

Child Malnutrition and the Provision of Water and Sanitation in the Philippines

JOSE CUESTA

Inter-American Development Bank, Washington, DC, USA

ABSTRACT *The prospects for achieving the Millennium Development Goal on nutrition are predicted to be bleak in the Philippines. These predictions, however, take no account of the interactions between nutritional and sanitary interventions. These interactions are reported to matter in the Philippines and elsewhere, but evidence is far from conclusive. Using a nationwide demographic survey, this paper employs two alternative estimation techniques (probits and propensity matching scores) to quantify such relations among Filipino households. The results confirm that water and sanitation provision have a positive effect on nutritional status, but these effects are not substantial. Community-based piped water provision and flush toilets have the greatest potential to reduce malnutrition. Household access to point source water and latrines are more likely to reduce the probability of birth malnutrition among poor households than other public infrastructure. Such interactions, however, cannot substitute for improving the coverage and quality of overall health and nutrition interventions.*

KEY WORDS: Child malnutrition, water and sanitation, Philippines, propensity matching scores, interaction effects

JEL-CLASSIFICATIONS: I12, O12, O53

Introduction

According to UNDP (2003), if the trends and the degree of policy and institutional support which were witnessed in the 1990s are maintained until 2015, the prospects of meeting the Millennium Development Goals (MDGs) for safe drinking water and under-5 mortality are high in the Philippines. Predictions are much less optimistic for maternal mortality and rather bleak for under-5 malnutrition. It is not possible, however, to understand progress in nutritional and health status and basic infrastructure in isolation. Poverty, malnutrition, lack of educational attainment and poor community infrastructure are inextricably linked.

The few international studies that have estimated the impact of public community services on malnutrition report substantial effects. For the Philippines, Thomas &

Correspondence Address: Jose Cuesta, Inter-American Development Bank, 1300 New York Avenue, NW; Washington, DC 20577. USA. Email: josecue@iadb.org

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Strauss (1992) find positive returns on children's nutritional status accruing from the provision of clean water, modern sewerage systems and electricity. Using different data sources, Barrera (1990) also demonstrates a relationship between water and sanitation facilities and children's malnutrition in the country. These relationships, however, are not uniform either by age group or maternal educational categories and are not always statistically significant. Indeed, the direction of such interactions is a matter for empirical study.

Beyond acknowledging the presence of such relationships, they do not seem to have much influence on policy-making in the Philippines. This study explores the extent to which progress in nutrition and public provision of basic services go hand in hand, and the direction of their relationship. Such an exploration is critical in evaluating whether the prospects for reaching the malnutrition MDG are indeed as bleak as currently painted. The next two sections summarize the current state of water and sanitation provision and of child malnutrition in the Philippines, respectively. The fourth section discusses the methodological strategy to quantify such relations, while the fifth section elaborates on the choice of the dataset and variables used in the empirical analysis. The sixth section reports the estimated links between water and sanitation services and malnutrition, before the seventh section presents the main conclusions of the study.

Water Supply and Sanitation in the Philippines

The relevance of the water and sanitation sectors in the Philippines goes beyond health and nutritional considerations alone. Water and sanitary provision at the community level provides opportunities to strengthen the participation of local government units in decisions affecting their livelihoods. Although not widespread, privatization (in the form of concessions) of water provision and sanitation constitutes a valuable experience for other major market-oriented reforms in the Philippines. In addition, the development of a rational and effective economic regulation mechanism for piped-water supply and sewerage systems (resulting in the 2002 Water Regulatory Commission Act) is a good example of institutional capacity building.

These potential benefits have attracted increased attention to these sectors. As a result, the government's medium-term developmental strategy (MTPDP) set an ambitious target for the provision of water (GoP, 2001). By 2004, 91.8 percent of the population was expected to have access to a safe supply of water. However, in 2000 (the last year for which national figures are available), access rates were at 78.5 percent, still far short of the official target. As Figure 1 indicates, meeting the 2004 MTPDP goal would have required that the historical rate at which coverage was expanded should increase fourfold between 1998 and 2004. Early fulfilment of the MDG on safe drinking water, by contrast, only requires that existing rates of service expansion be maintained.

