child length-for-age, the community-level infrastructure and services seemed to have little effect at lower cut off levels. None of the independent variables other than age were significant. However, at the ≤ -3 SD cutoff level for length-for-age, the regression equation performed better. The coefficients on 11 independent variables had the expected sign and 7 were statistically significant. These results suggested that community infrastructure and services affected the probability of severe shortness.

The results also showed that male children in these Indonesian communities were not thinner than female children, relative to their WHO/NCHS reference populations, but they were relatively shorter. The coefficient on sex (female = 1) in the length-for-age equations was systematically positive and significant, indicating that female children had a higher probability of manifesting adequate growth in length.

Model 2: Continuous Outcome

Use of raw anthropometric scores as dependent variable

The results produced using a dichotomous dependent variable were potentially sensitive to the cutoff used. This was deemed a particularly serious limitation. We therefore also used the raw anthropometric measurements (the recorded weights and lengths of children) as dependent variables. The use of these continuous variables allowed us to test the hypothesis that community infrastructure and service factors influenced child growth across the entire spectrum of growth outcomes. Another advantage of using the continuous variables was that they are independent of any reference curves (De Onis and Habicht, 1996). We simply determined whether there was any difference in size and weight among children from the same population. The model tested whether the independent variables had a similar effect on child weight or length throughout the age distribution.

The hypothesis that community-level variables affected child weights progressively as children aged could be modeled using the raw weights and lengths of children as shown in Equation 2.

(2) $S_{ij} = B_{ij}e^{(a_j+b_j\log A_{ij}+\varepsilon)}$, where

S_{ij} = weight or length of child i in community j,

B_{ij} = weight or length of child i in community j at birth,

a_j = effect of community factors on rate of child growth in community j, independent of age,

b_j = effect of community factors on rate of growth of children in community j, interactive with the age of the child, and

A_{ij} = age of child i in community j,

ε = error term.

The authors developed Equation 2, based on known and hypothesized factors affecting a child's growth from birth to the time of measurement, to permit a test of the hypotheses advanced. In Equation 2, the weight or length of child i at A months of age was assumed to be a function of its size at birth (the starting point, that can vary across children) and its average growth rate since birth under the hypothesis that growth was influenced by genetics (including sex) and age, as well as by household- and community-level factors. The exponent captures

the effect of various factors on the child's growth rate: village factors a_j whose effects are independent of child age, village factors b_j that are interactive with the child's age, and the child's age itself. We used the log of age to measure the strength of the age-community variable interaction as this specification allowed the child's estimated growth rate to decrease monotonically with age. This specification approximated known growth patterns in this age range, while also allowing household and community-level factors to influence growth interactively and/or independently of age. The age-interactive specification also had intuitive appeal because it explicitly allowed a test of whether community-level factors had a cumulative influence on growth as the child aged.

Equation 2 was converted into Equation 3 by taking logs of both sides, achieving a specification that was linear in the parameters.

(3) $\log S_{ij} = \log B_{ij} + a_j + b_j \log A_i + \varepsilon'$

Assuming that the estimated parameters a_j and b_j can each be approximated by linear functions of the observed community-level variables and sex, and that the birthweight is the same for all children (we had no information on birth weights), Equation 3 becomes Equation 4:

(4) $\log S_{ij} = \log B + a_0 + a_1 x_1 + ... + b_0 \log A + b_1 x_1 \log A + ... + \varepsilon$, where

x_i = community-level factor i in community j. The j subscripts are suppressed for simplicity.

As the raw anthropometric scores were continuously distributed, Equation 4 could be estimated by using ordinary least squares (OLS). The estimated constant, c, equals $\log B + a_{0.}$.

OLS using raw weight as the dependent variable

The regression results predicting raw weights are shown as Equation 4.1 in Table 4. Several different specifications were tried to determine whether the parameters were better estimated using the community-level factors alone and/or interactive with the log of age. An L before the variable name indicates the variable is multiplied by the log of child age. When the community-level variables were included alone and interactively with age, few coefficients were significant. A plausible problem was that this specification introduced substantial structural multicollinearity. We therefore ran regressions including the community-level variables

alone and then again including these variables only in age-interactive form. In general, the results were consistently better in terms of standard statistical criteria when the community-level variables were specified interactively with child age, though the variable SEX performed better when used alone. The results suggest that the community-level variables had their primary effect in an age-interactive form. If so, the effect of birthweight on observed size at a later age is probably small, though we could not directly test this hypothesis. Community-level variables may have had an effect on birthweights even if this effect is too small to be discerned in this model. Because of the possibility of heteroskedasticity in the errors, White's method for estimating a hetereroskedastic consistent covariance matrix (White, 1980) was used for calculating standard errors. The standard errors varied hardly at all indicating a lack of heteroskedasticity, presumably because of the age-interactive specification for the independent variables.

