THE DETERMINANTS OF CHILD HEALTH AND NUTRITION: A META-ANALYSIS

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1. INTRODUCTION

The reduction of infant and child death is one of the eight Millennium Development Goals (MDGs). In addition, one of the Goal 1 indicators is child malnutrition (Table 1). A central question for the development community is thus to understand the factors underlying child health and nutritional status. What are the determinants of these indicators, which of these determinants are amenable to policy intervention and which are the most effective channels for influencing health and nutrition outcomes?

Table 1 Child health and nutrition in the Millennium Development Goals

Goal	Target	Indicators
Goal 1: Eradicate extreme poverty and hunger	Target 2: Halve, between 1990 and 2015, the proportion of people who suffer from hunger	Prevalence of underweight in children (under five years of age) Proportion of population below minimum level of dietary energy consumption
Goal 4: Reduce child mortality	Target 5: Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate	Under-five mortality rate Infant mortality rate Proportion of one-year-old children immunized against measles

Many regression-based studies have been carried out to analyze these determinants. The earliest such studies were carried out using cross-country data (e.g. Rodgers, 1979). However, as described in section 2, models of child health and nutrition ascribe a central role to child and household characteristics, which are lost in the aggregation to national level. Potentially more insightful is analysis using data collected from household surveys which can include such variables. Many such studies have been published with both the increased availability of household data, in particular from the Demographic Health Survey (DHS)[1] and the Living Standards Measurement Survey (LSMS), and the computer power to analyze large data sets.

[*] Contact: hwhite@worldbank.org. The authors are grateful to Osvaldo Feinstein for comments on an earlier draft. However, the views expressed here are those of the authors alone, and cannot be taken as the opinion of the World Bank.

[1] DHS was preceded by the World Fertility Survey in the 1970s and Contraceptive Prevalence Survey in the early 1980s. These data did not produce the volume of papers generated by DHS data, presumably on account of the relative lack of computer power. These days a household survey can be downloaded from the internet or obtained on CD, usually in a form ready for analysis with one of the most common statistical packages (SPSS or Stata).

This paper summarizes the conclusions from these statistical studies of the determinants of child health (infant and child mortality) and nutritional status. We restrict our attention to papers utilizing household survey data given the ability of such studies to comprehensively model these determinants. The results from the various studies are combined using meta-analysis, which calculates the statistical significance of a variable included in more than one study by combining the results of those studies.

We begin in Part 2 with a brief review of theory to introduce the relevant variables and their classification. Part 3 discusses data and variable definition and econometric issues, including the use of meta-analysis. The results are presented in Part 4 and part 5 concludes. Annexes provide more details of the studies reviewed in this paper.

2. THEORETICAL PERSPECTIVES ON THE DETERMINANTS CHILD HEALTH AND MORTALITY

2.1 Mosley-Chen and UNICEF frameworks

Social scientists analyzing mortality frequently use the Mosley-Chen (1984) framework, whilst UNICEF's framework is well-established for nutritional analysis (UNICEF, 1990). Economists are sometimes the exception, drawing on a mathematical model of the household (see section 2.2). All these approaches have common elements. The main two points are that:

1. There are both immediate causes of poor health and nutrition, such as lack of food, low utilization of health facilities or the poor quality of those facilities, and underlying factors which affect these immediate causes, such as family income and education status and cultural factors (encompassing what economists call tastes or preferences) which may result in gender biases in the allocation of household resources. Some variables may mediate between underlying and immediate causes; for example, mother's education can affect the impact of clean water on child health and nutrition (possibly reducing it, since educated mothers will know to boil dirty water when that is the only available source, though it may increase if more educated mothers know to make the effort required to access clean water which may only be available with some effort).[2]

2. The determinants can be classified as child-specific, household characteristics and community characteristics. An alternative classification may call the first of these biological, the second socio-economic status (SES), and the third relating to service provision, environmental quality and possibly cultural factors, though the last of these may also fall under household characteristics. When community level data are not available for service provision and environmental quality and the like then geographical dummies (rural/urban or by region/province or even for each survey

[2] To use an economist's terminology, the various inputs are either substitutes or complements in the production of welfare outcomes. If inputs X_1 and X_2 are complements in the production of welfare outcome W, then the effect of increasing X_1 on W will be greater the higher the level of X_2. If they are substitutes then X_2 can play the role of X_1 so the effect of increasing X_1 is not so great when X_2 is also present. In a regression model these effects are captured by including an interactive term ($X_1 * X_2$, in addition to the separate regressors, X_1 and X_2). The coefficient on this term will be positive where the inputs are complements and negative where there are substitutes. To use a concrete example, studies of child nutrition have found that female education substitutes for income (Maxwell et al., 2000 and World Bank, 2004).

cluster) often serve to pick up these factors.[3] Such dummies are generally significant, but of limited policy relevance since we would like to know what it is about different areas that is explaining differences in child health and nutrition.

2.2 An economic perspective: household utility maximization:

Household models have their provenance in the human capital analysis of Becker (1981). The model presented here is adapted from Currie (2000). In these models the household maximizes utility:

$$U \;=\; U\{\; NF_{it}\,, L_{it}\,,\; H_{it}[N(F_{it},....),\; HEXP_{it}\;,\; HTIME_{it}....]\;\} \qquad (1)$$

where U is household utility, NF consumption of non-food and non-health items, L leisure, H health status, N nutritional status and F food consumption. The i subscript denotes person i in the household and t time. Utility maximization is inter-temporal, but the time subscripts can be dropped with no loss of generality. HEXP is the amount spent on healthcare for (not by) individual i and HTIME the time household members devote to the healthcare for that individual. N enters the utility function indirectly as a determinant of health status. It might be thought to also affect utility directly but changing the specification in this way would not alter the list of variables in the argument of the utility function.

The household maximizes utility subject to the total labor constraint, any unearned income and the behavioral health and nutrition production functions. These functions can be more fully specified as:

$$H = H[(H_{t-1}\,,\; N,\; HEXP(Y, PH, C, ACCESS)\;,\; HTIME(C, MED), ENV, MED....] \quad (2)$$

where H_{t-1} is health status in the previous period, Y household income per capita, PH the price of health services and products, C a vector of child characteristics (sex, age, birth order etc.), ACCESS a measure of the availability of health services, MED maternal education and ENV a vector of environmental risk factors faced by the child (pollution, both internal and external, availability of clean drinking water, living in a hazardous environment etc.).

$$N \;=\; H[F(Y, PF, PROD,...), N_{t-1}\,,\; H,\; C,\; MED....] \qquad (3)$$

where PF is the price of food and PROD the value of agricultural production by the household. Manipulation of (2) and (3) yields:

$$H\ and\ N = \;\; F(H_{t-1}\,,\; N_{t-1,}\; Y, PROD,\; PH, PF,\; C, ACCESS, MED,\; ENV) \qquad (4)$$

However, these are not reduced form equations, since income (Y) is determined by the labor allocation decision in the solution to the utility maximization problem; i.e. H, N and Y are simultaneously determined. As discussed below, income needs to either dropped or instrumented

[3] Some argue these dummies are inappropriate since the choice of household location is endogenously determined together with the nutrition status of children, because for example parents with sick children would move closer to healthcare facilities. This argument probably overstates the mobility of most households. Income and education, on the other hand, may well determine the area in which a family lives, reducing the statistical significance of these variables on account of multicollinearity.

for in estimating the health and nutrition equations implied by equation (3). It can readily be seen that, in common with the approach adopted by other social scientists, these equations contain each of child, household and community characteristics.

3. ECONOMETRIC ANALYSIS

3.1 Definition of dependent variable and data availability

Infant and child mortality

Infant mortality is defined as death during the first year of life and child mortality as that between the first and fifth birthdays. In child-level analysis the variable is necessarily dichotomous (usually 0 for survival and 1 for dying in the given age range) so that probit or logistic regression appears appropriate. A problem with this approach is that children not fully exposed to the risk of death have to be dropped from the sample, for example children aged less than a year cannot be included in the analysis of infant mortality. More recent papers use a hazards model, for which the full sample can be used as the estimation takes account of the censoring for those children not fully exposed. If the mother rather than the child is the unit of analysis then a "mortality rate" for the mother can be calculated, which may be treated as a continuous variable and OLS used for estimation.[4] However, child-specific analysis is to be preferred since it allows for the inclusion of child-specific factors.

Mortality data are collected from birth histories in household questionnaires. In the case of demographic health surveys (DHS) such histories are collected from all women aged 15-55.[5] The birth history records all births and some basic information on the child, such as sex and date of birth. More detailed questions are usually asked about a smaller range of children. For example, DHS surveys gather information on childrearing (breast feeding etc.), immunization status and anthropometric measurement for child under five years old (i.e. up to 60 months). If these data are not collected for children who have died (which of course the anthropometric data at least will not be) then clearly these missing variables cannot be used in the analysis of mortality.

Mortality also creates a sample selection problem for studies of nutrition, since only children still living are included in the analysis. These children are not an unbiased sample, since children who have died are likely to have been, on average, less well nourished than those who survive. Such problems of sample selection can be handled by the Heckmann procedure of first estimating a selection equation, in this case a mortality equation, and using the results to generate a sample selection correction term in the nutrition equation. However, none of the studies reviewed adopted this approach.

Child nutritional status

Data on children's consumption of calories and micronutrients are typically not available.[6] Hence empirical work typically utilizes anthropometric measures of child nutritional status based on

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[4] Or 2SLS if allowing for the endogeneity of income.

[5] Just over one-third of the thirty-eight studies analyzing mortality which are reviewed in this paper use DHS data. Six more use the similar family health surveys for India and Malaysia and one more WFS.

[6] There are some exceptions. Blocks (2002) has data on child hemoglobin concentration. Alderman and Garcia (1994) use per capita calories, protein and vitamin A consumption. Brown et al. (1994), Johnson and Lorge Rogers (1993) and Ruel et al. (1999) include calorie availability in their analysis.

measurements of height and weight combined with the child's age. Three such measures are commonly: height for age (HFA, stunting), weight for height (WFH, wasting) and height for weight (HFW, malnutrition). Low height for age is a cumulative indicator of past and present nutritional deficiencies and therefore a good measure of long-run social conditions. Wasting in contrast reflects current nutritional deficiencies more accurately, albeit at the cost of not accounting for past insufficient food intake. Furthermore, Stifel et al. (1999) and Glewwe et al. (2002) report that rapid improvement in children's nutritional status often leads to height increases that are larger than weight increases and thus to a higher incidence of wasting despite the fact that nutrition is improving. This makes the use of weight for height indices for intertemporal analyses problematic and it can be misleading amongst groups who have recently experienced improved nutritional status. Low weight for age can reflect both wasting and stunting and is thus not able to distinguish between long-term malnutrition and temporary undernourishment. The Body Mass Index (BMI = body weight in kilograms/height in meters squared), which is an appropriate measure of adult and adolescent nutritional status, is generally not examined in the context of child malnutrition. [7]

Height for age is the most appropriate measure to use in analyzing the determinants of child nutrition. But the simple measure of HFA is not itself a useful indicator of child nutritional status. To be meaningful it has to be compared to the height and weight of a healthy, well nourished reference population. The use of US children of the same age and gender is recommended by the WHO (1983) for this purpose, publishing tables based on the US National Center for Health Statistics (NCHS) data. The alternative reference population to the NCHS data is to use data based on well nourished children from the same population group as that under study, but few countries have surveys of adequate size to create the required reference tables of the distribution of height and weight by sex for each month.

The norm is to transform HFA (or WFH or HFW) into z scores, that is to standardize the measure as its deviation from the median of the reference population for that age in months and sex divided by the standard deviation from the reference population for that age and sex:

$$z_{it} = \frac{x_{it} - \overline{x}}{\sigma_X} \qquad (5)$$

where x_{it} is the individual observation and the $\overline{x}$ and σ_X are the median and the standard deviation of the reference population, respectively.[8] Thus the z-scores for the reference population have an asymptotic standard normal distribution. There is a general consensus to regard children as malnourished if their z-scores are further than -2 standard deviations from the reference median and extremely malnourished for z<-3.

As an alternative measure some authors utilize percentages of height-for-age and weight-for-height relative to the reference median as indicators.[9] This practice is criticized by Glick and Sahn (1998) since it does not allow for the fact that the standard deviation varies with age and sex in the reference population, so that a single threshold percentage of the median cannot be used to judge malnourishment.

[7] Cigno et al. (2001) are the only exception in all studies examined, but they are examining children age 6-12 years for whom BMI is appropriate rather than HFA.
[8] There are software packages which will generate these z values, such as WHO's ANTHRO package.
[9] See Barrera (1990), Blau (1986), Martorell et al. (1984) and Popkin (1980) for percentages of height-for-age and weight-for-height; Paknawin-Mock et al. (2000) for logarithms.

Anthropometric data are routinely collected in DHS, or similar family health surveys, In addition the Living Standards Measurement Surveys (LSMS) for some countries collect these data.[10] LSMS surveys were the most common source for the nutrition data analyzed in the papers reviewed for this paper.

The econometric analysis of child malnutrition involves the estimation of an equation based on the nutrition function in equation (4) using either a linear regression model with z-scores as endogenous variables or by estimating a binary model (probit or logisitic) categorizing children as either healthy or malnourished. Unless the nature of the data does not permit the estimation of a linear regression model then it is to be preferred to limited dependent variable specifications: the transformation of continuous z-scores into a categorical variables loses information without generating any obvious benefits.[11] Nonetheless, approximately one-fifth of the studies examined have binary specifications. Ordinary least squares (OLS) and 2-step least squares (2SLS) are chosen to estimate the linear models. The choice reflects assumptions about the possible endogeneity of explanatory variables in the regression, notably income and family size variables.

3.2 Meta-Analysis

Meta-analysis combines the results of different empirical studies in way that allows the test of statistical hypotheses. Most commonly, the joint significance of a regression coefficient from different studies is evaluated. Since the estimated regression coefficients are not independent of the units of measurement of the associated variables, a direct aggregation or comparison is often not meaningful. However the unit-less t-statistics can be employed for such purposes. Under the null-hypothesis of joint insignificance, and making use of the Central Limit Theorem, the combined t-statistic is

$$\lim_{M \to \infty} t_C = \frac{\sum t_i}{\sqrt{M}} \sim N(0,1) \qquad (6)$$

where t_i are the t-statistics to be combined and M is the number of studies included. There are two problems with this formulation for our purposes. First, since the number of degrees of freedom differ among the regressions, the standard deviation of the t-statistics are also different. Secondly, if different studies are based on the same data set, the t-statistics are unlikely to be independent. In both cases, the Central Limit Theorem cannot be applied. In aggregating empirical results on child mortality and nutrition, an approximation can avoid the need to apply the Central Limit Theorem. Since the degrees of freedom of the regressions in the studies considered here are generally in the hundreds if not thousands, the t-statistics approximate to a standard Normal distribution. Thus

$$t_C = \frac{\sum t_i}{\sqrt{M}} \overset{\circ}{\sim} N(0,1) \qquad (7)$$

Nonetheless, there is still a chance that t-statistics from different studies using the same data set are correlated. As a consequence, the standard deviation of t_C would not equal one. If the covariance between t-statistics is weakly positive, as one would expect it to be, the variance of t_C

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[10] DHS is a standardized survey instrument with virtually the same instrument applied in all countries (the exception being the modifications for countries with high incidence of HIV/AIDS). LSMS is a proto-type with countries creating their own income and expenditure survey by selecting and adapting modules as suits them, so that LSMS questionnaires can vary considerably between countries.