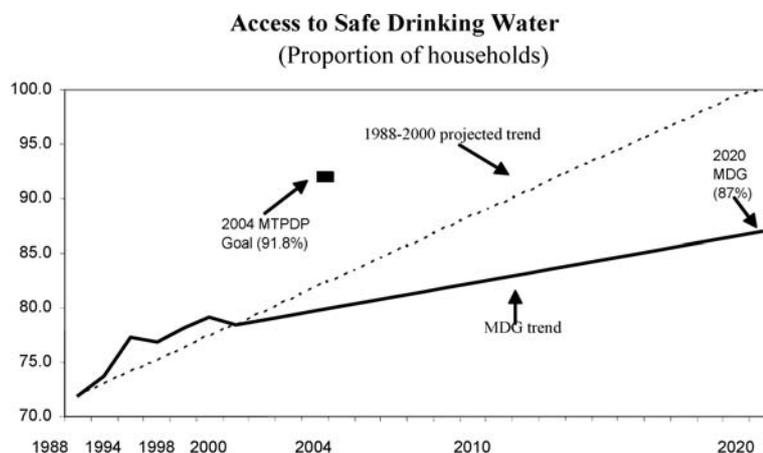


Figure 1. Access to safe water in the Philippines, 1998–2025.

Source: Family Income and Expenditures Surveys 1988, 1991, 1994, 1998 (NSO, 1998b); Annual Poverty Indicators Survey, 1998, 2000 (NSO, 1998a, 2000); MTPDP 2001–2004 (GoP, 2001); UNDP (2003); NSCB (2000).

The ambitious MTPDP national target also fails to account for wide regional differences. Table 1 shows that the urban–rural gap in both access to safe drinking water and sanitation facilities exceeds 20 percent. Although the gap is less than that demonstrated by other socio-economic indicators (see Table 2), it is still substantial. Regional differences in the access to safe drinking water are even wider.¹

Despite these marked geographical differences, UNDP (2003) regards as ‘fair’ the prospects of the water sector achieving substantial increases in coverage by 2015. Such an assessment might seem overly optimistic. While the privatization of services and the increased involvement of local government units in the provision of water may well be steps in the right direction, implementation of these steps is very slow. Improvements in access to water and sanitation facilities require increasing investment, whereas the MTPDP has projected a drop in sanitation investment in 2005 and 2006 (GoP, 1999), reversing the steady increase from 1999 to 2004. Furthermore, sectoral investments are biased in favour of water supply: the World Bank has estimated that water supply programmes appropriated 97 percent of the public joint investment budget for water, sewerage and sanitation in 2000 (World Bank, 2003: 28).

The treatment of wastewater has been unable to keep up with the increasing demands for water supply. Increases in demand for safe water have already reached worrying levels, and JICA (1998) has estimated that the aggregated water demand will triple in the major cities between 1995 and 2025. All major cities (except Iloilo

Table 1. Access to safe drinking water and sanitation facilities by urbanity

Main Source of Drinking Water	Urban	Rural	Total	Sanitation Facility	Urban	Rural	Total
Safe				Sanitary			
Piped into dwelling	46.6	14.0	30.2	Own flush toilet	71.1	48.1	59.5
Piped into yard/plot	7.8	5.4	6.6	Shared flush toilet	16.3	12.1	14.2
Piped into public yard	11.4	11.7	11.6	Closed pit latrine	4.9	9.6	7.3
Protected well	24.8	40.0	32.5	Unsanitary			
Bottled	1.6	0.0	0.8	Open pit latrine	2.4	9.7	6.1
Doubtful Source				No facilities/field	3.6	17.0	10.3
Unprotected well	1.9	11.2	6.6	Drop/overhang	1.4	2.9	2.1
Developed/underdeveloped spring	1.9	15.0	8.5	Other	0.0	0.1	0.1
River/stream/pond/lake/rainwater	0.5	1.5	1.1	Missing	0.4	0.5	0.4
Tanker truck/peddler	3.3	0.9	2.1				
Others	0.1	0.1	0.1				

Source: DoH (1999).

and Angeles) are expected to run water demand deficits by 2025. Within this bleak scenario, World Bank (2003) reports that up to 58 percent of sampled groundwater contains coliform contamination and needs further treatment. Data from the National Epidemiological Centre suggest that 31 percent of illnesses monitored in the Philippines came from water-borne sources (although the year of that data was not provided). Diseases caused by poor water include gastroenteritis, diarrhoea, typhoid, cholera, dysentery, hepatitis and, more recently, the severe acute respiratory syndrome.