Each of the community infrastructure and service variables except LCLINED had coefficients that were of the correct sign, but only that on LCGARBAGE was statistically significant. Because every independent variable includes a term multiplicative with the log of age, multicollinearity was a plausible reason for the high estimated standard errors on these variables. We therefore removed from the regression equation the independent variables whose coefficients had not been significant in Equation 1.1, obtaining Equation 4.2. The results were much better. The estimated coefficients on the remaining variables in Equation 4.2 were essentially the same as in Equation 4.1, but their standard errors were smaller and most of the estimated coefficients on the community-level variables, interactive with age, were now highly significant.

[See Table 2]

Two variables, L%ADMIN and LMEANWAGE, that capture broad socio-economic differences among the 24 communities, also had positive and statistically significant coefficients, suggesting that communities with a higher proportion of administrative (higher status) workers (L%ADMIN) and those with higher mean plantation wages (LMEANWAGE) had heavier children. LAGE and SEX had strong effects on child weight and their coefficients were highly significant. Female children weighed less than male children, but the model was not specified in a manner that permitted a test of whether females were thinner relative to the WHO/NCHS reference population than were males. R^2 was surprisingly high and the F statistic was highly significant. Thus,

these results also strongly support the hypothesis that better quality community infrastructure and services were associated with higher child weights throughout the child weight distribution.

OLS using raw length as the dependent variable

Although community infrastructure and service variables appeared to influence child weights fairly uniformly throughout the weight distribution, the analogous statement could not be made regarding child lengths. Contrary to the results obtained in Equation 1.8, Equations 4.3 and 4.4 explained a substantial amount of child growth, as shown by the high R^2 and F statistics, but essentially all of the explanatory power for these equations was in the constant term and the variables AGE and SEX. None of the community-level variables had a significant coefficient. This was a somewhat surprising result. The probit regressions using dichotomous indicators for adequate-inadequate child growth as the dependent variables had indicated that community infrastructure and service variables affected length-for-age in the sense that fewer children manifested severe stunting. However, the OLS results using raw length indicated that the latter was not affected by community level variables.

Community infrastructure and service variables may have had no systematic effect on raw lengths or the effect may have been hidden because of the model's specification. The effect also might be hidden because of other factors. Birth weight does not usually affect weight-for-length as much as length-for-age, and the lack of information on birth weight might preclude identification of the contemporaneous community influence on length-for-age. Community infrastructure and service variables also might have influenced child lengths, but only exerted a strong effect on children who were very short for their age, i.e., for same-aged children, community institutions may not have increased the lengths of short and tall children by an equal magnitude, though this is implicitly assumed in the specification of Equations 4.3 and 4.4.

Relative impact of the independent variables on nutritional status

In addition to variable significance, we wanted to determine the effect of the community infrastructure and service variables relative to that of age, sex and other community-level factors on child growth. One measure of the relative impact of the different variables can be obtained by multiplying the estimated coefficient, β_j, of each independent variable by its own sample standard deviation, σ_j, and comparing the absolute values of the

resulting statistics, $\beta_j\sigma_j$. The justification for this measure is as follows. As previously noted, the effects of a one unit change in the jth regressor on the probability that $y_i = 1$ is

$$\partial E[y_i | X_i]/\partial X_{ij} = f(X'\beta)\ \beta_j.$$

Since $f(X'\beta)$ is the same for all coefficients in a given equation, a comparison of the regression coefficients, β_j, yields the relative effects of a unit change in each of the jth regressors on the probability that $y_i = 1$. In turn, the standard deviation of each variable, σ_j, approximates that variable's expected degree of variation in the sample. Thus, multiplying each coefficient by its standard deviation yields an indication of the expected degree that each variable affects child growth. This statistic that can be compared across variables to obtain their relative effects.

This approach was first applied to Equation 1.1, Table 1, which predicted the probability that a child would manifest adequate weight-for-height. Statistics were calculated only for those variables whose estimated coefficients were at least marginally significant in Equation 1.1.

The results are shown in Table 3, with the variables ranked in descending order of their calculated effect. To make the comparison easier, in the last column each statistic is divided by the largest so that all are expressed in proportionate form.