[11] Pal (1999), for example, is forced to estimate a multinomial logit model because of the nature of the data source.

will weakly exceed one, and the correct critical values will be larger than the ones taken as reference. The null hypothesis of joint insignificance might be thus rejected erroneously. This should be borne in mind when evaluating the combined t-statistic.

The theory justifying the aggregation of statistics is analogous to that used when conducting tests on the mean of a sample. Collect several independent observations from the same distribution, find their mean, and deduce the distribution of the mean.[12] Second, a hypothesis test is conducted where the null hypothesis is $H_O : t = 0$ and the alternate hypothesis is $H_A : t < 0$ or $H_A : t > 0$ for a one-tail test or $H_O : t = 0$ for a two tail test.

Moreover, the limitations of a meta-analysis in examining child health and nutrition in different countries have to be clear. Originating in the fields of psychology and behavioral sciences, the meta-analysis is primarily designed to summarize experiments where the results are expected to be the same and differences in the significance of coefficients are solely due to errors. Hence in order for a meta-analysis to be meaningful in the context of child malnutrition, a crucial assumption has to be made: the underlying structural model of child nutrition, derived from equations (1) to (4) and the implicit constraints, has to be sufficiently similar in every country. Only then can the joint significance or insignificance of a variable be extrapolated back to the level of individual countries. It should also be the case that the explanatory variables themselves are sufficiently similar to be meaningfully combined. This is most likely to be the case for studies based on DHS or equivalent (which is the majority for the analysis of mortality) since the survey instruments are identical. The results in the following section should be read with those caveats in mind.

The method of estimation also matters. In the case of mortality both probit/logistic or hazards models are legitimate approaches, but it is not obvious that the results from the different estimation methods can be combined. Hence two separate analyses are conducted using hazard models and logistic or probit models.

Where studies report more than one set of estimates then the results of the most inclusive model are used. More than one result per study is used when regressions are estimated separately for regions, countries, time periods, or, in the case of mortality, infant and child mortality. In the case of nutrition the meta-analysis is restricted to those studies using the height for age z-score (HAZ) as the dependent variable. And as already indicated, only studies using an infant or child as the unit of observation are used for the meta-analysis. In studies where the levels of significance of coefficients rather than t-statistics or standard errors are reported, the lower limit of the t-statistic is used. For a coefficient that is significant at the 10%, 5%, and 1% level, t-statistics of 1.65, 1.96, and 2.58 are used. For an insignificant coefficient, a t-statistic of 0 is used. These assumptions are conservative, making the t-statistic calculated for the meta-analysis less likely to be significant.

[12] Assuming the number of observations in each study is large, the t-statistic from each study has a standard normal distribution with mean 0 and variance 1. This is because as the degrees of freedom goes to infinity, the t distribution goes to the standard normal distribution.

4. RESULTS

4.1 Studies used in the analysis

Search Strategy

In order to generate a comprehensive overview of the existing literature, a two-pronged approach was employed to identify papers and research reports to include in both the mortality and the malnutrition meta-analysis. An initial search of economic and population studies reference databases such as EconLit, the Social Science Research Network and IDEAS yielded a list of references which were examined with respect to the their suitability for a meta-analytic treatment. Bibliographic back-referencing, that is, following citations in the literature backwards through time, was then used to identify further material. In order to include research undertaken by non-governmental organizations which might not be referenced in published academic work, the internet homepages of organizations such as the UN and their agencies, the World Bank, IFPRI and the WHO were also searched.

While the approach outlined above seemed to provide a relatively inclusive bibliography for nutrition and mortality analyses, it seemed possible that some un-referenced papers would escape the attention. A search of the relevant databases – in fact a search for keywords and phrases in the title and abstract of their entries – would not find articles which, though relevant, do not include those keywords. To minimize the risk of omission, a manual search of relevant journals going back 15 years was conducted. Since it was observed that many studies predating the early 1990s were not suitable for meta-analytic examination and since the likelihood of an article not being referenced anywhere was assumed to be declining in its age, this time horizon is unlikely to lead to a serious omission in the literature examined.

Infant and child mortality

Only papers in which the child is the unit of analysis were used for the mortality meta-analysis. This means that papers using household data but other definitions of mortality (e.g. the death rate to infants born to a specific woman as in Benefo and Schultz, 1994) were dropped from the analysis. The dependent variable is necessarily dichotomous, so that possible estimation techniques are the hazards model and logit/probit. Studies using both techniques were used for the meta-analysis, though the two were not combined.

Thirty-eight papers were identified as suitable for inclusion; these papers are listed in Annex 1(a) (Annex 2a presents significance of regression variables for these studies). The majority (26) modeled both infant and child mortality, usually separately, 11 presented estimates just for infant mortality and one for children only. Eighteen papers presented hazard model estimates and 21 logit/probit (one paper reported both). The tables in this section report the results from the meta-analysis of the logit/probit papers, but any difference with the hazard model results (which are given in the summary Table 14) are noted. Twenty-one of the papers refer to Asian countries, six to African ones, eight to those in Latin America and three to other areas.

Nutrition

An initial survey of the child nutrition literature yielded 61 papers containing statistical analysis potentially suitable for a meta-analysis. These papers range from 1980 to 2003 in publication date and cover countries in Africa, Latin America and Asia. With the exception of Fedorov and Sahn (2003), who follow a sample of children over time, all estimation involved cross-section data.

Annex 1(b) provides an overview of these studies. Not all of these papers were included in the final analysis; the regression results that were included in the meta-analysis are summarized in Annex 2(b). The coefficients in binary estimation models cannot be compared to the results from a linear regression. The former coefficients indicate a change in the probability of being malnourished and the latter the variation in the normalized anthropometric measure caused by a change in the independent variable. Hence the aggregation of their t-statistics makes little sense. This is not a problem for the different types of linear regression, where the coefficients have the same meaning regardless of the model specification. Given the predominance of linear models logit and probit models were excluded from the meta-analysis.

Second, all papers not based on the normalized z-scores were dropped. This affected two types of models. First, the inherent non-linearity of semi-logarithmic models implies the non-comparability of the coefficients and therefore the exclusion of their t-statistics. Secondly, regressions of non-normalized anthropometric indicators, such as percentages of median measures, are likely to be characterized by heteroscedasticity, due to the variance of observed anthropometric measures changing with the age of children. With uncorrected heteroscedasticity leading to incorrect standard errors and therefore t-statistics, and information on heteroscedasticity correction not generally provided, it seems prudent not to include those.

Lastly, only t-statistics from height-to-age regression were used. The sensitivity of the weight-to-height measure to short term fluctuations in nutrition make it less desirable in connection with cross-sectional data. The design of household surveys can often not distinguish between short-term situations and long-term social conditions. Being a measure of chronic malnutrition, height-for-age indicators are therefore better suited and more likely to yield significant results. Furthermore, as essentially short term measures of nutritional status, weight-for-height scores will fluctuate seasonally. If surveys extend over several seasons, or if seasonal effects vary between regions, a regression based on weight-for-height indicators might thus lead to biased results. This last argument also applies in cases where some population subgroup has experienced rapid improvement in their nutritional status in recent times and others have not.

Following this selection process we were left with 35 studies and 61 usable regression equations. The discrepancy between the two numbers is due to authors covering different countries, time periods or segments of the population within their framework. If different segments of the population were estimated separately, the results were only included separately only if no joint estimation exists. Glewwe et al. (2002) and Chawla (2001) report both results based on OLS and 2SLS. Since they do not test for correct specification, only t-statistics from their respective OLS regressions were used.[13] Typically, segmentation of the population was along gender or urban/rural location. In most cases, the maximum age of the children examined is 60 months, but a number of authors include children up to 144 months, and a few have lower cut-off points. After a certain age, placed somewhere around puberty, genetic factors dominate the influence of nutrition in determining a child's height, and height-for-age z-scores become meaningless as indicators for nutritional status. The inclusion of children that are too old will thus bias the estimation.

The summary provided in Annex 1(b) shows the wide range of variables included in the initial 48 studies. Some researchers had access to very detailed information that allowed them to test very specific hypothesis, others were constrained by the generality of DHS or Living Standard Measurement Surveys. In consequence, the number of t-statistics differs for each of the variables discussed in the following sections.

[13] Including instead their 2SLS results does not change the conclusion of the meta-analysis.

Regional analysis

As will become clear, and although the overall meta-analysis t-statistics are often significant, results do vary widely for some variables. We therefore conduct analyses to see if the variation can be explained by regional differences. The results (presented in Annexes 3a for mortality and 3b for nutrition) are discussed in the relevant sections of the paper. However, the studies are more representative of some regions than others, making it difficult to make generalizations for some regions. Thus, there are many more studies of mortality in South and East Asia, and to a lesser extent Latin America, than Africa; for nutrition, there are more studies of sub-Saharan Africa than all other developing regions; for some regions (Europe and Central Asia), very few studies are either available or included here. It should also be borne in mind that the analysis is complicated by the different methodologies used: for nutrition, some studies report results for different years and rural and urban sectors separately, while others pool results; likewise, for mortality, different studies may estimate pooled regressions or separate by age group. These differences are indicated where necessary.

4.2 Discussion of main determinants

We report here the results for those variables included in sufficient studies to warrant performing meta-analysis.

Income

Income is a central variable in models of the determinants of child health and nutrition outcomes. More resources available to a household should translate into higher expenditures on food and health, implying a positive, statistically significant coefficient for the income variable on nutrition and a negative one on mortality in multivariate analysis.

Some measure of household economic well-being is included in many studies. Where it is available either income or expenditure (per capita) is included, usually logged or sometimes the earnings of the household head. However, DHS does not contain income or expenditure data. In these cases a wealth index is created which can be based on information on ownership of consumer durables and housing quality. Sometimes a selection of these variables is entered separately. The asset index is not usually normalized by household size, which means that, to the extent that normalization is required, any household size variables on the right-hand side of the model will play a role in imposing such a normalization.[14] That is, amongst the other things they are picking up, a household size variable will have a tendency to be negative to pick up this normalization.

There are two potential problems in the use of the income variable, both of which are lessened to some extent if assets are used rather than income. First, households may smooth consumption, so that expenditure is the preferred measure rather than income. However, both expenditure and income are treated equivalently in the meta-analysis presented here.[15] Second, the model outlined

[14] If the wealth index should be normalized depends on its components. Measures such as household quality, education of household head and access to electricity should not be normalized. But ownership of consumer items perhaps should be.

[15] To test the validity of this assumption the difference in mean t-statistics from nutrition regressions estimated using income and expenditure respectively was tested. The mean t-stat when income is the

in section 2.2 implies that income is determined endogenously together with child nutrition. Including income directly as a right-hand-side variable in an OLS regression therefore results in biased estimates. To address this problem, several authors use instrumental variable techniques to estimate 2SLS or 3SLS models. However, since we are concerned with extreme situations (death and severe malnutrition) consideration suggests that this simultaneity may not be such a serious concern. For example, suppose parents increase their work effort and hence income once they realize that their children are malnourished. For this behavioral response to introduce a bias into the estimation parents would have to wait *until* their children are stunted and only then begin to earn more. It also seems improbable that household that are so poor that their children have long-term nutritional deficiencies have much scope to adjust their income upwards through allocating additional labor to income earning activities. The length of the working day and the absence of higher paying employment is likely to act as a binding constraint. Finally, as height-for-age is an indicator for long-run nutritional status, current income is unlikely to be endogenous.

The use of instrumental variables can create its own problems. Firstly, if the fit of the instrumenting regression is poor, and there is some evidence that it often is, the poorly predicted variable may incorrectly be found insignificant in the second step estimation. Furthermore, the inclusion of the same variables in both the instrumenting and the main regression may lead to issues of co-linearity between the instrumented and other exogenous variables, reducing the significance of the latter. The results of the auxiliary regression to obtain the instruments are not reported in most studies. Also, few authors test directly for the endogeneity of income. Garrett and Ruel (1999), an exception, find that the endogeneity of expenditure cannot be rejected for children younger than 23 months, but they do not find evidence for endogenous expenditure for children between 24 and 60 months. Thomas et al. (1990) fail to reject the hypothesis that earnings are exogenous. A paired t-test was carried out for those nutrition studies reporting both OLS and IV results which found no significant difference in the results, supporting the idea that the endogeneity of income is not a concern of practical significance.[16]

A regression without income in either straight or instrumented form is reported by 13 authors. Despite this being the technically correct estimation of the reduced form of the model it does not allow the separation of the direct effect of variables like education and their indirect effect through higher income, making the results less valuable as policy making tools.

Table 2 summarizes the results from the meta-analysis.[17] There is a clear difference between infant and child mortality: the meta-analysis results in a significant t-statistic on income (or its proxy) for child mortality, but insignificant for infant mortality, in both logit/probit models and hazard models (results reported in Table 14). Only in one study of India (Kishor and Parasuraman, 1998) is income significantly associated with lower infant mortality in multivariate analysis – in the remaining eight studies of infant mortality, income is estimated to have an insignificant effect. This result is consistent with the view that general socio-economic conditions are important for child survival, whereas that of infants depends more on factors

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regressor is 3.1 and 2.8 when expenditure is used. The t-statistic for the difference of these means is just 0.43 implying that it is legitimate to treat the two variables as equivalent for our purposes.

[16] The mean t-stat from the OLS regressions was 3.2 and that from IV estimation 2.9. The t-statistic to test the difference of these means was just 0.35.

[17] Almost all papers that include per capita income or expenditure use its logarithmic transformation in the estimation. Glewwe (1999) and Chawla (2001) report both IV and OLS estimates. Table 2 includes only OLS estimates. Using IV results does not significantly alter the conclusion (e.g. joint t-statistic: 14.3 in the case of nutrition).

related to medical care and childrearing, such as antenatal care, attended delivery and breastfeeding, all of which can be independent of household income.

These results are fairly evenly distributed across regions (see Annex 3a Table 1). In the nine studies estimating infant and child mortality together using a hazard model, income is significantly negative at least at the 10 percent level in eight of them (90 percent); income also has a significantly negative effect on mortality in all three studies using logit/probit (results not reported here). Using the 29 available observations for nutrition, per capita income is jointly significant at the 1% level with the expected positive sign. Nearly three-quarters (72 percent) of the studies find per capita income to be significant at least at the 10% level. Furthermore, income never has an estimated negative impact in nutrition studies.