Water-related diseases are estimated to have caused over five million episodes of illness between 1996 and 2000, ranking second to respiratory diseases as the main source of illness in the Philippines (World Bank, 2003). Estimates from the

Table 2. Urban–rural gaps among household socio-economic proxies

	Total	Urban	Rural	Urban-rural gap
Access to safe drinking water	81.7	92.2	71.1	21.1
Access to sanitary facilities	81.0	92.3	69.8	22.5
Household has quality flooring	56.9	73.5	40.8	32.7
Household has electricity	71.3	91.1	51.9	39.2
Households has 1-2 persons per sleeping room	52.9	57.9	48.0	9.9
Household consumes iodized salt	10.9	15.4	6.4	9.0

Source: DoH (1999).

Note: Safe drinking water sources include any kind of piped water and from protected wells. Sanitary facilities include own flush and shared flush toilets and closed pit latrine. Quality flooring refers to parquet, asphalt strips, ceramic tiles, cement and marble.

Department of Health (cited in World Bank, 2003) suggest that direct income losses accruing from water-related illnesses amounted to Ph. Pesos 2.3 billion in 2002, or approximately 0.2 percent of GDP.² Costs to the tourism and fisheries industries, estimated at Ph. Peso 47 billion and Ph. Peso 17 billion, respectively (BFAR, 2002) constitute additional losses. At the same time, buying bottled water represents a sizeable economic cost, especially for the poor. The average price of bottled water at Ph. Peso 50 per gallon (Ph. Peso 2642 per cubic metre) makes it vastly more expensive than the average price of drinking water supplied by the Metropolitan Waterworks and Sewerage System in Manila (Ph. Peso 10–19 per cubic metre). It is estimated that as much as 45 percent of the population of Metro Manila (some 4.8 million people) buy bottled water (WSP, 2002, cited in World Bank, 2003). Challenges related to water and sanitation are thus considerable, irrespective of projections made in the context of the MDGs.

Child Malnutrition in the Philippines

High levels of child malnutrition (CMN) are observed in the Philippines: serious deficiencies of vitamin A among children under 5 and pregnant women, iron deficiency (anaemia), and protein-energy malnutrition are the main nutritional deficits (FAO, 2004). FAO's latest Food and Nutrition Country Profile for the Philippines (2004) concludes that protein-energy malnutrition and micronutrient deficiencies remain the leading nutritional problem in the country. About 4 million (31.8 percent) of the pre-school population were found to be underweight-for-age in 1998. Some 3 million (19.8 percent) adolescents and 5 million (13.2 percent) adults were reported to be underweight and chronically energy-deficient in that year. Worryingly, the earlier decline in underweight, wasting and stunting among Filipino children was reversed in 1998. The large proportions of pregnant women and of children aged 6 months to 5 years who presented vitamin A deficiencies (7.1 percent and 8.2 percent respectively) also constitute a serious concern.

The latest official estimates from the Department of Health drawn from the 1998 National Demographic and Health Survey (NDHS) show clear links between birthweight and household geographical and socio-economic characteristics (particularly rural location and maternal education levels). Figure 2 shows that there is a positive and linear relation between maternal education and mean weight at birth (expressed in grams). When the distribution of birthweight is expressed in terms of Z-scores, these scores increase with maternal age, as does their dispersion. Table 3 shows that birthweights above 2.5 kg are reported more frequently by mothers in urban households and with higher levels of education.³ The same pattern is observed for mothers' perceptions of newborns' length at birth. In contrast, mother's age at birth and birth order do not follow a linear pattern with respect to weight and length at birth. In fact, the incidence of low and high birthweights demonstrates an inverted-U pattern with respect to mother's age. As for birth order, low and high birthweights both decline

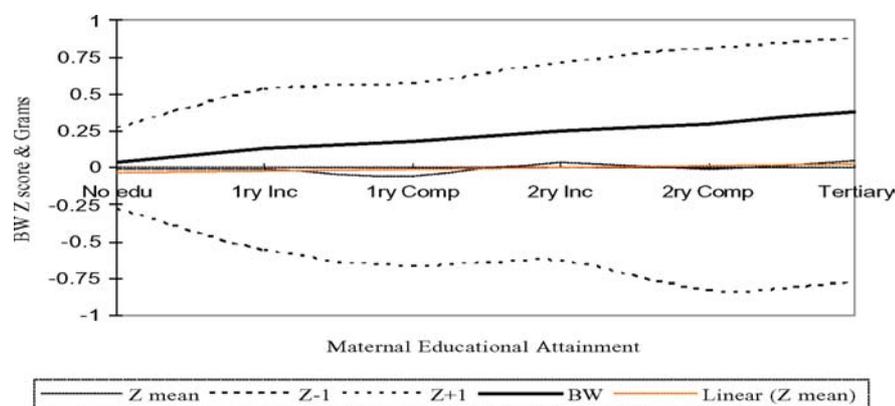


Figure 2. Birthweights by maternal educational attainment.