As expected, AGE had the greatest effect on the dependent variable. Older children had a considerably higher probability than younger children of manifesting mild thinness. However, given that communities manifested very similar child age structures, AGE had little effect on the prevalence of inadequate growth across communities. As hypothesized, however, the community infrastructure and service variables, %IMMUNIZE, CDAYCARE, and CGARBAGE, also had important effects, occupying the second, third and fifth positions in terms of their absolute effects on child growth. Each variable had roughly half the effect of AGE. Thus, although the effects of the different variables cannot simply be added, the community infrastructure and service variables jointly had a strong effect on child growth. Indeed, given their variation across communities, they are a major reason for the observed variation in the prevalence of inadequate growth across communities. The socioeconomic variables, %ADMIN and ANINCPER, had lesser effects than the infrastructure and service

variables, but the magnitudes of these effects were still important. HHWATER ranked fourth in magnitude of effect among all variables, despite its relatively small variation across communities. COMWATER, another community infrastructure variable, had a negative and lesser, but still significant effect.

(See Table 3)

Similar results were obtained when we used this approach to analyze the effects of variables included in Equation 4.2, Table 2, which predicted child weight. See Table 4. In this regression, the log of AGE (LAGE) was used to capture the effect of aging on weights and each of the other dependent variables (except SEX) was multiplied by LAGE. The results show that AGE had the most important effect on child weight, being represented through both LAGE and also each of the other age-interactive community-level variables. Weight rose strongly with age, as expected. SEX also was important; girls weighed less than boys. However, neither LAGE nor SEX implied differences in child weights across communities. In contrast, the socioeconomic variables were important in explaining cross-community differences in child weights, as shown by the strong effects of L%ADMIN, L%EDUSECOND, and LMEANWAGE, occupying the 2nd, 4th, and 5th ranks in terms of importance. L%EDUSECOND had an unexpected negative effect that we cannot explain. It may be spurious as the coefficient was significant only in this regression. The community infrastructure and service variables, LCGARBAGE, LLATRINPC, LCDAYCARE, and L%IMMUNIZE had smaller, but also important effects on child weights. Of the explained variation in child weights across communities, the community infrastructure and service variables jointly appear to explain about half.

(See Table 4)

Lastly, the approach was applied to Equation 1.8, Table 1, which predicted the probability that a child would manifest adequate length-for-age. The results, shown in Table 5, differ in the sense that age had much less importance in the determination of extreme stunting than it had in mild thinness and, though each of a fairly broad group of community variables had some importance, community infrastructure and service variables are more important than expected. CDAYCARE had the strongest effect of any variable. The quality of child care was presumably important because young children were provided with a range of services nearly every day and also monitored by staff so that many obvious growth problems were attended. HHWATER, ANINCPER and

%IMMUNIZE also had important effects. AGE and SEX had relatively small effects, as did MEANWAGE. LATRINPC and CLINED had important effects, but these were not in the expected direction.

(See Table 5)

Prediction of low growth prevalence among communities

We also wanted to determine whether the estimated model could accurately predict the prevalence of inadequate growth across communities. To do this, we first reestimated Equation 1.1, including only those variables whose coefficients had been significant. The regression coefficients of the reestimated regression were then multiplied by the respective values of the independent variables for each community and the resulting products, along with the constant, were summed. These values were evaluated using the cumulative normal distribution to obtain the predicted probability of low growth from the equation and these probabilities are taken as representative of community prevalence rates. The mean age of children in each community was used for the value of AGE, thus allowing any (small) difference in the community age structures to help explain the observed differences in low growth prevalence. The results were very similar when a standard age, e.g., 18 months, was used as the value for AGE in evaluating Equation 1.1.

The predicted prevalence rates for inadequate growth (weight-for-length ≤ -1 SD of the WHO/NCHS reference group) corresponded closely with the actual rates for the 24 communities.. The estimated model accurately predicted community prevalence rates, again demonstrating that differences across communities in infrastructure and service variables were an important cause of the observed variance in child growth. The correlation between the predicted and observed prevalence levels was positive and strongly statistically significant when tested with a Spearman rank order correlation ($\rho = .94$, $p < .0001$).

The results were similar when a variation of Equation 1.8 was used to predict the prevalence of inadequate growth for length-for-age (≤ - 3 SD of the WHO/NCHS reference group). The actual prevalence rates varied from 0% to 26% while the predicted rates varied from 0% to 21%. Although there are several communities where the predicted rate differed significantly from the actual, the rank correlation between the observed and predicted preference rates was again very high: Spearman $r = .91$ ($p = .0001$). Thus, even in the case of more severe growth inadequacies where household idiosyncrasies might be expected to be especially important in

determining outcomes, a model relying mainly on community variables did a surprisingly good job of predicting differences in prevalence rates across communities.