Table 2. Per capita income/expenditure or proxy (e.g. asset index)

	Mortality			Nutrition
	Infant	Child	Infant&Child	
Joint t-statistic	-1.30	-4.29***	-6.73***	15.34***
Distribution of results (%)				
Positive at 5%	0.0	0.0	0.0	65.5
Positive at 10%	0.0	0.0	0.0	72.4
Insignificant	85.7	28.6	11.1	25.6
Negative at 10%	14.3	71.4	88.9	0.0
Negative at 5%	14.3	57.1	88.9	0.0
Number of regressions	7	7	9	29

Notes: mortality results are for logit/probit model, except for combined child and infant models which report results for hazards models.
Significance: * 10%, ** 5%, *** 1%

There is a literature that suggests that income earned by women (or expenditure controlled by them) may have a greater propensity to be used to benefit child health and nutrition than men's income. Data are not generally available on these aspects of intra-household resource allocation. Some studies have found that the children in households with working mothers on average have a lower nutritional status but these findings tend not to be based on multivariate analysis.[18] One proxy is the sex of the head of household who is thus implicitly assumed to have the greatest control over allocation. Children in female headed households are significantly better fed in 30 percent of the 15 cases in which this variable is included, with no significant difference in 54% of the cases. The t-statistic for the sex of the household head from meta-analysis is 5.1, which is significant at the 1 percent level.

The impact of female headship on household well-being operates through contradictory direct and indirect channels. Directly, households in which women have a greater say in decision making tend to have better indicators of child well-being. But female-headed households tend to have lower income and therefore worse nutritional status. Coefficients on female household head dummies are positive or insignificant in all studies of nutrition that include it as an explanatory variable (see Annex 3b Table 2). With the exception of Kenya (Kennedy and Cogill, 1987), studies reporting positive coefficients on female head variable also include income as a dependent variable in the specification, which suggests impact of female headship independent of the income effect.

[18] See, for example, Rabiee and Geissler (1992) and Wandal and Holomboe-Ottesen (1992).

However, in order to test for a significant household-level gender impact on nutrition, it is important to account for household size also, since female-headed households are often those in which working-age men have since migrated or died and therefore smaller. Including the composite variable income per capita is not sufficient, even when also accounting for household composition, because there are other effects of household size that operate outside an income effect, e.g. having more people means the child is likely to have a carer. Studies not accounting for household size separately therefore may not register significant coefficients on female household head dummies due to downward (omitted variable) bias, e.g. possibly here in the case of Thomas et al.'s (1996) study of Côte d'Ivoire

There is some interesting regional variation in the nutrition results. All West African studies indicate that female-headed households do not have better child nutrition outcomes than male-headed households on average (Annex 3b Table 2). This makes sense given women's typically greater control over income and decision making in West Africa than is the norm elsewhere: husbands and wives often control separate income streams in West Africa, to the extent that wives may pay their husband a wage for working on their land. Hence a child being in a "female headed household" will not be at an advantage since women also control an important part of resource allocation in "male headed households". Asian countries are also more likely to operate a "pooled resource - joint decision-making" model, so a female household head dummy would be expected to be insignificant here too. However, no South Asian studies reviewed here (including studies of mortality) incorporated a female head dummy variable. As noted above, given limited studies of nutrition in Asia and Latin America, compared to those in sub-Saharan Africa, it is hard to say anything concrete about other regional variations. However, female households on average do have better child nutrition, other things equal, in the studies presented here of East Asia (Vietnam) and in Central America.

Household size and composition

Household size and composition can have different effects. What usually matters is the dependency ratio, that is the ratio of non-working to working (or total) household members. If a household is large because it comprises a large number of able-bodied people of working age then, partly by virtue of economies of scale in consumption, the welfare of household members should, *ceteris paribus*, be higher and so child health and nutrition status better. But if there are many young children they compete for resources, children of higher birth order being particularly vulnerable. Anthropologists writing of different continents have documented how parents reluctantly practice triage, neglecting the care of certain children who die as a result (Turnbull, 1973, and Scheper-Hughes, 1992), or even actively intervene to bring about death usually of daughters (see Croll, 2000, for a general discussion of "endangered daughters" and Venkatramani, 1992, for detailed discussion of one community practicing murder of female infants).[19]

Finally, related to household size is the length of the preceding and succeeding birth interval, which is likely to be shorter for mothers with high fertility. The birth interval also affects quantity and quality of care that mothers provide their children. For both these intervals, t-statistics for a continuous variable (the number of months between births) and higher month dummies are used. If only one dummy is used and the omitted category is a higher birth interval, then the t-statistic is

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[19] Masset and White (2003) show that females of high birth order in Andhra Pradesh, India, have a high probability of death especially if they have all female siblings, this demonstrating that the discrimination results from son preference.

multiplied by (-1). If the omitted category is a higher interval and several lower interval dummies are used, t-statistics from the study are not included in the meta-analysis.

As for income, household size can be seen as being endogenous, at least with respect to mortality. The common story with respect to the demographic transition is that fertility reduction follows the decline in mortality as large numbers of children for "replacement" are no longer necessary and parents begin to invest in child quality rather than child quantity. However, it is less clear that the individual child characteristics of birth order and interval should also be regarded as endogenous, so mortality estimates using these variables side step the endogeneity problem.

Table 3 summarizes the effects of other variables relating to the households' demographic make-up. In contrast to the usual empirical finding of a negative relationship between household size and household welfare (particularly in income/expenditure/poverty regressions), household size appears to have a positive effect on child nutrition (although it is insignificant in two-thirds of cases).[20] This is almost entirely due to the positive relationship between household size and nutrition found in some studies in East and Southern Africa (see Annex 3b Table 3); there are, however, more countries for which household size is estimated to be insignificantly correlated with nutrition, including in ESA. The presence of younger children has a significantly negative impact, whereas older children have an insignificant impact. The positive effect of a larger household can come from the earning/production effect discussed above but also the availability of additional child carers, such as grand parents or older children. If economies of scale in consumption were not allowed for in constructing the per capita income/expenditure variable then the household size variable is also picking this up. And, as argued above, the household size variable can also pick up the normalization of the wealth index.

Table 3 Household size and composition

	Mortality					Nutrition		
	Infant		Child					
	Birth order	Birth Interval	Birth order	Birth Interval		Household size	Young children	Older children
		Pr		Pr	Sc			
Joint t-statistic	1.69*	-9.00***	0.30	1.01	-9.43***	2.98***	-3.33***	1.48
Distribution of results (%)								
Positive at 5%	21.1	5.9	10.0	11.1	0.0	13.4	6.7	16.7
Positive at 10%	26.3	5.9	10.0	22.2	0.0	30.4	6.7	33.3
Insignificant	68.4	41.2	90.0	66.7	0.0	65.3	63.3	66.7
Negative at 10%	5.3	54.3	0.0	11.1	100.0	4.3	30.0	0.0
Negative at 5%	5.3	51.4	0.0	11.1	85.7	4.3	20.0	0.0
Number of regressions	19	35	10	9	7	23	30	6

Notes: mortality results are for logit/probit model. Pr: preceding birth interval; Sc: succeeding birth interval (not available for infant mortality). Significance: * 10%, ** 5%, *** 1%

The categories "young children" and "older children", representing the number of young and older children present in a household, were created for the meta-analysis – individual authors define different age limits when dealing with the number of siblings of different ages, which are

[20] The negative relationship between household size and household well-being is often over-stated because of failure of many studies to adjust for household composition as well as economies of scale arising from household public goods consumption. See White and Masset (2003) who find for Vietnam that failing to account for size and composition results in underestimation of poverty among female-headed households.

not exactly comparable. Generally, "young children" are of approximately the same age as the children whose nutritional status is examined; older children reach up to fourteen or fifteen years of age. The rationale for looking at the number of children by age group is clear: while younger children act strictly as consumers of scarce household resources, be they financial, nutritional or in terms of parental time, older children are able to contribute to the supervision and care for younger siblings and to general household chores. This rationale is supported by the finding that having other young children in the household significantly reduces a child's nutritional status, whereas having older children has a positive but insignificant effect (and is never negative in any of the six studies for which it is available).

The meta-analysis indicates that birth order has a positive effect on mortality on average (see also Table 14 which gives results for regressions of infants and children together and of hazard models). However, results are highly varied, which reflects the unclear intuition behind the effect of birth order on mortality – mortality among first births is usually seen as higher, possibly because of the adverse effect of giving birth before physical and reproductive maturity is reached, though most of these studies also control for maternal age.

A higher preceding birth interval is found to have a negative impact on infant mortality using logit/probit models, whereas for children it is the succeeding interval that is significant. These results are plausible. For young children a short succeeding interval means that the mother's attention is taken with the younger sibling at the expense of the care of the older child who will likely be less than 18 months old when the child is born if the birth interval is short. But for infants it is the preceding interval that matters. Indeed, it will be very rare to have any infants for whom the succeeding interval is defined so that this variable is not used. But where the preceding interval is short the mother will still have demands from the older sibling, and possibly be generally weaker as a result of the very narrow spacing between births. The analysis of these results by region does not appear to yield insightful differences (Annex 3a Tables 2 and 3).

Parental education

The role of parental education in determining children's health and nutritional status is two-fold. First, better education should translate into higher incomes. In studies where income is not included as a separate variable, then this effect should exert a positive effect on the coefficient of parental education variables. Even when income is included in the estimated equation, more parental schooling could be beneficial for child health and nutrition. Better educated parents are likely be able to make better use of available information about child nutrition and health, partly as being educated themselves may increase their preference for child quality over quantity (a decision which can also reflect the increased opportunity cost of the mother's time). Most likely, successful completion of primary schooling or functional literacy is sufficient in this context, and post-primary school education might only add limited benefits, though this depends on the quality of schooling. Furthermore, education might be a signal for parents' innate intellectual abilities, leading to a positive coefficient even if education itself possesses no value.

Of particular interest in the analysis of education is the differential impact maternal and paternal schooling might have. Since it is mainly mothers who care for children, while men are presumably working outside of the household, mothers' ability to access information and make use of existing health care facilities is likely to be more important. Female education should thus be directly relevant, whereas paternal education should affect child health and nutritional status mainly through its income generating properties.

Parental education can be measured as years of education or a dummy for the level of education (or literacy) achieved. Where there are multiple dummies for different levels of education that for primary education has been used in carrying out the meta-analysis. Because the t-statistic is unit-less, t-statistics for both years of education and a primary education dummy variable can be combined. If the primary education dummy is the omitted category then the no education dummy t-statistic is used and multiplied by (-1). The composite t-statistic captures the combined impact of increasing maternal (paternal) education on infant and/or child mortality. Table 4 summarizes the empirical results.

Table 4: Parental education

	Mortality				Nutrition	
	Infant	Child	Infant&Child			
	Maternal	Maternal	Maternal	Paternal	Maternal	Paternal
Joint t-statistic	-6.48***	-3.48***	-4.59***	-2.08**	6.48***	3.03**
Distribution of results (%)						
Positive at 5%	0.0	0.0	0.0	12.5	16.7	22.2
Positive at 10%	0.0	0.0	0.0	12.5	33.3	29.6
Insignificant	71.4	62.5	65.2	50.0	66.7	63.0
Negative at 10%	28.6	37.5	34.8	37.5	0.0	7.4
Negative at 5%	25.7	37.5	26.9	37.5	0.0	3.7
Number of regressions	35	8	21	8	30	27

Notes: mortality results are for logit/probit model except paternal education effects (hazard rate models)
Significance: * 10%, ** 5%, *** 1%

Mother's education is found to have a significant negative impact on infant and/or child mortality, except for both infant mortality and child mortality hazard models (see Table 14). Father's education is found to have an insignificant impact on infant and/or child mortality. However, only eight studies include some measure of the father's education.

Table 5 Literacy and Education

	Full sample		Restricted sample			
	Maternal education	Paternal education	Maternal education	Paternal education	Maternal literacy	Paternal literacy
Joint t-statistic	5.24***	2.13**	5.95***	5.39***	6.14***	3.47***
Distribution of results (%)						
Positive 5%	21.7	9.1	27.7	42.9	31.3	25.0
Positive 10%	34.8	9.1	38.9	50.0	43.8	25.0
Not significant	65.2	90.9	55.5	50.0	56.2	75.0
Negative 10%	0.0	0.0	5.6	0.0	0.0	0.0
Negative 5%	0.0	0.0	0.0	0.0	0.0	0.0
Number of regressions	23	11	19	14	16	8

Significance: * 10%, ** 5%, *** 1%

The number of studies that did not find statistically significant educational effects of mortality and nutrition is surprisingly high, despite the overall significance of the variables. There may be three reasons for this result. First, it is learning outcomes that matter rather than simply attending school. If schooling is of poor quality then it may have no beneficial effects. To consider this possibility we calculated the t-statistic for the impact of parental literacy on nutrition (Table 5). Whilst also significant, it is again the case that there are many studies finding no significant relationship. The second explanation is that closer inspection shows that some studies containing regressions for a number of different countries, which are included as separate observations in the meta-analysis, do not obtain significant coefficients. Since the inclusion of multiple regressions from a single source might bias the joint t-statistic in either way, if the results are driven by model selection rather than the data, a second calculation includes only average t-statistics for each study. The results, reported in Table 5, provide a stronger indication of the positive effect of education on nutrition. In order to rule out issues of correlation between income variables and education in instrumental variables models, tests comparing the t-statistics resulting from the two types of specification were undertaken. No significant difference was found. Further tests to see if the significance of education variables was affected by the presence of income or expenditure variables yielded no statistically significant differences. Finally, Glewwe (1999) argues that it is mother's health knowledge that matters – controlling for that removes the effect of maternal education. If education does not provide such knowledge it will not be significant. Alternatively, if this information is provided outside of the education system and understood by the less educated then the effect of education will be removed.

Some regional patterns are apparent (Annex 3a, Table 4; Annex 3b Tables 5-8). Female education and literacy are nearly always insignificant determinants in West Africa, but seem to positively affect nutrition in more studies in East and Southern Africa. The difference between West Africa and East and Southern Africa is particularly acute in female literacy, which has a significantly positive effect on nutrition in nearly all ESA cases. Female literacy also seems to have beneficial implications for child well-being in terms of nutrition and mortality in the majority of Latin American studies reviewed here. On the other hand, education of the male household head is an insignificant determinant of nutrition in all African studies reviewed, although again literacy does better.

Female education nearly always has a beneficial impact on mortality in Asian studies, though it is difficult to see any trend for nutrition, the results for Vietnam being particularly varied, which reflect the different samples used in studies.[21] Finally, the fact that in Tanzania and Pakistan education stopped being a significant determinant of nutrition may reflect deteriorating quality of education over time.

Gender

The t-statistic for the infant or child's gender is obtained from a dummy variable that is 1 for male children and 0 for females. For studies in which the gender dummy was defined as 1 for females and 0 for males, the t-statistic was multiplied by (-1). The results are summarized in Table 6.

Mortality is found to be higher among male infants compared to female infants, a result that seems particularly striking in East Asia (see Annex 3a Table 5). However, male children are less likely to die than female children, and in no studies of child mortality does being male have a positive effect. Nearly half the nutrition studies find that male children are less well nourished than females – this is true of almost all of the studies in East and Southern Africa (Annex 3b

[21] Thus while Wagstaff et al. (2003) report a positive impact of female education in 1993, with this effect disappearing in 1998, Glewwe et al.'s (2002) results from the same dataset (the VLSS) show that the significance of female education is only in urban areas. It also appears that male education has greater impact in rural areas (which is the opposite of the finding for females in Vietnam).