Source: DoH (1999). Notes: The 'birthweight' line is scaled to tenths of grams.

with birth order. Non-linearity is also observed in the relation between maternal age at birth and ante-natal and post-natal care; and between maternal age and delivery in health centres (as opposed to delivery at home). This may suggest a trade-off between reproductive experience and biological risk associated with age or number of previous births. The demand for ante-natal and post-natal care decreases steadily as maternal age and birth order increase, indicating that experience may dominate over biological risk. These results are in line with empirical evidence from other studies of mothers' educational status affecting overall child health (Glewwe, 1998), urban and rural differences (Adair *et al.*, 1993) and nutritional impacts of public health programmes (Barrera, 1990; Golden, 1994).

Previous CMN studies in the Philippines show that water and sanitation services affect infant and child nutritional status. Horton (1986) and Barrera (1990) conclude that water resources, sewage disposal and toilet facilities affect children's height. Interestingly, these effects are not uniform either among children's age groups or among services. Barrera (1990)—using a sample of 3821 children in Bicol from the Multipurpose Survey 1979 and its supplementary survey in 1981—reports that the availability of sanitation facilities in the community is associated with increased height for the 3–6 and 11–15 year-olds, but not for children in other age groups. In contrast, the availability of safe water has significant and positive effects on the height of 0–2 year-olds but not that of the remaining age groups. The study also reports several interaction effects. Maternal education and cleanliness (that is, absence of visible excreta) are found to be substitutes, as are maternal education and community water connections. Maternal education, on the other hand, is complementary to the provision of waste disposal services in the community.

Table 3. Birthweight and length and demand of health services

	Ante-natal care	Post-natal care	Health centre delivery	Birthweight			Size of birth	
				<2.5 kg	2.5 kg>	D.K	Very small or smaller than average	Average or larger
Mother's age at birth								
15–20	82.3	32.3	29.0	9.5	41.7	48.8	21.2	78.2
20–34	87.0	42.8	35.6	9.7	51.9	38.4	18.1	81.4
35–49	80.9	38.4	30.3	9.2	43.7	47.1	19.1	80.4
Birth order								
1	92.0	50.1	49.8	11.9	59.8	28.3	19.2	80.5
2–3	88.5	45.5	37.0	9.5	54.3	36.2	17.7	81.4
4–5	83.6	36.2	26.5	8.3	44.3	47.4	18.9	80.4
6+	72.2	24.8	13.8	8.0	30.8	61.2	18.9	80.5
Residence								
Urban	92.4	55.5	52.1	11.5	66.2	22.2	17.3	82.5
Rural	79.9	29.4	19.2	8.0	35.8	56.2	19.7	79.5
Mother's education								
No education	27.2	4.7	4.7	2.1	7.9	90.0	23.5	75.6
Elementary	75.5	23.1	12.6	8.1	28.9	63.0	21.3	78.2
High school	90.3	43.2	33.3	11.0	54.2	34.8	19.5	80.0
College	96.3	66.3	67.7	10.1	75.1	14.8	12.9	86.7
Total	85.7	41.4	34.2	9.6	49.8	40.6	12.7	81.0

Source: DoH (1999)

More recent studies have made use of the Cebu Longitudinal Health and Nutritional Survey (CLHNS) collected every four years from 1983/4 to 1999⁴ (see the fifth section, below). Using the CLHNS, Adair *et al.* (1993) confirm urban–rural differences in nutritional outputs, reflecting geographical differences in opportunities and constraints but also differences in mothers' behaviour. Isolated rural communities have poorer access to safe water but higher incidence of breast-feeding. This results in lower levels of child morbidity and higher prevalence of linear growth retardation. In urban, highly-populated squatter dwellings, the greater socio-economic opportunities of households do not necessarily outweigh their increased exposure to infectious diseases. Overall, Adair *et al.* (1993) conclude that chronically poor socio-economic conditions are more often associated with stunting than wasting. Consequently, improvements in environmental sanitation, such as the provision of safe water, decrease the prevalence of wasting but may have little effect on stunting (Keller, 1988). Although stunting and wasting are typically closely related, these studies show that public provision of basic services may affect different aspects of nutrition, a finding that requires further exploration from a policy point of view. Mothers' height (a proxy for the genetic potential of children) and mothers' education are reported to have a positive effect on all nutritional indicators. In contrast, household size, crowding

and number of children under 6 all have a negative effect on child nutrition status. Disappointedly, the study does not report the magnitude of these effects.