Although similar models were used to explain the prevalence rates for inadequate growth for weight-for-length (-1 ≤ SD WLZ) and for length-for-age (-1 ≤ SD LAZ), the correlation between these rates was low. The Spearman rank correlation between the actual prevalence rates for weight-for-length and those for length-for-age was r = .26 (p = .22). The analogous rank correlation for predicted prevalence rates was r = .17 (p = .14). Thus, there is strong evidence that weight-for-length and length-for-age are two distinct growth processes [31, 39] and that the relationship between them was not close in these villages. Communities that had a higher proportion of children that were at least mildly thin did not, as a rule, have a higher proportion of children that were severely short. Nonetheless, the underlying model performed well. Age affected mild thinness much more than severe shortness. Child care and immunization rates were important to both, but immunization affected mild thinness relatively more while child care affected severe shortness relatively more. Community garbage affected only mild thinness. Thus, a different combination of effects predicted each of the prevalence rates rather well.

DISCUSSION

Although the contribution of environmental factors has been widely appreciated, a surprising amount of the literature discussing child growth has focused exclusively on proximate biological and household factors. The evidence presented here suggests that, within these Southeast Asian communities at least, community infrastructure and services play a substantial role in determining child growth.

The methodological approach utilized, that of carefully measuring the existence and quality of community infrastructure and services, yielded strong, plausible indication that community services contribute importantly to child growth. Each of the estimated Equations 1.1, 1.8, and 4.2 performed well using standard statistical criteria and the community-level infrastructure and service variables accounted for a large part of each equation's explanatory ability, as shown in Tables 3-5. We believe that the independent evaluation of infrastructure and service quality that was reflected in the construction of our community-level variables was essential to distinguishing between the environment in different communities. For example, all communities had day care centers, but some were much of higher quality than others and the measured differences in these centers was closely associated with child growth. The result suggests that policies designed to improve child growth should consider the existence as well as the quality of community infrastructure and services. It may seem somewhat surprising that these equations worked so well in explaining individual child growth and predicting community prevalence, even though the equations emphasized the effects of community infrastructure and services rather than household factors, but our results seem consistent with a number of other recent studies that have also identified the effects of community factors.

Our findings have limitations that should be considered. The estimated effects of community-level infrastructure and services are biased because household level factors, which are known to be important to child growth outcomes, could not be included in the regression. Given the available data set there was nothing that could be done about this. This bias may have been reduced if the community-level socioeconomic variables that were included successfully captured, at least partially, the influence of household-level consumption on child growth. To the extent that some communities were systematically more affluent and educated than others, the community-level socioeconomic variables likely picked up some of the effect of household-level differences.

Our analysis suggests that the 24 communities studied received differing degrees of support from the plantation and/or had different resources and commitment to maintain the types of services that improve the environment for child growth. In interviews, estate administrators and community leaders stated that they were aware that some communities did not have what appeared to be minimum standards for community goods and services. Administrators attributed these problems to the plantation's recent decline in profitability. They explained that the drastic decline had forced unfortunate but necessary cutbacks that had led to the deterioration of services and infrastructure. The distribution of these cutbacks had not been uniform across communities.

The results point to significant opportunities for public efforts to improve child growth status. Moderate differences in the quality of infrastructure and services were associated with differences in growth performance, suggesting that additional community-level investments could have yielded important benefits for children. Health-oriented community activities appear to have a worthwhile impact. Because the community-level factors measured are relevant to children in many places in the world, the results lead us to believe that similar community investments should be considered in other low income communities.

The importance of the community infrastructure and service variables, including the special importance of CDAYCARE in avoiding extreme stunting, was not obvious from the regression results until the effects of the independent variables were ranked. The strength of these results and their potential policy implications suggest that the ranking approach has analytical utility.

Individual-level factors

Child age measures the period during which a child has been subject to the cumulative effects of external stress (or benefit) created by community-level influences on growth. As children progress through the developmental stages, they expand their exploration and experience increasing contact with their surroundings. The importance of age revealed the frequently observed pattern in poor rural communities that growth falters during the weaning period under conditions of socioeconomic and environmental stress. This result is consistent with many studies which show that child growth in adverse environments often begins to lag the WHO/NCHS reference population after six months of age and that the deficit increases steadily over 15-24 months. Our results show that as children become older and interact with the community environment, community-level factors have cumulative benefit that is expressed across the full range of weights. The absence of certain factors over time progressively reduces the probability of children growing at adequate levels.

Although preferential treatment based on gender has been well-documented in some parts of Asia, we found no ethnographic or statistical evidence of a bias against girl children in these communities. In fact, girls were predicted to have a significantly lower probability of being severely short.