Table 4).[22] [23] This compares to 5 percent with the opposite finding, making the t-statistic significantly negative at the 1 percent level. This means that roughly half of the authors do not find a significant gender effect. Sex of child is always an insignificant determinant of nutrition in the Latin American studies reviewed here. In Asia, the experience is mixed and no strong conclusions can be drawn, even for individual countries.[24]

Table 6 Gender: Boys

	Mortality		Nutrition
	Infant	Child	
Joint t-statistic	9.74***	-6.95***	-9.93***
Distribution of results (%)			
Positive at 5%	61.9	0.0	3.4
Positive at 10%	61.9	0.0	5.2
Insignificant	38.1	33.3	46.5
Negative at 10%	0.0	66.6	48.3
Negative at 5%	0.0	63.6	36.2
Number of regressions	21	12	58
Notes: mortality results are for logit/probit model. Significance: * 10%, ** 5%, *** 1%			

The lower HAZ has been interpreted as a sign that boys tend to be more malnourished than girls, contrary to what many authors have expected. The low priority of girls in many cultures, they surmised, would bias food consumption towards boys. A statistically jointly significant average gender coefficient of -0.175 would seem to contradict this theory.

Location (rural versus urban)

For location, t-statistics for a rural/urban dummy that is 0 if rural and 1 if urban. If the dummy is 1 for rural areas and 0 for urban areas, the t-statistic is multiplied by (-1).

The results, shown in Table 7, show no significant impact on mortality, although the results from hazards models do show a significant impact. A higher risk of death is associated with a rural residence only in hazard models for infant and child mortality. Even though in 50% of the cases, urban children do not have a significantly different nutritional status from their rural counterparts *ceteris paribus*, jointly, they are significantly better nourished, maybe due to the better access of urban households to health care and other unobservable infrastructure that has a positive effect on child nutrition. Otherwise, the availability of food in the countryside would lead to the expectation that rural children should have a better nutritional status. The fact that it does not lends weight to Sen's entitlements approach.

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[22] With the exception of Mozambican children aged 24 to 60 months (Garrett and Ruel, 1999) (this result reflects the general finding that boy children do better than boy infants) and in Tanzania, where Stifel et al. (1999) find the significance of a negative male dummy to disappear over the 90s.

[23] In only one paper is being a male associated with better nutrition on average, that is, in the Philippines for Senauer and Garcia's (1991) study, though Horton (1986, 1988) finds a negative and insignificant impact for the Philippines using a different data set, and in Glewwe's (1999) study of Morocco, male children are on average significantly better nourished in one specification (OLS estimation).

[24] For example, for Vietnam, Wagstaff et al. (2003) report male child dummy to be significantly negative in both 1993 and 1998, whereas Glewwe et al. (2002) report this effect as insignificant, though they do include other determinants which sex of child may proxy for (e.g. religion and ethnicity dummies, which, with the exception of the dummy for Protestant religion, are generally insignificant).

Table 7 Location (urban =1)

	Mortality		Nutrition
	Infant	Child	
Joint t-statistic	-0.24	-0.82	5.61***
Distribution of results (%)			
Positive at 5%	0.0	0.0	27.3
Positive at 10%	0.0	0.0	40.9
Insignificant	100.0	75.0	50.0
Negative at 10%	0.0	25.0	9.1
Negative at 5%	0.0	25.0	4.4
Number of regressions	6	4	22
Notes: mortality results are for logit/probit model. Significance: * 10%, ** 5%, *** 1%			

Services: sanitation, water supply and electricity

The provision of sanitation and drinking water is seen as an essential complement to the availability of food in preventing child malnutrition. Even if the food supply for children is sufficient, diarrhea hampers the intake of calories and micro-nutrients and thereby prevents adequate nutritional outcomes and increase the likelihood of mortality. By reducing the risk of bacterial infections and diarrheal diseases, sanitation and clean water will indirectly contribute to a child's nutrition. The reduction in infections from contaminated water and the lack of hygiene may also have spill-over effects to other households in the neighborhood as the probability cross-infections will fall. The rise in the availability of these services may thus even affect households that do not have direct access to them. Sharing of piped water, and probably to a much lesser extent toilet facilities, may also contribute to this. For availability of clean water, t-statistics for dummy variables that indicate whether or not a household has a regular water supply, well water, piped water, or public tap water are used; T-statistics from dummy variables indicating lack of safe water are therefore multiplied by (-1). Similarly, for toilet sanitation and electricity, t-statistics for dummy variables that indicate the existence of a toilet in the household and availability of electricity are used.

Table 8 Water and Sanitation

	Mortality				Nutrition	
	Infant		Child			
	Sanitation	Water	Sanitation	Water	Sanitation	Water
Joint t-statistic	-5.29***	-4.01***	0.00	-1.96**	6.68***	3.94***
Distribution of results (%)						
Positive at 5%	0.0	0.0	0.0	0.0	33.3	16.7
Positive at 10%	0.0	11.1	0.0	0.0	40.0	16.7
Insignificant	33.3	33.3	100.0	50.0	60.0	83.8
Negative at 10%	66.7	55.6	0.0	50.0	0.0	0.0
Negative at 5%	66.7	55.6	0.0	50.0	0.0	0.0
No. of regressions	6	9	2	4	30	24
Notes: mortality results are for logit/probit model. Significance: * 10%, ** 5%, *** 1%						

The results of the meta-analysis (Table 8) show that availability of clean water does reduce infant and child mortality. For infant mortality and combined infant and child mortality hazard models the effect is insignificant. Using infant mortality and combined infant and child mortality logit/probit models, the availability of a toilet in the household has a negative impact on the likelihood of death among infants and children. The effect of electricity availability is included in only four studies. Electricity has a negative impact on infant mortality using logit/probit models, though no significant impact in the one study of child mortality accounting for it (Howlader and Bhuiyan, 1999). For nutrition, in no studies do household sanitation or water negatively impact on child nutrition.[25] Sanitation appears more important than clean water for nutritional outcomes, though the reverse is the case for mortality.

Table 9 Community Water and Sanitation (nutrition)

	Community sanitation	Community water
Joint t-statistic	-1.12	1.67*
Distribution of results (%)		
Positive 5%	0.0	25.0
Positive 10%	0.0	25.0
Not significant	75.0	75.0
Negative 10%	25.0	0.0
Negative 5%	25.0	0.0
No. of regressions	4	4

Notes: mortality results are for logit/probit model.
Significance: * 10%, ** 5%, *** 1%

Table 9 shows results for community-level access in the case of nutrition only. Community-level variables were constructed as percentages of households in survey clusters that possess the respective facility. The beneficial impact of sanitation and water is clearly statistically significant at the level of the household. Community variables, on the other hand, seem less important in preventing child malnutrition, although the number of observations is small and the percentage of households with access to piped water in the neighborhood is statistically significant at 10%. These results are most likely picking up that a water resource, such as a standpipe, may be shared amongst community members, whereas sanitation facilities are not.

Regional variations in the results are not immediately apparent: water and sanitation's impact is relatively evenly split between significance and insignificance in all regions (Annex 3a Tables 6 and 7; Annex 3b Tables 9 and 10), though clean water availability and sanitation nearly always have beneficial implications for mortality and nutrition in the East Asian studies reported here. The impacts of access to sanitation and clean water on child nutrition seem to reverse over the 1980s and 90s, particularly in Africa: i.e. sanitation's impact went from significantly positive in earlier periods to insignificant, while clean water's went from insignificant to significantly positive (though in Indonesia the impact of sanitation on mortality seems to have improved over time). This may be because clean water coverage breached a minimum threshold, below which a positive effect on nutrition is not possible to estimate (unless it is really strong), and therefore, being likely correlated with sanitation, captured sanitation's otherwise positive impact. Alternatively, the increased availability of facilities reduced variation in the explanatory variable.

Infant's/Child's Age

For an infant's or child's age, t-statistics for the age in years as well as age dummies in comparison to a lower age are used. The composite t-statistic therefore captures the impact of a

[25] In Gragnolati's (1999) study of Guatemala, community-level sanitation does impact negatively on nutrition – a result the author suggests may results from measurement error or reverse causation "e.g. the choice of parents with shorter children to install a flush toilet in the household" (p. 19), though including aggregate community-level variables should in theory reduce this bias).

higher age on infant and/or child mortality. Infants and children are less likely to die the older they are (Table 10).

Table 10 Mortality and age

	Child's age			Mother's Age		
	Infant	Child	Infants and Children	Infant	Child	Infants and Children
Joint t-statistic	-18.75***	-6.56***	-19.67***	-1.31	0.08	-4.91***
Distribution of results (%)						
Positive at 5%	0.0	0.00	20.51	15.0	0.0	10.5
Positive at 10%	0.0	0.00	20.51	20.0	0.0	10.5
Insignificant	6.25	47.62	7.69	50.0	84.6	26.3
Negative at 10%	93.75	52.40	71.79	30.0	15.3	63.2
Negative at 5%	93.75	28.57	71.79	30.0	15.3	52.6
No. of regressions	16	21	9	20	13	19

Notes: mortality results are for logit/probit model, except for infants and children combined (hazard rate). Significance: * 10%, ** 5%, *** 1%

Mother's age

For the mother's age, t-statistics for her age in years as well as age dummies in comparison to younger mothers are used. The result for the impact of the mother's age on infants is insignificant in logit/probit (Table 10) and positive in hazard models (Table 14) – older mothers are more likely to experience the death of their infant than younger mothers. The results for the analysis that combines infants and children are different for hazard and logit/probit models. For hazard models, infants and children with older mothers have a lower risk of death. On the other hand, for logit/probit models, infants and children with older mothers are more likely to die. However, this relationship may be non-linear, with higher risk for both older and younger mothers. Most studies in which mother's age enters as a quadratic bear this out. Bivariate analysis invariably shows children of very young mothers to be high risk. Raising the age of marriage, which tends to occur as part of the demographic transition, directly reduces mortality by increasing the age of first birth and indirectly through lower fertility.

Breastfeeding

The beneficial impact of breastfeeding on infant and child mortality is evident from the result of the meta-analysis. The t-statistics for the number of months an infant or child was breastfed and of dummies that are 1 if the infant/child was breastfed for a specific time period and 0 otherwise are used. Where the dummy is defined as the opposite, the t-statistic is multiplied by (-1). Infants or children who are breastfed for a longer time period are found to have a higher chance of survival (Table 11). This variable was not included in sufficient nutrition studies for its inclusion in the analysis (since it is not collected in LSMS studies).

Table 11 Breastfeeding

	Mortality		
	Infant	Child	Infants and Children
Joint t-statistic	-8.74***	-4.79***	-16.69***
Distribution of results (%)			
Positive at 5%	0.0	0.0	0.0
Positive at 10%	0.0	0.0	0.0
Insignificant	0.0	33.3	0.0
Negative at 10%	100.0	66.7	100.0
Negative at 5%	83.3	66.7	100.0
No. of regressions	6	3	4
Notes: mortality results are for logit/probit model, except for Infants and Children combined (hazard rate). Significance: * 10%, ** 5%, *** 1%			

Fate of Previous Child

The fate of previous children is a good indicator of biological factors specific to the mother that have an impact on her child's survival. T-statistics for a dummy variable that is 1 if the previous infant or child died and 0 otherwise and for a measure of the proportion of dead children a mother has had are used. The death of the previous child increases the likelihood of the death of both infants and children (Table 12).

Table 12 Fate of previous child

	Mortality		
	Infant	Child	Infants and Children
Joint t-statistic	5.46***	3.77***	4.07***
Distribution of results (%)			
Positive at 5%	37.5	33.3	33.3
Positive at 10%	37.5	33.3	33.3
Insignificant	50.0	66.7	66.7
Negative at 10%	12.5	0.0	0.0
Negative at 5%	0.0	0.0	0.0
No of regressions	8	3	6
Notes: mortality results are for logit/probit model, except for Infants and Children combined (hazard rate). Significance: * 10%, ** 5%, *** 1%			

Health services: Antenatal care, place of birth and immunization

Infants and children of mothers who received antenatal care, either by a physician or a midwife, have a higher likelihood of survival. T-statistics for a dummy variable that is 1 if the mother received any antenatal care and 0 otherwise and for dummies that are 1 if the mother received antenatal care from a physician, midwife, or other health worker and 0 otherwise are used. T-statistics are also included for a hazard study that uses the number of antenatal visits, which is a unit-less variable and therefore can be combined with results based on dummies.

To capture the effect of an infant's place of birth on his or her risk of death, the t-statistic for a dummy that is 1 if the child is born in a hospital, clinic, or other health facility and 0 otherwise is used. If a dummy that is 1 if the child is born at home and 0 otherwise is included in the study then the t-statistic of this variable is multiplied by (-1). The results of the meta-analysis indicate that infants born in a health facility are less likely to die than infants born at home (Table 13).[26] Likewise, the mother having attended antenatal care reduces the risk of mortality for both infants and children in all studies for which this variable is included (t-statistic significant at the 1% level – Table 14).

Table 13 If born in health facility

	Mortality		
	Infant	Child	Infants and Children
Joint t-statistic	-3.05***	0.00	-5.37***
Distribution of results (%)			
Positive at 5%	0.0	0.0	0.0
Positive at 10%	0.0	0.0	0.0
Insignificant	40.0	100.0	33.3
Negative at 10%	60.0	0.0	66.7
Negative at 5%	60.0	0.0	66.7
Number of regressions	5	1	3

Notes: mortality results are for logit/probit model, except for Infants and Children combined (hazard rate). Significance: * 10%, ** 5%, *** 1%

Immunization

One would expect that if an infant or child received a vaccination against tetanus toxoid, DPT3, or measles, he or she is less likely to die. However, only three studies include immunization dummy variables. In these studies immunization significantly reduces the risk of mortality.

One would also expect that the availability of other public health services – general and specialized health facilities, pediatric services, obstetric and gynecology facilities, and the number of maternity clinics, health workers, and doctors in region – generally lower the risk of death among infants and children. However, the results of the meta-analysis show that these services are collectively insignificant in lowering infant and child mortality. But it should be borne in mind that it has already been shown that the things that do matter most to children – antenatal care, birth in a health facility and immunization, all have a significant impact on mortality.

5. Summary

The meta-analysis reveals a degree of consistency in the determinants of child health and nutritional outcomes across countries. These results are summarized in Table 14. However, there is also heterogeneity in the results, suggesting that policies need to be adapted to the country-specific context.

[26] Only in Howlader and Bhuiyan's (1999) study of Bangladesh is the effect of health facility birth on infant and child mortality insignificant.