Methodology

General Discussion

Glewwe's widely accepted framework of determinants of child health and nutritional status identifies health and nutrition inputs provided by the household, the local health environment and the child's health endowment as critical factors (Glewwe, 1998). Typically, the first set is related to socio-economic characteristics, mothers' behaviour and health provision (quality of drinking water, toilet facilities, breastfeeding, access to medicines, ante-natal care, among others). The local health environment refers to community characteristics such as parasite prevalence or contagious diseases that may affect child health. These are typically beyond the control of the parents, as are the third set of factors, children's health endowments, which are associated with genetic inheritance. Importantly, these factors can affect malnutrition directly, indirectly and/or through interaction: the result is a complex framework of interrelations. However, reverse relations among the sets of factors tend to be ignored. For instance, not only do household incomes affect child health, but child health may also affect labour decisions of household members and, therefore, determine the household's final income.

An interesting question is whether this framework of child malnutrition determinants differs substantially from determinants of malnutrition at birth – that is, the well-being of a foetus at the time of birth. One would expect that the impacts on the foetus might differ somewhat from those observed among children or infants. In the first place, direct determinants such as risky maternal behaviour, maternal knowledge and household socio-economic factors can only affect malnutrition at birth indirectly through the well-being of the mother. Similarly, environmental conditions will affect the development of the foetus to the extent that they affect the health status of the pregnant mother. Furthermore, health care may not be as effective or direct with a foetus as it is with newborns, children and infants. These impacts are more difficult to identify from the available data (since the surveys do not report information on the development of a foetus); moreover, one may expect them to be less marked than the equivalent effects among children and infants. In contrast, genetic influences affect the condition of the foetus directly, and may have a greater influence on the observed health and nutritional status at birth.

A related empirical question is whether indirect and interactive effects which are reported to have an impact on child malnutrition also affect (and in similar ways) the nutrition conditions observed at birth. In principle, they might be expected to affect the well-being of the foetus. Thus, as socio-economic status rises, mothers are more likely to have the knowledge and the means to implement better health and nutrition practices, to avoid risky behaviour (such as hard physical work, consumption of alcohol and smoking), and to make use of the available care technology (from

sonograms, to monitor the development of the foetus, to access to vitamins for the mother). Crowded households may affect maternal health through higher exposure to illness and more demanding domestic chores for the pregnant mother; on the other hand, she is more likely to receive advice and assistance on pregnancy matters from other household members. Increasing age typically provides the mother with more experience and expertise on reproductive issues, but at the same time carries more biological risks for the foetus. Age also shapes individual preferences, employability, fertility and bargaining, which may act in different directions to determine the nutritional status of a household's children. To the extent that contagious diseases correlate with climate conditions, type and density of vegetation, and the presence of cattle in built-up areas of the country, geography may affect the foetus through its impact on the mother's well-being. Population density increases exposure to transmitted diseases but may also imply better access to health services.

Thus, evidence from the Philippines suggests that determinants of child malnutrition may have an impact on conditions at birth. However, the evidence currently available relates to only a few effects; the magnitudes of these effects are not always analysed; and the relevance of some interaction effects for newborns are usually overlooked.⁵ To address this, the following section adjusts the widely-used production function approach to make it relevant to the case of newborns.

Basic Theoretical Underpinnings

In the tradition of previous CMN studies, the methodological strategy of this paper consists of constructing and estimating a reduced-form demand function for nutrition at birth. The usual maximization of parents' utility (based on consumption of commodities and services, individual leisure and quality and quantity of children), derives a reduced form equation relating health or nutritional outcomes and exogenous determinants (Gertler *et al.*, 1988):

$$CMN_i = f(X_i, B_i, H_i, C_i, \varepsilon_i) \quad (1)$$

where CMN_i indicates the health output, that is, whether a household '*i*' has one or several malnourished children. X_i comprises a set of socio-economic and demographic characteristics that describe household '*i*'. Usually, this set includes indicators such as income and consumption levels of the household (or, alternatively, poverty levels); its size and composition; the education of parents or household heads; and the geographical (urban, rural or regional) location.