Community-level infrastructure and services

CDAYCARE was an important variable, presumably because of the range of services offered children, including a cleanly environment, clean water, nutrition, nurturing, and continual growth monitoring that identified severe problem cases for treatment. Day care centers are a vital component of economic survival and child health in these tea plantation communities. Mothers and fathers labored in the tea bushes and factories 25 days per month, being separated from their children for eight or more hours per day. To mitigate against the impact of parent-child separation, the plantation administration guaranteed community day care services for workers in each community as part of the social contract. The plantation met this obligation by providing care facilities and paying caregivers a modest wage to run the centers. Nonetheless, there were important variations in the quality of the day care centers and these variations were associated with differences in child growth across communities.

We had expected that the quality of community water sources would have an important effect on child growth performance. Water quality in rural West Java is poor (Wibowo and Tisdell, 1993). Throughout the

plantation, surface water seeps down slope and transmits fecal contaminants. These surface flows contaminate drinking water that was collected from shallow wells and "springs." The analysis of water from community water sources confirmed that drinking water was a serious environmental health risk in all 24 communities. Even if households boil (all) of their drinking water, they are not likely to boil the water they use to wash dishes and for other cleaning purposes. Children can also drink from watersources outside the household.

The coefficient on community water quality was consistently positive, as expected, but never significant in the equations for length-for-age. In contrast, the coefficient on the quality of community water source was consistently negative and significant in the weight-for-height equations, unexpectedly suggesting that worse community water quality reduced thinness. There are several plausible reasons for the latter result. We may have collected an insufficient number of samples from community water sources to adequately measure community water quality and the result could be spurious. Alternatively, that nearly all households boiled their drinking water may have substantially negated any effect of community water source. We were unable to determine whether people universally boiled water to drink tea or because health education in community-based women's groups and *posyandus* had successfully warned residents about contaminated community water sources.

Clinics and health posts provided primary medical care in most communities. In many of these communities, clinics were staffed by nurses and paraprofessionals with some post-secondary training and supervised by physicians based at estate clinics in larger communities. The marginal significance of the clinic variable could suggest that these services were not of great importance to child health. However, interviews suggested otherwise. Clinic closures had become a source of tension between the administration and communities. It is unlikely that people would have been concerned about losing these services if they were not valuable. Given that child mortality throughout the plantation was very low and that few children were severely malnourished, primary care services may have contributed substantially to controlling disease.

Community health and hygiene norms

In these communities, as throughout most of Indonesia, *posyandus* conducted preventative health activities such as immunizations, monthly baby weightings, nutrition education, and oral rehydration counseling. The

community immunization rate was an important predictor of child growth. *Posyandus* were built on the foundation of *gotong royong* - mutual self help and community participation (Balderston, Cohn and Soekirman, 1989). They were organized and maintained almost entirely by the community through volunteer action and plantation assistance. *Posyandu* volunteers maintained immunization records and encouraged mothers to follow the immunization schedule while the clinic staff were responsible for administering the vaccinations. In our estimation, levels of participation in *posyandu* activities represent a convergence of a communities' awareness and ability to support child health.

Community garbage standards are a community-level phenomenon of well-established importance to child health because biological and chemical contaminants are concentrated in physical waste and excrete. The results of our analysis show an association between community garbage disposal practices and child thinness. Children grew better in communities where residents made a collective effort to systematically burn and bury their trash in sites located far from buildings and water. In contrast, growth was limited in communities that allowed ripe garbage heaps to accumulate indiscriminately where free-ranging chickens, ducks, goats and other animals rummage. One plausible explanation for observed differences in growth is that community-based health education shaped community standards about garbage treatment.

Water quality is another important environmental factor in child growth because young children are particularly vulnerable to gastrointestinal infections caused by water-borne pathogens. Boiling water at home had a positive effect in our regression results. While women devoted considerable time and energy to boiling water, reducing their ability to satisfy other household needs, the results show considerable benefits for children.

Socioeconomic characteristics

Certain communities had higher concentrations of high status salaried male workers. Interviews and observations suggested a pattern of class stratification in the various communities
according to the clustering of occupational groups. The concentration of political and administrative influence appears to have had a sizable effect on child growth. Upper-level officials in the plantation made important decisions about resource allocations and played important roles in civic and fiscal affairs. As a group, high-

status employees earned higher wages and had more disposable income and wealth, allowing them to contribute more material resources to community-level programs.

The division of labor along gender lines was also evident in the upper levels of the occupational hierarchy. Men held nearly all higher-level salaried administrative positions. However, across the 24 communities, the proportion of male plantation employees holding administrative positions varied widely, ranging from 6% to 45%. For women, the range of plantation employees holding administrative positions ranged only from 0% to 3%. However, the wives of high status male workers, because of their own higher educational and social status, also influenced the resources available to women's groups. We observed that high-status women were primarily responsible for maintaining community-wide child health programs.