Table 14 Determinants of Infant and Child Mortality – A Meta-Analysis

	Infant Mortality		Child Mortality		Infant and Child Mortality		Nutrition
	Hazard	Logit/ Probit	Hazard	Logit/ Probit	Hazard	Logit/ Probit	
Socio-Economic Factors							
Mother's education	-1.13	-6.48***	-1.49	-3.48***	-7.10***	-4.59***	6.48***
Father's education	..	0.90	..	0	-2.08**	..	3.03***
Household income/wealth	0	-1.30	-2.55**	-4.29***	-6.73***	-5.80***	15.34***
Sex of household head (female=1)	..	..	..	..	..	..	5.06***
Location (urban =1)	0	0.24	..	-0.82	2.22**	0.51	5.61***
Water	0	-4.01***	-3.21***	-1.96**	-1.30	-2.91***	3.94***
Sanitation	0	-5.29***	0	0	-0.95	-3.16***	6.68***
Electricity	..	-4.16***	..	0	-1.19	..	..
Biological and demographic factors							
Child's gender (male=1)	0	9.74***	-2.58***	-6.95***	2.32**	1.65*	-9.93***
Child's age	..	-18.56***	..	-6.56***	-25.77***	..	..
Mother's age	1.85*	-1.31	-0.18	0.08	-4.91***	20.84***	..
Birth order	-0.88	1.69*	2.98***	0.30	1.67*	2.08**	..
Preceding birth interval	0	-8.69***	0	1.07	-1.37	..	..
Succeeding birth interval	..	..	..	-9.43***	-1.94*	..	..
Breastfeeding	-3.49***	-8.74***	..	-4.79***	-16.69***	..	..
Previous child died	..	5.46***	..	3.77***	4.07***	-1.82**	..
Household size	..	..	..	..	..	..	2.98***
Other young children in household	..	..	..	..	..	..	-3.33***
Older children in household	..	..	..	..	..	..	1.48
Health Services							
Place of birth	..	-3.05***	..	0	-5.37***	..	..
Antenatal Care	-2.58***	-6.23***	..	-4.65***	-1.35	..	..
Immunization	-2.58***	-4.65***	..	-4.88***	..	..	..
Public health measures	..	-1.47	..	..	-0.30	-7.32***	..
Notes: Significance: * 10%, ** 5%, *** 1%							

There can be little doubt that household income is a crucial factor in determining both child health and nutrition. In general the evidence supports the view that economic growth provides the foundation for improving other welfare outcomes. However, it is notable that income is not a significant determinant of infant mortality in the majority of cases. As mortality rates fall the bulk of under-five mortality is infant rather than child death, and these deaths are more sensitive to health provision that general socio-economic conditions (White, 2004). Countries or regions with low rates of antenatal care, attended delivery and breastfeeding can expect substantial returns from changing parental behavior.

A number of authors have speculated about the differential impact of income earned by mothers and fathers. There is some limited empirical evidence that mothers' income is more important in feeding children, but so far not enough work has been done to subject this line of argument to a meta-analysis. Clearly, future support for the importance of mothers' access to financial resources would have fundamental policy implications.

The importance of mothers' education is supported by joint significance of variables measuring schooling and literacy. However, it is not clear if education by itself has any effect, or if education is only useful if it leads to a higher knowledge about health and nutrition. Indeed, Glewwe (1999) finds that education does not have a significant coefficient once health knowledge is controlled for. This issue, too, requires further attention. Fathers' education, while less significant, also contributes to child nutrition but is not significant for either infant or child mortality. Part of this effect works through higher income associated with better education. However, there are a large number of cases in which education is not significant, which may also be related to the quality of education.

A third important determinant of child health and nutrition outcomes is the availability of clean drinking water and sanitation. By preventing infections and diarrhea these two factors lead to better nutritional outcomes for a given nutrition supply and so reduce mortality. The results from the meta-analysis provide strong support this claim.

The finding that children living in urban locations are taller for their age can only be explained by the omission of significant variables in the original studies. A better provision of healthcare in cities and towns relative to the countryside is likely to matter. Some authors have data on access to different sources of healthcare, but on the whole there is not enough information to reach a conclusion regarding nutritional outcomes, which need not be the case in principle since DHS data, used for some studies, does contain such information. Whilst the urban dummy is not significant for mortality, the mortality meta-analysis does provide some direct measures of child health which are significant, namely birth in a health facility, attending antenatal care and immunization. Various childrearing practices, which can be linked to reproductive health services, also reduce mortality, notably wider child spacing (and so longer birth intervals) and breastfeeding. The absence of rival younger siblings also improves nutritional status.

What do these results tell us about the questions raised regarding the MDGs at the start of the paper. First, PRSPs have been criticized for the continued focus on growth which critics see as signaling no real change from earlier adjustment policies. These findings confirm, however, that growth is a necessary part of a poverty reduction strategy, even when poverty is defined in terms of child health and nutrition rather than as income-poverty. However, the findings support a balanced approach which expands access to services. Low cost interventions, such as encouraging exclusive breastfeeding, can improve health and nutrition outcomes even in the absence of higher incomes. Immunization is a similar low cost intervention which saves lives, though data show that immunization rates peaked at 75 percent in the mid-90s and have since declined.

The main conclusion is that the poverty reduction strategy for each country needs to be built upon a sound statistical analysis of the determinants of child health and nutrition outcomes in that country, combined with an analysis of what are the areas of greatest potential for intervention, i.e. which determinants "do badly" compared with international norms. These are some common themes in this paper, but the specifics can vary by country.

Annex 1(a) Studies of infant and child mortality included in the meta-analysis

Study	Author	Country/Dataset	Dependent Variable	Independent Variables	Estimation Method
1	Nguyen-Dinh and Feeny (1999)	Vietnam - DHS 1988	Infant mortality/child mortality (= 1 if dead, 0 if alive)	*Child characteristics:* Year of birth, gender, birth order + square, birth interval. *Household characteristics:* Mother's education, stability of father's income, mother's and father's industry, mother's age + square. *Community characteristics:* Rural/urban dummy, north/south dummy, life trend, level of child mortality in community.	Logistic
2	Sastry (1996)	Brazil - DHS 1986	Infant + child's risk of death	*Child characteristics:* Age, gender, birth order, duration of breastfeeding, birth interval, fate of previous child. *Household characteristics:* Mother's education, mother's age + square, household income. *Community characteristics:* Rural/urban dummy, water supply, electricity, sanitation, trash collection, schools, health facilities, population growth rate, monthly temperature and precipitation.	Hazard
3	Koenig et al. (1990)	Bangladesh - DSS 1966-1994	Infant mortality/child mortality	*Child characteristics:* Age + square, gender, fate of previous child, birth interval, time parameters. *Household characteristics:* Mother's education, number of children ever born to mother + square, housing area.	Hazard
4	Pebley and Stupp (1987)	Guatemala - INCAP	Infant + child's risk of death	*Child characteristics:* Age, gender, birth order, birth place, fate of previous child, birth period and village, birth interval, duration of breast-feeding. *Household characteristics:* Mother's education, mother's age + square, family income.	Hazard

Annex 1(a) Studies of infant and child mortality included in the meta-analysis

Study	Author	Country/Dataset	Dependent Variable	Independent Variables	Estimation Method
5	Kravdal (2003)	India - NFHS 1998-1999	Infant + child's risk of death	*Child characteristics:* Birth interval, another child born afterwards. *Household characteristics:* Mother's education, father's education, mother's age, average education among women, average education among men, health knowledge index for mothers.	Hazard
6	Panis and Lillard (1995)	Malaysia - MFLS 1988	Infant + child's risk of death	*Child characteristics:* Ethnicity, age, similar age sibling, gender, birth weight, premature birth, twins, time dummies, use of ante-natal care, institutional delivery, length of pregnancy. *Household characteristics:* Mother's education, father's earnings, mother's age.	Hazard
7	Kanaiaupuni and Donato (1999)	Mexico – Mexican Migration Project 1987-1988, 1992-1993	Infant mortality	*Household characteristics:* Mother's education, mother's age + square, number of minors, socioeconomic status, number of relatives with US experience, number of US trips of household head, US experience of US head, time dummies. *Community characteristics:* Running water, paved access to federal highway, female and male labor force participation rate, community population, annual migration dollars, migration intensity.	Linear Probability
8	Vanzo and Habicht (1986)	Malaysia – MFLS 1976-1977	Infant mortality	*Child characteristics:* Full and part breastfeeding, birth interval, ethnicity. *Household characteristics:* Mother's education, piped water, toilet sanitation, interactions of piped water and toilet sanitation with full and part breastfeeding.	Logistic

Annex 1(a) Studies of infant and child mortality included in the meta-analysis

Study	Author	Country/Dataset	Dependent Variable	Independent Variables	Estimation Method
9	Da Vanzo et al. (1983)	Malaysia – MFLS 1976-1977	Infant mortality	*Child characteristics:* Birth interval, gender, birth-weight, birth order, breastfeeding, year of birth, birth place, ethnicity. *Household characteristics:* Mother's education, household income, mother's age, proportion of other pregnancy intervals < 15 months, proportion of stillbirths, household composition, piped water, toilet, persons per room. *Community characteristics:* Rurality	Logistic
10	Frankenberg (1995)	Indonesia – DHS 1987	Infant mortality	*Child characteristics:* Birth date, child's gender, birth interval, birth order, first birth. *Household characteristics:* Mother's education. *Community characteristics:* Maternity clinics, health workers, doctors.	Logistic
11	Sear et al. (2002)	Gambia – UK MRC 1950-1980	Infant mortality/child mortality	*Child characteristics:* Age, gender, birth order, preceding and succeeding birth interval, whether mother/father/grandmothers /grandfathers/siblings dead or alive. *Household characteristics:* Mother's age. *Community characteristics:* Region dummies.	Logistic
12	Zenger (1993)	Bangladesh – DSS 1966-1994	Infant mortality	*Child characteristics:* Gender, fate of previous child, birth interval, birth order, year of birth (famine or post-famine). *Household characteristics:* Mother's education, mother's age, Hindu.	Logistic

Annex 1(a) Studies of infant and child mortality included in the meta-analysis

Study	Author	Country/Dataset	Dependent Variable	Independent Variables	Estimation Method
13	Miller et al. (1992)	Bangladesh – DNFS 1975-1978, Philippines – CLHNS 1983-1986	Infant + child's risk of death	*Child characteristics:* Age, birth order/conception interval, proportion of previous children dead, child's age (breastfeeding and not breastfeeding). *Household characteristics:* Mother's education, mother's age.	Hazard
14	Curtis et al. (1993)	Brazil – DHS 1986	Infant + child mortality	*Child characteristics:* Child's gender, birth interval, fate of preceding child. *Household characteristics:* Mother's education, mother's age, region of residence. Interactions.	Logistic
15	Miller (1989)	Hungary and Sweden – WHO 1973	Infant's risk of death	*Child characteristics:* Gestation period, birth interval, gender, fate of previous child. *Household characteristics:* Mother's age.	Logistic
16	DaVanzo (1988)	Malaysia – MFLS 1976-1977	Infant mortality	*Child characteristics:* Birth interval, ethnicity. *Household characteristics:* Mother's education, mother's age, piped water, toilet sanitation. Interactions with unsupplemented and supplemented breastfeeding.	Logistic
17*	Muhuri and Menken (1997)	Bangladesh – DSS 1966-1994	Child mortality	*Child characteristics:* Age, birth-to-subsequent-conception interval, younger siblings. *Household characteristics:* Mother's education, owned 1 of 5 items, more dwelling space, family composition. Interactions.	Logistic

Annex 1(a) Studies of infant and child mortality included in the meta-analysis

Study	Author	Country/Dataset	Dependent Variable	Independent Variables	Estimation Method
18	Sastry (1997)	Brazil – DHS 1986	Infant + child's risk of death	*Child characteristics:* Age, gender, birth order, duration of breastfeeding, birth interval, fate of previous child. *Household characteristics:* Mother's education, mother's age + square, household income.	Hazard
19	Guo (1993)	Guatemala – INCAP RAND 1974-1976	Infant + child's risk of death	*Child characteristics:* Age, birth order, birth interval, fate of previous child. *Household characteristics:* Mother's education, mother's age + square, family income.	Hazard
20	Forste (1994)	Bolivia – DHS 1989	Infant + child's risk of death	*Child characteristics:* Gender, birth spacing and lactation, fate of previous child, ante-natal care and delivery. *Household characteristics:* Mother's education, mother's age, husband's education, mother works full time, birth before first union, no husband. *Community characteristics:* Region.	Hazard
21	Mellington and Cameron (1999)	Indonesia – DHS 1994	Infant + child mortality	*Household characteristics:* Mother's education, mother's age, log per capita family expenditure, owns land, husband present, husband's occupation, religion, toilet sanitation, piped water, instrument for log expenditure. *Community characteristics:* Rural residence, province.	Probit
22*	Kishor and Parasuraman (1998)	India – NFHS 1992-1993	Infant mortality/child mortality	*Child characteristics:* Age, gender, birth interval, birth order, *Household characteristics:* Mother's education, asset-ownership index, mother's employment status and employment status by type, scheduled caste, mother's age, toilet-and-water-facilities index. *Community characteristics:* region, rural residence.	Logistic

Annex 1(a) Studies of infant and child mortality included in the meta-analysis

Study	Author	Country/Dataset	Dependent Variable	Independent Variables	Estimation Method
23*	Bairagi et al. (1999)	Bangladesh – Matlab DSS 1966-1994	Infant's/child's risk of death	*Child characteristics:* Gender, birth cohort, birth order + square. *Household characteristics:* Mother's education, mother's age + square, religion. *Community characteristics:* Area. Interactions	Hazard
24*	Gyimah (2002)	Ghana – DHS 1998	Infant's risk of death	*Child characteristics:* Ethnicity, birth order, birth interval, breastfeeding status. *Household characteristics:* Mother's education, mother's age, toilet sanitation, drinking water. *Community characteristics:* Rural/urban residence, region.	Hazard
25*	Brockerhoff and Derose (1996)	5 East African Countries (Kenya, Madagascar, Malawi, Tanzania, and Zambia) – DHS 1992 onwards	Infant mortality/child mortality	*Child characteristics:* Gender, multiple births, premature birth, ante-natal visits, birth place, immunization, birth interval, birth order. *Household characteristics:* Mother's education, mother's height, mother's age, piped water. *Community characteristics:* Residence in city, country, public tap water.	Logistic
26*	Hill et al. (2001)	Kenya – DHS 1993, 1998	Infant + child's risk of death	*Child characteristics:* Gender, birth order, birth interval. *Household characteristics:* Mother's education, mother's age, household wealth quintile. *Community characteristics:* Rural/urban residence, HIV prevalence in district at time of child's birth.	Hazard
27*	Dashtseren (2002)	Mongolia – RHS 1998	Infant mortality	*Child characteristics:* Gender, birth interval. *Household characteristics:* Mother's education. *Community characteristics:* Electricity.	Logistic