The mean wage of plantation workers was used to capture one important source of differences in community incomes. It regularly had the expected sign, and was significant in the probit regression explaining adequate growth in terms of weight-for-length and for all OLS regressions explaining both weight and also length. Thus, measured income differences had an impact on child growth. Note that the coefficient on the average plantation wage could pick up (partly) both the effect that wealthier households can provide their children with a better overall environment and also the effect that a wealthier community can bestow better services and infrastructure on its members (beyond those community factors specifically measured here).

Although only rather simple proxies could be constructed to measure the per capita "independent" agricultural income generated in each of the communities studied, the regression results suggest that income received from animals has a stronger effect on child growth than the income received from crop production. The result could stem from animal income's greater importance in these communities, but differences in mean plantation wage and salary income were not very important in these regressions, suggesting that income, per se, was not a major determinant of community prevalence. The importance of animal income also is consistent with recent findings that child growth is especially sensitive to the consumption of animal products (Brown et al., 1993; Allen, 1994; and Dagnalie and Staveren, 1994). The availability of these animal products may be more important than the income they represent.

Final considerations

Waterlow (1988) and Mosley and Chen (1994) have discussed growth as the interaction between children and their environments. They, like others, have emphasized the pivotal role the household environment plays in shaping child development. Our conceptual framework also emphasizes the importance of environment and recognizes the importance of households, but places more attention on community-level factors that promote child growth. We have asked: how much do communities matter in the early growth of children? The results of this study suggest that community-level variables can matter a lot. We have shown that apparently small differences in community-level investments in public goods and services, particularly as related to the quality of these investments, can significantly affect the health of young children.

To permit a more complete test of the effects of community-level infrastructure and services, it is important to carry out this analysis in a context where more complete data are available, e.g., on household characteristics such as education and income as well as information on maternal size and health, birthweight and birth parity. Efforts to capture other aspects of community-level influences are also warranted. More detailed studies also must be undertaken before an evaluation of the actual costs and benefits of different types of community investments can be determined.

The literature on nutrition and growth in early childhood has shifted somewhat in the last decade as studies have demonstrated that food consumption, particularly as it relates to energy intake, is relatively less important that previously thought in its effects on child growth and that disease is more important (e.g., Pinstrup-Andersen P., et al., 1995; Alderman and Garcia, 1993). This shift in view has brought about an increased emphasis on public health as part of the effort to improve child "nutrition" and growth. The evidence presented here is in keeping with this trend insofar as most of the community investments analyzed in this study have to do with preventing and curing infection. Nonetheless, the importance of the day care variable in avoiding severe stunting may reflect a larger number of causes since daycare centers provide nutrition and nurturing as well as a degree of protection from pathogens and referrals to medical treatment.

TABLE 1

Probit regressions for adequate growth: weight-for-length and length-for-age

Equation	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8
Dependent Variable	-1 SD WLZ	-1.5 SD WLZ	-2 SD WLZ	-3SD WLZ[#]	-1 SD LAZ	-1.5 SD LAZ	-2 SD LAZ	-3 SD LAZ
# w/inadequate growth	111	45	15	1	338	267	172	45
Independent Variable								
Constant	–2.30 (0.61)	–5.96 (1.02)	58.94 (1.08)	na	4.91 (1.08)	4.95 (1.23)	0.39 (0.11)	13.07 (1.35)
AGE	–0.13[a] (6.16)	–0.11[a] (4.10)	–0.06[d] (1.45)	na	–0.12[a] (5.44)	–0.10[a] (5.31)	–0.08[a] (4.53)	–0.08[a] (3.06)
SEX (F=1, M=0)	–0.03 (0.22)	–0.10 (0.54)	–0.12 (0.41)	na	0.25[d] (1.57)	0.33[b] (2.47)	0.22[c] (1.66)	0.66[a] (3.27)
CGARBAGE	0.42[b] (2.22)	0.24 (0.88)	0.54 (0.55)	na	–0.28 (1.32)	0.14 (1.00)	0.04 (0.26)	0.45 (1.00)
CDAYCARE	0.15[c] (1.90)	0.23[b] (2.00)	–0.73 (0.71)	na	–0.07 (0.81)	–0.09 (1.30)	0.05 (0.76)	(0.46)[b] (2.09)
%IMMUNIZE[1]	0.15[b] (2.02)	0.21[b] (2.04)	0.05[b] (1.97)	na	0.00 (0.16)	–0.02 (0.33)	0.05 (0.72)	0.19[d] (1.44)
CLINED[1]	–0.16 (0.75)	–0.18 (0.61)	–0.10 (0.56)	na	–0.06 (0.26)	–0.17 (0.85)	–0.02 (1.30)	–0.95[b] (2.23)
LATRINPC[2]	0.12 (0.35)	–0.27 (0.56)	1.80 (0.59)	na	0.45 (1.20)	0.34 (1.13)	0.36 (1.22)	–0.01[b] (1.89)
COMWATER	–0.30[c] (1.96)	–0.42[b] (2.17)	–1.69 (1.20)	na	0.07 (0.42)	0.07 (0.50)	0.02 (0.14)	–0.19 (1.03)
HHWATER	0.31[d] (1.90)	0.39[d] (1.63)	–1.19 (0.55)	na	–0.10 (0.52)	–0.09 (0.61)	–0.05 (0.33)	0.80[b] (1.81)
%ADMIN	4.64[d] (1.59)	0.44 (0.10)	–37.48 (1.03)	na	1.16 (0.36)	3.21 (1.23)	3.14 (1.23)	7.94 (1.36)
MEANWAGE[3]	0.15 (0.22)	1.85[d] (1.46)	17.90 (1.32)	na	–0.28 (0.32)	0.34 (0.58)	0.93[d] (1.62)	9.66[b] (2.23)
%EDUSECOND	–2.57 (0.89)	–7.22[c] (1.90)	22.09 (1.03)	na	–0.65 (0.20)	1.90 (0.71)	–0.56 (0.22)	–2.39 (0.61)
AGINCPER[3]	0.18 (0.68)	1.34 (0.34)	28.49 (1.41)	na	–0.88 (0.32)	0.35 (0.15)	–1.71 (0.74)	0.94 (0.18)
ANINCPER[3]	0.98[d] (1.45)	0.70 (0.64)	–8.43 (0.95)	na	–1.25[d] (1.53)	–0.83 (1.35)	0.50 (0.83)	3.53[d] (1.53)
ELEV[3]	–0.25 (0.13)	2.27 (0.86)	31.35 (1.44)	na	–1.80 (0.87)	–2.28 (1.37)	–0.42 (0.26)	1.34 (0.39)
DISTAN[2]	0.62 (0.23)	–4.65 (1.27)	–62.17 (1.36)	na	–1.08 (0.35)	–3.42 (1.29)	–5.24[b] (2.04)	2.85 (0.55)
Log Likelihood	203.08	120.57	47.82	na	176.44	244.86	256.08	119.80

[#] No results were obtained as there was only one child with -3SD WLZ.

1. The regression coefficient is multiplied by 10 to obtain a value that can be concisely displayed in the table.
2. The regression coefficient is multiplied by 100 to obtain a value that can be concisely displayed in the table.
3. The regression coefficient is multiplied by 1000 to obtain a value that can be concisely displayed in the table.

a. Significant at 1%
b. Significant at 5%
c. Significant at 10%
d. Significant at 15%

TABLE 2

OLS regressions for weight and length

Equation	4.1	4.2	4.3	4.4
Dependent Variable	Log(weight)	Log(weight)	Log(length)	Log(length)
Independent Variable				
Constant	1.32[a] (4.34)	1.33[a] (5.66)	3.89[a] (34.45)	3.93[a] (44.99)
LAGE	0.30[a] (4.07)	0.23[a] (12.24)	0.17[a] (6.33)	0.15[a] (20.79)
SEX[1]	–0.62[a] (5.94)	–0.61[a] (5.97)	–0.14[a] (3.70)	–0.14[a] (3.78)
LCGARBAGE[1]	0.52[b] (2.31)	0.61[a] (3.07)	–0.02 (0.33)	–0.00 (0.31)
LCDAYCARE[1]	0.40 (1.39)	0.54[b] (2.29)	–0.02 (0.21)	0.01 (0.14)
L%IMMUNIZE[1]	0.49 (1.33)	0.38 (1.33)	0.02 (0.13)	–0.05 (0.47)
LCLINED[3]	–0.54 (0.88)		–0.25 (1.09)	
LCOMWATER[3]	0.83 (0.20)		–0.36 (0.23)	
LLATRINPC[3]	0.12 (1.25)	0.16[b] (2.36)	0.27 (0.73)	0.21[b] (2.02)
LHHWATER[1]	0.12 (0.17)	0.28 (0.53)	–0.03 (0.13)	–0.04 (0.19)
L%ADMIN[1]	0.49[b] (2.47)	0.58[a] (4.60)	0.04 (0.50)	0.10[b] (2.12)
LMEANWAGE[3]	0.045[b] (2.47)	0.043[b] (3.08)	0.10 (1.54)	0.08[d] (1.46)
L%EDUSECOND[1]	–0.86 (1.06)	–1.23[b] (2.55)	0.16 (0.53)	0.02 (0.12)
LAGINCPER[4]	–0.79 (0.11)		–0.54 (0.20)	
LANINCPE[3]	–0.21 (1.10)		–0.05 (0.71)	
LELEV[3]	–0.37 (0.77)		–0.13 (0.75)	
LDISTAN[3]	–0.27 (0.30)		–0.35 (1.09)	
Adjusted R^2	0.419	0.424	0.633	0.620
Durbin Watson	1.86	1.86	1.85	1.84

An L at the beginning of the variable name implies that the independent variable with the root name has been multiplied by the log of the child's age.