Annex 1(a) Studies of infant and child mortality included in the meta-analysis

Study	Author	Country/Dataset	Dependent Variable	Independent Variables	Estimation Method
28*	Bicego and Boerma (1993)	17 countries – DHS 1987-1990	Infant mortality / infant+child mortality	*Child characteristics:* Birth interval. *Household characteristics:* Mother's education, non-use of health services, index of household economic status, indicators of water-borne exposure to disease (water and sanitation facilities).	Logistic / hazard
29*	Brockerhoff (1990)	Senegal – DHS 1986	Infant's/child's risk of death	*Child characteristics:* Birth interval, birth order. *Household characteristics:* Mother's education, migration status, rural/urban background, marital status, husband's occupation, mother's work status, mother's age, flush toilet, piped drinking water. *Community characteristics:* Region.	Hazard
30*	Dorsten et al. (1999)	Pennsylvania – Amish Data	Infant mortality	*Child characteristics:* Gender, date of birth, first born child dummy, birth order, birth interval, fate of previous child. *Household characteristics:* Mother's age. *Community characteristics:* Church district.	Logistic
31*	Muhuri and Preston (1991)	Bangladesh - DSS 1966-1994	Infant + child mortality	*Child characteristics:* Age, gender, child born in MCH-FP area, birth order dummies. *Household characteristics:* Mother's education dummy, household wealth (owned at least 1 of 5 items, more dwelling space), family composition, dwelling space per capita. Interactions of family composition with child gender dummy.	Logistic
32*	Bhuiya and Streatfield (1991)	Bangladesh - DSS 1966-1994	Infant + child's risk of death	*Child characteristics:* Gender, age dummies. *Household characteristics:* Mother's education dummies, economic condition of household (low, medium, high). *Community characteristics:* Health program in area (intensive, less intensive, none).	Hazard

Annex 1(a) Studies of infant and child mortality included in the meta-analysis

Study	Author	Country/Dataset	Dependent Variable	Independent Variables	Estimation Method
				Interaction of mother's education with child's gender dummy.	
33*	Casterline et al. (1989)	Egypt - EFS	Infant/child mortality	*Child characteristics:* Gender. *Household characteristics:* Mother's education dummies, net household income dummies, paternal status dummies, household source of water, household toilet facilities, educational aspirations for daughter, maternal demographic status (index combining maternal age, birth order, and elapsed months since previous birth - low to high risk), parental kin relationship. *Community characteristics:* Lower/upper Egypt, rural/urban residence.	Logistic
34*	Martin et al. (1983)	Philippines, Indonesia, Pakistan - WFS 1975-1980	Infant + child's risk of death	*Child characteristics:* Age dummies, gender, period of birth, birth order. *Household characteristics:* Mother's education dummies, mother's age, father's education dummies, toilet facility, electricity. *Community characteristics:* Urban/rural residence, region.	Hazard
35*	Goldberg et al. (1984)	Brazil - BEMFAM	Infant mortality	*Child characteristics:* Breastfeeding, ante-natal care, place of delivery, previous birth interval. *Household characteristics:* Mother's education dummies, mother's employment status, mother's age, number of births. *Community characteristics:* Urban/rural residence.	Logistic

Annex 1(a) Studies of infant and child mortality included in the meta-analysis

Study	Author	Country/Dataset	Dependent Variable	Independent Variables	Estimation Method
36*	Razzaque et al. (1990)	Bangladesh - DSS 1966-1994	Infant/child mortality	*Child characteristics:* Gender. *Household characteristics:* Famine-born dummy, famine-conceived dummy, articles owned, mother's age dummies. Interactions of famine-born with child's gender, articles owned, mother's age. Interactions of famine-conceived with child's gender, articles owned, mother's age.	Logistic
37*	Masset and White (2003)	Andhra Pradesh, India - NFHS	Infant (IM) + child mortality (CM)	*Child characteristics:* Gender, birth order (+ square, IM only). *Household characteristics:* Mother's age + square, household wealth index. *Community characteristics:* Unsafe water dummy, unsafe sanitation dummy, unsafe fuel dummy. IM regression only: birth interval, multiple birth dummy, immunization, number of antenatal visits, never breastfed. CM regression only: mother illiterate, region, lack of knowledge of ORT, Scheduled Tribe, Scheduled Caste, Hindu.	Hazard
38*	Howlader and Bhuiyan (1999)	Bangladesh – DHS 1996/7	Infant/child mortality	*Child characteristics:* Birth order, birth interval, gender dummy, fate of preceding child, breastfed, immunization/vaccination, antenatal care, place of delivery, assisted delivery *Household characteristics:* Mother's age dummies, mother's education, land ownership, piped/public tap water, flush toilet, electricity, visit by family planning worker *Community characteristics:* Urban/rural residence	Hazard

* Due to the absence of standard errors or t-statistics reported in these studies, the lower levels for t-statistics are used based on the level of significance. For 1% a t-statistic of 2.58, for 5% a t-statistic of 1.96, and for 10% a t-statistic of 1.65 is used. A t-statistic of 0 is used for insignificant coefficients.

Annex 1(b) Studies of determinants of nutrition

	Author	Country/ data set	Dependent variable/ Age (months)	Independent variables	Estimation method
1	Alderman (1990)	Ghana/ LSMS	HAZ/WAZ <60	*Child characteristics:* Gender, age, siblings. *Household characteristics:* Parental education, parental height, log per capita income. *Community characteristics:* Rural/urban.	IV
2	Alderman and Garcia (1994)	Pakistan/ Longitudinal survey	HAZ/WAZ	*Child characteristics:* Gender, child's age, gender, sickness, birth at hospital, vaccinations, breastfed. *Household characteristics:* Log per capita calories, log per capita proteins, parental education, household size, mother's height.	IV
3	Alderman et al. (2003)	Peru/ LSMS	HAZ <60	*Child characteristics:* Gender, age, ethnicity *Household characteristics:* Log per capita income, maternal education, paternal education, water, sanitation. *Community characteristics:* Water, sanitation, log expenditure, female education, urban/rural.	OLS(?)
4	Bairagi (1986)	Bangladesh Matlab	%WA 12-60	*Child characteristics:* Gender *Household characteristics:* Housing floor space. *Community characteristics:* Famine, season.	OLS
5	Barrera (1990)	Philippines/Bicol region survey	%HA <15	*Child characteristics:* Gender, age. *Household characteristics:* Mother's height, maternal education, mother's age, income. *Community characteristics:* Price of drugs, food prices, urban/rural, travel time to health center, water, female wage rates, sanitation.	OLS
6	Blau (1986)	Nicaragua	%HA/%WA <60	*Child characteristics:* Gender. *Household characteristics:* Log wage, other income, parental education, mother's age. *Community characteristics:* Urban/rural.	IV

Annex 1(b) Studies of determinants of nutrition

	Author	Country/ data set	Dependent variable/ Age (months)	Independent variables	Estimation method
7	Blocks (2002)	Indonesia/ NSS and Helen Keller International survey	Chb <60	*Child characteristics:* Gender, age. *Household characteristics:* No. of children, maternal education, maternal nutrition knowledge, log per capita expenditure. *Community characteristics:* Water, waste, food prices.	OLS, IV
8	Brown et al. (1994)	Niger IFPRI/ INRAN survey	WAZ <72	*Child characteristics:* Gender, age. *Household characteristics:* Public works participation, paternal labor supply, maternal labor supply, number of children, number of females, household size, per capita calorie intake, female household head.	IV
9	Burgard (2002)	Brazil/DHS, South Africa/Integrated h/h survey	HAZ <60	*Child characteristics:* Age, gender, ethnicity, age at weaning. *Household characteristics:* Parental education, wealth, mother's age, water, sanitation. *Community characteristics:* Rural/urban, literacy, hospital beds.	Logit
10	Carter and Maluccio (2003)	South Africa KIDS	HAZ <60	*Child characteristics:* Gender, age. Household characteristics: Financial losses and gains. Community characteristics: Financial gains.	OLS (FE)
11	Chawla (2001)	Nicaragua LSMS	HAZ/WHZ/WAZ <60	Child characteristics: Gender, age, breastfeeding. *Household characteristics:* Log per capita income, log per capita food expenditure, female household head, living density, number of dependents, housing quality, sanitation, maternal literacy, maternal employment. *Community characteristics:* Expected health care cost.	OLS, IV, Logit
12	Christiansen and Alderman (2003)	Ethiopia Welfare monitoring survey; I&ES; HNS	HAZ 3-60	*Child characteristics:* Gender, age. *Household characteristics:* Female education, male education, log per capita expenditure. *Community characteristics:* Water, sanitation, TV, radio.	IV

Annex 1(b) Studies of determinants of nutrition

	Author	Country/ data set	Dependent variable/ Age (months)	Independent variables	Estimation method
13	Cigno et al. (2001)	India Human development survey	BMI 72-144	*Child characteristics:* Gender, age. *Household characteristics:* Maternal age, income, poverty status, land ownership, household size. *Community characteristics:* School, child morbidity.	OLS(?)
14	Engle and Pedersen (1989)	Guatemala Institute of Nutrition Survey	HAZ/WAZ <48	*Child characteristics:* Gender, birth order. *Household characteristics:* Housing quality, maternal education, marital status, sibling help, adult help, occupation.	OLS
15	Fedorov and Sahn (2003)	Russia Longitudinal Monitoring Survey	HAZ <144	*Child characteristics:* Gender, age, lagged height. *Household characteristics:* Parents' height, maternal education, paternal education, maternal age, log per capita expenditure, food prices. *Community characteristics:* Road conditions, hospital, urban/rural.	RE
16	Gage (1997)	Kenya DHS	HAZ/WHZ 12-35	*Child characteristics:* Gender, ethnicity. *Household characteristics:* Mother's marital status, socioeconomic level, maternal education, land ownership, livestock ownership, maternal employment, maternal age, no. of siblings, no. of females, mother's height. *Community characteristics:* Urban/rural.	Logit
17	Garrett and Ruel (1999)	Mozambique Demographic and expend. survey	HAZ <60	*Child characteristics:* Gender, age. *Household characteristics:* Log per capita expenditure, paternal education, maternal education, land ownership, household composition, household size, water, sanitation, female household head, rooms per capita. *Community characteristics:* Season of survey.	OLS,IV

Annex 1(b) Studies of determinants of nutrition

	Author	Country/ data set	Dependent variable/ Age (months)	Independent variables	Estimation method
18	Girma and Genebo (2002)	Ethiopia DHS	HAZ/WHZ/ WAZ <60	*Child characteristics:* Gender, age, birth order, antenatal visits. *Household characteristics:* Maternal education, paternal education, maternal employment, economic status, sanitation, water. *Community characteristics:* Urban/rural.	Logit
19	Glewwe (1999)	Morocco LSMS	HAZ <60	*Child characteristics:* Gender, age. *Household characteristics:* Parents' height, parental schooling, per capita expenditure, health knowledge, land holdings, children overseas, language skills.	OLS (FE)
20	Glewwe et al. (2002)	Vietnam LSMS	HAZ <60	*Child characteristics:* Gender, age, ethnicity. *Household characteristics:* Mother's height, father's height, log per capita expenditure, maternal education, paternal education, religion. *Community characteristics:* Community fixed effects.	OLS, IV (FE)
21	Glick and Sahn (1998)	Guinea Cornell Health Survey	HAZ <60	*Child characteristics:* Gender, age, birth order. *Household characteristics:* Maternal labor supply, maternal income, maternal schooling, mother's age, parents' height, no. of children.	OLS, IV
22	Gragnolati (1999)	Guatemala Survey of Family Health	HAZ <60	*Child characteristics:* Gender, age, ethnicity. *Household characteristics:* Maternal education, paternal education, per capita expenditure. *Community characteristics:* Water, sanitation, TV, female literacy, road quality, distance to markets, commercial farms, population, food prices, health care services.	FE, RE

Annex 1(b) Studies of determinants of nutrition

	Author	Country/ data set	Dependent variable/ Age (months)	Independent variables	Estimation method
23	Haddad and Hoddinot (1994)	Côte d'Ivoire LSMS	%ln(HA) %ln(WA) <60	*Child characteristics:* Gender, age, relation to household head. *Household characteristics:* Mother's height, mother's age, maternal education, female income proportion, log per capita expenditure. *Community characteristics:* Male daily wage, distance to health care, distance to primary school.	FE
24	Haddad and Kennedy (1994)	Ghana/LSMS, Kenya/South Nyanza District Survey	WAZ Pre-school	*Child characteristics:* Gender, age, child of household head. *Household characteristics:* Mother's age/height, maternal education, paternal education, per capita expenditure, household size, no. of children, no. of men in household, marital status.	Logit
25	Haughton and Haughton (1997)	Vietnam VLSS	HAZ/WHZ <156	*Child characteristics:* Gender, age, birth order, sickness, ethnicity. *Household characteristics:* Parent's weight, height, age, education; farm household, water, sanitation. *Community characteristics:* Water, sanitation, urban/rural.	OLS, FE
26	Hazarika (2000)	Pakistan Integrated Household Survey	HAZ/WHZ/ WAZ <60	*Child characteristics:* Gender, age. *Household characteristics:* Parental education, parents' age, annual expenditure, household size, water, sanitation, garbage disposal, land holdings. *Community characteristics:* Urban/rural.	OLS
27	Horton (1986)	Philippines Bicol regional survey	HAZ	*Child characteristics:* Gender, age, older/younger siblings. *Household characteristics:* Assets, parental education, parental age, occupation, sanitation, water, mortality. *Community characteristics:* Rural/urban.	OLS

Annex 1(b) Studies of determinants of nutrition

	Author	Country/ data set	Dependent variable/ Age (months)	Independent variables	Estimation method
28	Horton (1988)	Philippines Bicol regional survey	HAZ/WAZ	*Child characteristics:* Gender, age, birth order. *Household characteristics:* Maternal education, total assets, parents' height, occupation, water, sanitation. *Community characteristics:* Rural/urban.	OLS
29	Johnson and Lorge Rogers (1993)	Dominican Republic Tufts/USAID survey	HAZ <72	*Child characteristics:* Age, birth weight, birth order. *Household characteristics:* Percentage female earnings, log per capita income, calories, number of children, use of healer.	OLS
30	Kennedy and Cogill (1987)	Kenya IFPRI survey	WAZ,HAZ,WHZ 6-72	*Child characteristics:* Age, gender, diarrhea, calories. *Household characteristics:* Female household head, mother's height, household size.	IV
31	Mackinnon (1995)	Uganda Integrated Survey	HAZ,WHZ <60	*Child characteristics:* Gender, age, birth order. *Household characteristics:* Expenditure, parental education, health knowledge, parents' profession, sanitation, water. *Community characteristics:* Food prices, health services.	OLS
32	Madise et al. (1999)	6 African countries LSMS	WAZ <35	*Child characteristics:* Gender, age, size at birth prenatal care, birth order, sickness, breastfed, birth intervals. *Household characteristics:* Mother's height, mother's nutritional status, mother's age, maternal education, maternal occupation, paternal occupation, no. of children, number of dead siblings, sanitation, number of household items. *Community characteristics:* Urban/rural.	OLS
33	Madise and Mpoma (1997)	Malawi DHS	WAZ <60	*Child characteristics:* Gender, age, breastfed, birth weight. *Household characteristics:* Maternal education.	OLS