1. The regression coefficient is multiplied by 10 to obtain a value that can be concisely displayed in the table.
2. The regression coefficient is multiplied by 100 to obtain a value that can be concisely displayed in the table.
3. The regression coefficient is multiplied by 1000 to obtain a value that can be concisely displayed in the table.
4. The regression coefficient is multiplied by 100,000 to obtain a value that can be concisely displayed in the table.

a. Significant at 1%
b. Significant at 5%
c. Significant at 10%
d. Significant at 15%

TABLE 3

Relative effect of independent variables on probability of adequate weight-for- height

(From Equation 1.1, Table 3)

Independent Variable	col 1. Coefficient	col 2. Std. Deviation	col 3. Coefficient*S.D. (absolute value)	col 4. Relative Effect On Growth
AGE	-0.131	3.62	0.47	1.00
%IMMUNIZE	0.015	18.76	0.28	0.59
CDAYCARE	0.150	1.76	0.26	0.56
HHWATER	0.311	0.80	0.25	0.52
%ADMIN	4.640	0.05	0.23	0.45
CGARBAGE	0.421	0.51	0.21	0.44
COMWATER	-0.302	0.66	0.20	0.43
ANINCPER	0.001	179.00	0.18	0.37

The relative effects shown in Col 4. are obtained by dividing each of the values in Col 3. by 0.47, the largest value.

TABLE 4

Relative effect of independent variables on child weight

(From Equation 2.2, Table 4)

Independent Variable	col 1. Coefficient	col 2. Std. Deviation	col 3. Coefficient*S.D. (absolute value)	col. 4. Relative Effect On Growth
LAGE	0.2310	0.31	0.072	1.00
L%ADMIN	0.0580	0.55	0.032	0.44
SEX	-0.6100	0.50	0.031	0.42
L%EDUSECOND	-0.1230	0.15	0.018	0.25
LMEANWAGE	0.0000	398.00	0.017	0.24
LCGARBAGE	0.0610	0.27	0.017	0.23
LLATRINPC	0.0002	96.00	0.016	0.22
LCDAYCARE	0.0540	0.28	0.015	0.21
L%IMMUNIZE	0.0380	0.28	0.011	0.15

The relative effects shown in col 4. are calculated by dividing each of the values in col 3. by 0.072, the largest value.

TABLE 5

Relative effect of independent variables on child length-for-age

(From Equation 1.8, Table 3)

Independent Variable	col 1. Coefficient	col 2. Std. Deviation	col 3. Coefficient*S.D. (absolute value)	col 4. Relative Effect On Growth
CDAYCARE	0/464	1.76	0.84	1.00
HHWATER	0.804	0.79	0.64	0.76
ANINCPER	0.004	179.00	0.63	0.76
LATRINPC	-0.012	35.80	0.43	0.51
CLINED	-0.095	4.50	0.43	0.51
%IMMUNIZE	0.019	18.80	0.36	0.43
SEX	0.657	0.50	0.33	0.39
AGE	-0.079	3.62	0.29	0.34
MEANWAGE	0.010	19.40	0.19	0.22

The relative effects shown in col 4. are calculated by dividing each of the values in col 3. by 0.84, the largest value.

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Abstract

The present study uses a socioecological-economic approach to identify community-level factors that influence the physical growth of young children. A multidisciplinary team of investigators collaborated to study the different prevalence rates of low growth among children living in 24 communities located in a tea plantation near Bandung, West Java, Indonesia. Measurements of weight and length were taken for 415 children between the ages of 6 and 18 months. Low growth prevalence rates were determined by calculating the number of children in each community who fell below two anthropometric cutoffs. Epidemiological and ethnographic methods were used to measure community infrastructure and services related to child growth. The principal finding is that a probit model using community-level variables successfully predicted the prevalence rates of low growth across communities. Quality community vaccination programs, child care services, environmental sanitation and latrines are associated with better child growth. The quantitative and qualitative evidence strongly suggests that community-level goods and services contribute substantially to health in early childhood.