Annex 1(b) Studies of determinants of nutrition

	Author	Country/ data set	Dependent variable/ Age (months)	Independent variables	Estimation method
34	Marini and Gragnolati (2003)	Guatemala LSMS	HAZ,WHZ,WAZ <60	*Child characteristics:* Gender, age. *Household characteristics:* Household size, no. of children, no. of women, parental education, parents' height. *Community characteristics:* Water, gas, electricity, housing quality, TV, phone, garbage collection, food prices, travel time to health service, urban/rural.	OLS
35	Martorell et al. (1984)	Nepal World Bank survey	%HA, %WA <120	*Child characteristics:* Gender, age. *Household characteristics:* Mother's age, caste, parental education, dietary variables.	OLS
36	Madzingira (1995)	Zimbabwe DHS	HAZ <60	*Child characteristics:* Gender, age, vaccination, sickness, previous birth interval. *Household characteristics:* Maternal education, sanitation, water, household size. *Community characteristics:* Rural/urban.	Logit
37	Maxwell et al. (2000)	Ghana IFPRI survey	HAZ <36	*Child characteristics:* Gender, age, care index. *Household characteristics:* Household food availability, maternal education, log per capita income, household size, female household head, mother's age.	OLS, Logit
38	Paknawin-Mock et al. (2000)	Indonesia ESFS survey	Ln(HAZ) Ln(WAZ) 6-18	*Child characteristics:* Gender, age. *Community characteristics:* Garbage, daycare availability, water quality, sanitation, average wage, education, crop, livestock production, elevation.	Probit, OLS
39	Pal (1999)	India WIDER survey of 6 villages	WHZ <60	*Child characteristics:* Gender, age, birth order. *Household characteristics:* Per capita income, religion, caste, female literacy, literacy.	Ordered probit
40	Ponce et al. (1998)	Vietnam VLSS	HAZ <120	*Child characteristics:* Age. *Household characteristics:* Parents' height, female household head, parental education.	FE, IV

Annex 1(b) Studies of determinants of nutrition

	Author	Country/ data set	Dependent variable/ Age (months)	Independent variables	Estimation method
41	Popkin (1980)	Philippines Household survey	%HA, %WA	*Child characteristics:* Age, gender. *Household characteristics:* Maternal child care time, paternal child care time, mother's nutritional status, water.	Probit(?)
42	Quisumbing (2003)	Ethiopia Rural household survey	HAZ, WHZ <60, 60-108	*Child characteristics:* Gender, age. *Household characteristics:* Food-for-work aid, food aid, female recipient of aid.	RE
43	Ricci and Becker (1996)	Philippines Cebu longitudinal survey	HAZ <30	*Child characteristics:* Gender, age, birth weight, prenatal visits, breastfed. *Household characteristics:* Maternal education, paternal education, mother's age, TV, radio, water, sanitation, housing quality, persons per room.	Logit
44	Rubalcava and Contreras (2000)	Chile Household Survey	Nutrition status <30	*Child characteristics:* Gender, birth order. *Household characteristics:* Parental education, parent's age, mother's income, father's income.	Logit
45	Ruel et al. (1992)	Lesotho	Weight	*Child characteristics:* Gender, age, clinic attendance, birth order. *Household characteristics:* Nutrition knowledge, maternal schooling, family composition, wealth.	IV
46	Ruel et al. (1999)	Ghana IFPRI Survey	HAZ 4-48	*Child characteristics:* Gender, age. *Household characteristics:* Mother's age, maternal education, mother's height, female household head, ethnicity, care score index, income, calorie availability, assets, household size.	OLS, IV
47	Sahn (1990)	Côte d'Ivoire LSMS	HAZ <60	*Child characteristics:* Age, birth order, sickness. *Household characteristics:* Parents' height, number of children, log per capita expenditure, household size, mother's age, parental education, distance to health care, land holdings.	IV

Annex 1(b) Studies of determinants of nutrition

	Author	Country/ data set	Dependent variable/ Age (months)	Independent variables	Estimation method
48	Sahn and Alderman (1997)	Mozambique Integrated household survey	HAZ <24, 24-72	*Child characteristics:* Gender, age. *Household characteristics:* Log per capita expenditure, maternal education, female household head, mother's height, mothers age, sanitation, time to clinic, migration status.	IV
49	Senauer and Garcia (1991)	Philippines National nutrition council/IFPRI survey	HAZ, WHZ <84	*Child characteristics:* Gender, age, birth order. *Household characteristics:* Parents' age, parental education, men's wage, women's wage. *Community characteristics:* Food prices.	FE, OLS
50	Senauer and Kassouf (1996)	Brazil Health and Nutrition Survey	HAZ, WAZ, WHZ 24-60	*Child characteristics:* Gender, age. *Household characteristics:* Parents' nutritional status, parental education, log mother's wage, log father's wage, log total income. *Community characteristics:* Urban/rural.	IV
51	Skoufias (1999)	Indonesia National socioeconomic survey	WAZ <60	*Child characteristics:* Age. *Household characteristics:* Maternal education, paternal education, mother's age, female household head, log per capita expenditure, radio, water, sanitation.	IV
52	Sobrado et al. (2000)	Panama LSMS	HAZ, WAZ, WHZ <60	*Child characteristics:* Gender, age, vaccinations, sickness, breastfeeding. *Household characteristics:* Maternal education, mother's age, mother sick, mother absent, per capita food consumption, land holdings, workers per capita, agriculture. *Community characteristics:* Rural/urban.	OLS
53	Stifel et al. (1999)	9 African countries DHS	HAZ, WAZ, WHZ <60	*Child characteristics:* Gender, age, birth order. *Household characteristics:* Prenatal care, family composition, female head of household, mother's age, parental education sanitation, water. *Community characteristics:* Rural/urban.	OLS

Annex 1(b) Studies of determinants of nutrition

	Author	Country/ data set	Dependent variable/ Age (months)	Independent variables	Estimation method
54	Strauss (1990)	Côte d'Ivoire LSMS	Ln(HAZ) <72	*Child characteristics:* Gender, age, child of senior wife. *Household characteristics:* Log mother's height, maternal education, paternal education, mother's age, land holdings. *Community characteristics:* Male wages, distance to healthcare, distance to school, water, Major health problems, traditional healer.	FE, RE
55	Tharakan and Suchindran (1999)	Botswana Child nutritional status survey	HAZ, WAZ, WHZ <72	*Child characteristics:* Age, birth weight, dairy products intake, staple foods intake, breastfed. *Household characteristics:* Female household head, parental education.	Logit, ordered logit
56	Thomas and Henriques (1990)	Brazil ENDEF survey	%HA <107	*Household characteristics:* Maternal education, paternal education, parental height, log income, log expenditure.	OLS
57	Thomas et al. (1990)	Brazil DHS	Ln(%HA), ln(%WA) <60	*Child characteristics:* Age, gender. *Household characteristics:* Parental educational, TV, radio, newspaper, female household head. *Community characteristics:* Water, sanitation, health care facilities, schools.	OLS, IV
58	Thomas et al. (1996)	Côte d'Ivoire LSMS	HAZ,WAZ <144	*Child characteristics:* Age, child of household head, gender. *Household characteristics:* Log per capita expenditure, maternal education, paternal education, female headed household. *Community characteristics:* Health facilities, infrastructure, availability of medicine, food prices.	IV
59	von Braun et al. (1989)	Guatemala IFPRI survey	HAZ, WAZ, WHZ 6-120	*Child characteristics:* Gender, age, birth order, breastfeeding. *Household characteristics:* Per capita expenditure, male/female income share not from agriculture, income share from export crops.	OLS

Annex 1(b) Studies of determinants of nutrition

	Author	Country/ data set	Dependent variable/ Age (months)	Independent variables	Estimation method
60	Wagstaff et al. (2003)	Vietnam VLSS	HAZ <120	*Child characteristics:* Gender, age. *Household characteristics:* Log per capita consumption, water, sanitation, maternal education, paternal education.	OLS, FE
61	Yasoda Devi and Geervani (1994)	India Medak District Survey (AP)	HAZ, WAZ <48	*Child characteristics:* Age, diarrhea, calorie adequacy, regular bathing. *Household characteristics:* Help from grandparents, father affectionate, caste, no. of children attending school, income, land holding, per capita food expenditure.	Ordered logit

Logarithms of variables are in *italic*.

Annex 2(a) Significance of regression variables: mortality

	Specification	Income/ earnings	mother's education	mother's age	mother's age squared	boys	birth order	preceding birth interval	succeeding birth interval	breast-feeding duration	previous child died	antenatal care	electricity	urban	sanitation	water
Bairagi et al. (1999)	I		--	---	+++	+++	--									
Bairagi et al. (1999)	C		---	--		---	+++									
Bhuiya and Streatfield (1991)	I+C	---	---			---										
Bicego and Boerma (1993)	I		#													
Bicego and Boerma (1993)	C		--													
Brockerhoff (1990)	I	#	#				#	#							#	#
Brockerhoff (1990)	C	--	#				#	#							#	--
Brockerhoff and Derose (1996)	I		#	---		+++[1]	#	---				---				---
Brockerhoff and Derose (1996)	C		#	--			#					---				--
Casterline et al. (1989)	I	#	#			#								#	#	#
Casterline et al. (1989)	C	--	#			#								#	#	#
Curtis et al. (1993)	I+C		--	-		+++					-					
Da Vanzo (1988)	I		---	#		++		---							---	---
Da Vanzo and Habicht (1986): 1946-60	I		#					---		---					---	---
Da Vanzo and Habicht (1986): 1961-75	I		---					#		---					#	--
Da Vanzo et al. (1983)	I	#	--	#		+++	#	---		---				#	---	#
Dashtseren (2002)	I		---			+++		---					--			
Dorsten et al. (1999)	I					++	#	#			+++					

Annex 2(a) Significance of regression variables: mortality

	Specification	Income/ earnings	mother's education	mother's age	mother's age squared	boys	birth order	preceding birth interval	succeeding birth interval	breast-feeding duration	previous child died	antenatal care	electricity	urban	sanitation	water
Forste (1994)	I+C		#	-		#	+++			---	#	-				
Frankenberg (1995)	I		---			++	+	---								
Goldberg et al. (1984)	C		#	#				#		---		---		#		
Guo (1993)	I+C	--	---	--	++		#	-	#		#					
Gyimah (2002)	I		#	+++			#	0		---				#	#	--
Hill et al. (2001)	I+C	---	---	---		#	#	---						++		
Howlader and Bhuiyan (1999)	I		---	---		+++	+++	---		-	+++	---	---	#	---	#
Howlader and Bhuiyan (1999)	C		---	---		---	#	0		---	+++	---	#	--	#	#
Kanaiaupuni and Donato (1999)	I		---	---	++											++
Kishor and Parasuraman (1998)	I	---	---	---		+++	#	---						#		
Kishor and Parasuraman (1998)	C	---	---	#		---	#	---						#		
Koenig et al. (1990)	I		#			#		---[1]			#					
Koenig et al. (1990)	C		--			---		#	---		+++					
Kravdal (2003)	I+C		---	++			---	-								
Martin et al. (1983): Philippines	I+C		--	--		++	++						--	--	--	
Martin et al. (1983): Indonesia	I+C		--	--		++	++							#		
Martin et al. (1983): Pakistan	I+C		--	--		#	++							#		
Masset and White (2003)	I	#		#	+	#	#			-		---			#	#
Masset and White (2003)	C	-	#	++	--	---	+++								#	---
Mellington and Cameron (1999)	I+C	---	---	+++			+++							#	---	---

Annex 2(a) Significance of regression variables: mortality

	Specification	Income/ earnings	mother's education	mother's age	mother's age squared	boys	birth order	preceding birth interval	succeeding birth interval	breast-feeding duration	previous child died	antenatal care	electricity	urban	sanitation	water
Miller (1989)	I			+++		+++		#			+++					
Miller et al. (1992): Bangladesh	I+C		-	#			#				+++					
Miller et al. (1992): Philippines	I+C		---	#			#									
Muhuri and Menken (1997)	C	-	#													
Muhuri and Preston (1991)	I+C	---	---			-	#									
Nguyen-Dinh and Feeny (1999)	I	#	--	#	#		#	#						#		
Nguyen-Dinh and Feeny (1999)	C	#	#	#	#		+++	#						#		
Panis and Lillard (1995)	I+C	---	---	#		+++						--				
Pebley and Stupp (1987)	I+C	---	--	+++	+++	#	#	--	#	---	#					
Razzaque et al. (1990)	I	#				+++[1]										
Razzaque et al. (1990)	C	---				---										
Sastry (1996)	C (NE Brazil)	--	-	#	#	#							#	#	--	--
Sastry (1996)	C (S/SE Brazil)	#	-	#	#	#							#	+++	#	#
Sastry (1997)	I+C	---	---	---	+++	++	+		#	---	#					
Sear et al. (2002)	I			#		#	#	+++								
Sear et al. (2002)	C			#		--	#	+++	--							
Zenger (1993)	I		#[1]	+[1]		+++[1]	+++[1]	---[1]			+++[1]					

Notes: 1/ Results for neonatal mortality; I Regression of determinants of infant mortality; C Regression of determinants of child mortality; I+C determinants of infant and child mortality pooled regression.
Significance: + 10%, ++ 5%, +++ 1%, # variable included, but not significant at 10%, - 10%, -- 5%, --- 1%

Annex 2(b) Significance of regression variables: nutrition

	Income	female head	household size	young children	older children	female education	female literacy	male education	male literacy	boys	urban	sanitation	water	community sanitation	community water
Alderman (1990)	+		-				#		#	#	#				
Alderman and Garcia (1994)			---			+		+		#					
Alderman, Hentschel and Sabates (2003)	+++					+++		#		#	+++	# [1]	# [1]	#	#
Brown, Yohannes and Webb (1994)		#	+	#	++					--					
Carter and Maluccio (2003)								#							
Chawla (2001)	+++	+					+++			#		+	#		
Christiansen and Alderman (2003)	+++	#	+++				+++		+++	---				#	#
Engle and Pedersen (1989)						+++				#					
Fedorov and Sahn (2003)	#							#			-				
Garrett and Ruel (1999): children younger than 24 months, rural	++	#	#	--	#		++		#	---		#	#		
Garrett and Ruel (1999): children younger than 24 months, urban	++	#	#	--	#		++		#	---		#	#		
Garrett and Ruel (1999): children between 24 and 60 months, rural	+++	#	++	#	#		#		#	#		#	#		
Garrett and Ruel (1999): children between 24 and 60 months, urban	+++	#	++	#	#		#		#	#		#	+++		
Glewwe (1999)	++					#				#					
Glewwe, Koch and Nguyen (2002): rural 1992	++					#		+		#					
Glewwe, Koch and Nguyen (2002): rural 1997	#					#		#		#					
Glewwe, Koch and Nguyen (2002): urban 1992	+++					+		--		#					
Glewwe, Koch and Nguyen (2002): urban 1997	#					#		#		#					
Glick and Sahn (1998)	++			-			#			--					
Gragnolati (1999)	+++					+++	#	+++	#	#				---	++
Haughton and Haughton (1997)						++		++		#	+++		+++		
Hazarika (2000)	#		#			#		#		--		#	#		
Horton (1986)							#		++	-	#	#	+++		

Annex 2(b) Significance of regression variables: nutrition

	Income	female head	household size	young children	older children	female education	female literacy	male education	male literacy	boys	urban	sanitation	water	community sanitation	community water
Horton (1988)							#			#		#	++		
Johnson and Lorge Rogers (1993)	#			#						#/+					
Senauer and Kassouf (1996)	+++						+++		#	#	---	+++	+++		
Kennedy and Cogill (1987)		+++	#							--					
Mackinnon (1995)				#		#		#		---	+++				
Madise and Mpoma (1997)							+			---					
Madise, Matthews and Margetts (1999):Ghana				---		#				--		+++			
Madise, Matthews and Margetts (1999): Malawi				#		#				---		+++			
Madise, Matthews and Margetts (1999): Nigeria				---		#				---		+++			
Madise, Matthews and Margetts (1999): Tanzania				#		++				--		#			
Madise, Matthews and Margetts (1999): Zambia				--		#				---		+++			
Madise, Matthews and Margetts (1999): Zimbabwe				--		#				---		#			
Marini and Gragnolati (2003)	+++	++	#	#			#		#	#	++			#	#
Maxwell, Levin, Armar-Klemesu, Ruel, Morris and Ahiadeke (2000)	+++	#	#			#				#					
Ponce, Gertler and Glewwe (1998): rural	+++	+++					++		+						
Ponce, Gertler and Glewwe (1998): urban	++	+++					+		#						
Ruel, Habicht and Pinstrup-Andersen (1992)										---					
Ruel, Levin, Armar-Klemesu and Maxwell (1999)		#					+++			#					
Sahn (1990)	+		#	++	++	#		#		#					
Sahn and Alderman (1997)	++	++					#			---		#			
Senauer and Garcia (1991)						#		#		+++					
Stifel, Sahn and Younger (1999):			#	#		#		#		#	#	+	#		

Annex 2(b) Significance of regression variables: nutrition

	Income	female head	household size	young children	older children	female education	female literacy	male education	male literacy	boys	urban	sanitation	water	community sanitation	community water
Ghana 1988															
Stifel, Sahn and Younger (1999): Ghana 1993			#	--		#		#		--	++	#	+		
Stifel, Sahn and Younger (1999): Madagascar 1992			#	---		#		#		--	+	+	#		
Stifel, Sahn and Younger (1999): Madagascar 1997			#	---		++		--		---	++	#	#		
Stifel, Sahn and Younger (1999): Mali 1987			#	#		#		#		#	#	#	#		
Stifel, Sahn and Younger (1999): Mali 1995			-	#		#		#		--	++	#	#		
Stifel, Sahn and Younger (1999): Senegal			#	#		+++		++		#	+++	#	#		
Stifel, Sahn and Younger (1999): Tanzania 1991			+++	#		+		#		---	#	+++	#		
Stifel, Sahn and Younger (1999): Tanzania 1996			++	#		#		#		#	#	+++	+		
Stifel, Sahn and Younger (1999): Uganda			#	#		#		#		---	+++	#	#		
Stifel, Sahn and Younger (1999): Zambia			++	#		#		#		---	+	+++	#		
Stifel, Sahn and Younger (1999): Zimbabwe			#	-		-		#		--	#	+++	+		
Thomas, Strauss and Lavy (1996)	#	#				#	#	+++	++	#					
von Braun, Hotchkiss and Immink (1989)	++									#					
Wagstaff, van Doorslaer and Watanabe (2003)	+++					+		#		---					

Significance: + 10%, ++ 5%, +++ 1%, # variable included, but not significant at 10%, - 10%, -- 5%, --- 1%,
[1] presence of both water and sanitation has significant positive effect

Annex 3a Significance of variables in mortality regressions by region

Table 1 Income and expenditure			
Region	*Negative*	*Zero*	*Positive*
W Africa	Senegal (C)	Senegal (I)	
E & S Africa	Kenya (I+C)		
N Africa	Egypt (C)	Egypt (I)	
C America	Guatemala (I+C)		
S America	NE Brazil (I+C)	S/SE Brazil (I+C)	
E Asia	Indonesia (I+C), Malaysia 1988 (I+C)	Vietnam (I, C), Malaysia 1977 (I)	
S Asia	Bangladesh (I+C, C), India (I, C), Andhra Pradesh (C)	Bangladesh (I), Andhra Pradesh (I)	
Notes: C regression of child mortality; I regression of infant mortality; I+C regression of infants and children together.			

Table 2 Preceding birth interval			
Region	*Negative*	*Zero*	*Positive*
W Africa		Senegal (I, C), Ghana (I)	Gambia (I, C)
E & S Africa	Kenya (I+C)		
C America	Guatemala (I+C)		
S America		Brazil (C)	
E Asia	Malaysia 1961-75 (I), 1977 (I), Mongolia (I), Indonesia 1987 (I)	Malaysia 1946-60 (I), Vietnam (I, C), Guatemala (I+C)	
S Asia	Bangladesh (I), India (I, C)	Bangladesh (C)	
Notes: C regression of child mortality; I regression of infant mortality; I+C regression of infants and children together.			

Table 3 Succeeding birth interval			
Region	*Negative*	*Zero*	*Positive*
W Africa	Gambia (C)		
C America		Guatemala (I)	Guatemala (C)
S America		Brazil (I+C)	
S Asia	Bangladesh 1966-94 (C)		
Notes: C regression of child mortality; I regression of infant mortality; I+C regression of infants and children together.			

Table 4 Mother's education			
Region	*Negative*	*Zero*	*Positive*
W Africa		Senegal (I, C), Ghana (I)	
E & S Africa	Kenya (I+C)		
N Africa		Egypt (I, C)	
C America	Guatemala (I+C), Mexico (I)		
S America	Brazil (I+C)	Bolivia (I+C), Brazil (C)	
E Asia	Malaysia (I, I+C), Mongolia (I), Indonesia (I, I+C), Philippines (I+C), Vietnam (I)	Vietnam (C)	
S Asia	Bangladesh 1966-94 (C, I+C), Bangladesh (C), India (I,C), Pakistan (I+C)	Bangladesh (I), Andhra Pradesh (C)	

Notes: C regression of child mortality; I regression of infant mortality; I+C regression of infants and children together.

Table 5 Male child

Region	*Negative*	*Zero*	*Positive*
W Africa	Gambia (C)	Gambia (I)	
E & S Africa		Kenya (I+C)	
N Africa		Egypt (I,C)	
C America		Guatemala (I+C)	
S America		Bolivia (I+C)	Brazil (I+C)
E Asia			Malaysia (I), Mongolia (I), Indonesia (I), Philippines (I+C)
S Asia	Bangladesh (C), India (C), Andhra Pradesh (C)	Bangladesh (I), Pakistan, Andhra Pradesh (I)	Bangladesh (N), India (I)

Notes: C regression of child mortality; I regression of infant mortality; I+C regression of infants and children together; N neonatals only.

Table 6 Water

Region	*Negative*	*Zero*	*Positive*
W Africa	Senegal (C), Ghana (I)	Senegal (I)	
N Africa		Egypt (I,C)	
C America			Mexico (I)
S America	NE Brazil (C)	S/SE Brazil (C)	
E Asia	Malaysia (I), Indonesia (I+C)		
S Asia	Bangladesh (I,C), Andhra Pradesh (C)	Andhra Pradesh (I)	

Notes: C regression of child mortality; I regression of infant mortality; I+C regression of infants and children together.

Table 7 Sanitation

Region	*Negative*	*Zero*	*Positive*
W Africa		Senegal (I,C), Ghana (I)	
N Africa		Egypt (I,C)	
S America	NE Brazil (C)	S/SE Brazil (C)	
E Asia	Malaysia (I), Philippines (I+C), Indonesia 1994 (I+C)	Indonesia 1975-8 (I+C)	
S Asia	Bangladesh (I)	Bangladesh (C), Andhra Pradesh (I,C)	

Notes: C regression of child mortality; I regression of infant mortality; I+C regression of infants and children together.

Annex 3b Significance of variables in nutrition studies by region

Table 1 Income and expenditure

Region	*Negative*	*Zero*	*Positive*
W Africa		Côte d'Ivoire 1986	Côte d'Ivoire 1986, Ghana, Guinea
E & S Africa			Ethiopia, Mozambique
N Africa			Morocco
E Asia		Vietnam 1998	Vietnam 1993
C America		Dominican Rep.	Nicaragua, Guatemala
S America			Brazil, Peru
S Asia		Pakistan	Bangladesh
Europe & C Asia		Russia	

Notes: Different studies on the same data report different impacts of income, as e.g. in the case of LSMS data for Côte d'Ivoire where Sahn (1990) estimates a significantly positive coefficient on per capita expenditure, but Thomas et al. (1996) report positive but insignificant coefficients in most specifications. In the case of Vietnam's LSMS, both Wagstaff et al. (2003) and Glewwe et al. (2002) find income significantly positive in all OLS specifications but in the latter paper, income becomes insignificant in community-level fixed effects estimation in 1998 (which is the specification reported here) and for most IV estimations. While per capita expenditures are significant in Morocco in OLS (Glewwe, 1999), this result is not robust in some 2SLS specifications (instrumenting for expenditure and skills) nor when income is proxied by measures of household assets.

Table 2 Female head

Region	*Negative*	*Zero*	*Positive*
W Africa		Côte d'Ivoire, Ghana, Niger	
E & S Africa		Ethiopia, Mozambique 1996	Kenya, Mozambique 1992
E Asia			Vietnam
C America			Nicaragua, Guatemala

Notes: The female household head dummy is significantly positive in Mozambique 1992 (Sahn and Alderman, 1997), though insignificant in 1996 (Garrett and Ruel, 1999). This may represent better conditions for children in households where women have more power as demonstrated by female headship, though may also arise because the later study includes more household-level explanatory variables such as for household size and composition and physical size of home (rooms per capita and land per capita), the effects of which on nutrition perhaps the female head dummy would otherwise pick up.

Table 3 Household size

Region	*Negative*	*Zero*	*Positive*
W Africa	Ghana 1980s, Mali 1995	Côte d'Ivoire, Ghana, Guinea, Mali 1987, Senegal	Niger
E & S Africa		Kenya, Madagascar, Uganda, Zimbabwe, Mozambique	Ethiopia, Tanzania, Zambia
S America		Guatemala	
S Asia	Pakistan 1986	Pakistan 1991	

Notes: Household size is an insignificant determinant of nutrition in Mozambique (Garrett and Ruel, 1999) in all OLS specifications, but has a positive impact for children aged 24-60 in 2SLS (instrumenting for income). Studies of Pakistan imply the impact of household size changed over time, from negative in 1986 to insignificantly different from zero by 1991, though the negative significance in 1986 could simply reflect inclusion of fewer household controls such as for income/wealth (per capita), sanitation and water in that study (Alderman and Garcia, 1994) – if any of these are negatively correlated with household size then their exclusion would bias the latter coefficient downward (i.e. more negatively).

Table 4 Male child

Region	*Negative*	*Zero*	*Positive*
W Africa	Ghana 1993, Guinea, Mali 1995, Niger	Côte d'Ivoire, Ghana 1980s 1997, Mali 1987, Senegal	
E & S Africa	Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Uganda, Zimbabwe, Mozambique (<24 mos.), Tanzania 1991 1993, Zambia	Mozambique (>24<60 mos.), Tanzania 1996	
N Africa		Morocco	
E Asia	Vietnam 1993 & 1998	Philippines, Vietnam 1993 & 1998	Philippines
C America		Nicaragua, Guatemala, Dominican Rep.	
S America		Brazil, Peru	
S Asia	Pakistan 1991	Pakistan 1987	

Table 5 Female education

Region	*Negative*	*Zero*	*Positive*
W Africa		Côte d'Ivoire, Ghana, Guinea, Mali, Nigeria	Senegal
E & S Africa		Madagascar 1992, Malawi, Uganda, Zimbabwe, Tanzania 1996, Zambia	Ethiopia, Madagascar 1997, Tanzania 1991 1993
N Africa		Morocco	
E Asia		Philippines, Vietnam 1993 (Rural), 1998	Vietnam 1993 (Urban)
C America			Guatemala
S America			Peru
S Asia		Pakistan 1991	Pakistan 1986, Bangladesh

Notes: Female schooling is an insignificant determinant of nutrition in Morocco (Glewwe, 1999) in specifications reported here, though it is significantly positive where per capita expenditure is not included as dependent variable (and assets are instead) – in contrast male education is insignificant in these specifications.

Table 6 Female literacy

Region	*Negative*	*Zero*	*Positive*
W Africa		Côte d'Ivoire, Ghana 1980s, Guinea	Ghana 1997
E & S Africa		Mozambique (>24<60 mos.)	Ethiopia, Madagascar 1997, Mozambique (<24 mos.)
E Asia		Philippines	Vietnam
C America		Guatemala	Nicaragua
S America			Brazil

Table 7 Male education

Region	*Negative*	*Zero*	*Positive*
W Africa		Côte d'Ivoire, Ghana, Mali	
ES Africa		Madagascar, Uganda, Zimbabwe, S Africa, Tanzania, Zambia	
E Asia	Vietnam 1993 (Urban)	Philippines, Vietnam 1998	Vietnam 1993 (Rural)
C America			Guatemala
S America		Peru	
S Asia		Pakistan 1991	Pakistan 1986
Europe & C Asia			Russia

Table 8 Male literacy

Region	*Negative*	*Zero*	*Positive*
W Africa		Ghana	Côte d'Ivoire
E & S Africa		Mozambique	Ethiopia
E Asia		Vietnam (Urban)	Philippines, Vietnam (Rural)
C America		Guatemala	
S America		Brazil	

Table 9 Sanitation

Region	*Negative*	*Zero*	*Positive*
W Africa		Ghana 1993, Senegal	Ghana 1988, Nigeria
E & S Africa		Madagascar 1997, Uganda, Zimbabwe 1994, Mozambique, Tanzania 1993	Madagascar 1992, Malawi, Zimbabwe 1988 & 94 (pooled), Tanzania 1991 1996, Zambia
E Asia		Philippines 1978	
C America			Nicaragua
S America		Peru	Brazil
S Asia		Pakistan	Bangladesh

Table 10 Water

Region	*Negative*	*Zero*	*Positive*
W Africa		Ghana 1988, Mali, Senegal	Ghana 1993
E & S Africa		Madagascar, Uganda, Mozambique 1991 1996, Tanzania 1991, Zambia	Zimbabwe, Mozambique Urban 1996 (>24<60 mos.), Tanzania 1996
E Asia			Philippines 1978, Vietnam
C America		Nicaragua, Peru	Brazil
S Asia		Pakistan	

Notes: Sanitation and water have insignificant effect on nutrition in Mozambique in all specifications apart from in urban 1996/7 for children aged between 24 and 60 months.

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