Critical in this analysis is the basic infrastructure experienced by the household, including the quality of construction materials, and access (and quality of access) to water, sanitation and electricity services. B_i refers to behavioural features that affect the incidence of children's malnutrition within the household, such as hygienic habits, number of meals, or gender discrimination. H_i refers to policy-making variables.

These can be thought of as ‘supply side’ factors that affect malnutrition: they include a range of factors such as the presence of health centres in the municipality (or the distance/time to the nearest centre), population per hospital bed, and the availability of nutritional and/or health programmes in the area. They can also include average public (and private) expenditures on preventive and curative activities. C_i refers to other community variables that may have an impact on the household’s propensity to malnutrition; it captures cultural preferences for boys over girls, environmental vulnerability, municipal incidence of illness, and the existence of community social networks, among other things. Finally, ε_i , will capture children’s unobservable characteristics (such as genetically-related propensity to illness or learning abilities), omitted variables (such as incomes and consumption expenditures of the household) and measurement errors from the included variables. In as much as genetic reasons are not systematically correlated with the included determinants of malnutrition, their omission will not cause biases. By contrast, incomes and consumption expenditures are expected to be correlated with education levels, maternal behaviour, age, access to quality health services and favourable local environments.

Estimation Techniques

Typically, the estimation of a demand function (1) encounters a number of practical caveats. Endogeneity, measurement error and omitted variables may cause serious biases in the estimated effects. In the context of malnutrition and health, endogeneity – that is, a double causation between variables – usually refers to children’s status driving changes in public service provision (Pitt *et al.*, 1995) and the simultaneous decision-making of consumption, leisure, time allocation and child health (Thomas & Strauss, 1992). Both relations, however, affect household decisions in distinct ways. As households are unable to affect public health allocation – typically decided by the centralized health administration – and ‘health reasons’ are usually a marginal cause of household migration (Glewwe, 1998), the simultaneous relation between health status and public health provision may be present at the community level but is unlikely at the household level. With longitudinal information, estimating community fixed effect probits could have tested this assumption, but unfortunately the NDHS in the Philippines does not provide panel data information. Nonetheless, the demand equation estimating household-based effects will also include community-based (*barangays*) variables on health service provision to control for possible endogeneity relations between health inputs and outputs at that level (see Glewwe, 1998).

Another cause of endogeneity is that human capital accumulation and child malnutrition may be determined simultaneously within the household. As reported above, mothers’ breast-feeding habits are known to be affected by maternal educational attainment, and this has been shown to have an impact on infant and child malnutrition (Behrman, 1996; World Bank, 1993). Children’s educational attainment is lower among malnourished children; furthermore, parents seem to delay school entry of

their malnourished children (Glewwe *et al.*, 2001). Illness episodes associated with malnourishment may also demand additional care-taking time from some household members (for example, older siblings). It is, however, unlikely that parents can estimate their children's *potential* for future human capital accumulation (that is, their learning endowment, ε_i in equation (1)) and make distinctive nutritional investment decisions for their children at the time of birth based on this. What parents have been shown to do is to favour infants and children based on the expectations of future earning gaps (Bhalotra & Attfield, 1998; Thomas, 1994). Although the NDHS does not permit the approximation of such earnings (no information on incomes is provided), a mother's expectations of living with her children in the future are proven not to have significant impacts on birthweight.

In studies analysing CMN dynamically with longitudinal data, a recurrent strategy has been to instrument the variable of children's current nutritional status with their nutritional status at previous age. Cross-sectional data sources usually fail to collect the complete nutritional status history of the individual, so this option is not available from the NHDS. Using the birth anthropometrics of a younger sibling may be a second-best solution, although this would imply eliminating one-child households from the survey, which may result in a bias if these households are over-represented in an early state of the reproductive cycle (that is, one-child households have typically younger parents). In addition, evidence on the phenomenon of 'catch-up' (see Adair, 1999; Golden, 1994) – that is, malnourished children who recover a normal weight or height at an older age – casts some doubts on the adequacy of past nutritional status to instrument for the variable of current nutritional status. In any event, as the NDHS fails to report *previous* height and weight of children and only reports anthropometrics *at birth*, the estimation of the determinants of malnutrition is targeted at newborns.

Incomes and/or consumption expenditures are the obvious candidates for causing omitted variable biases. In the context of the Philippine NDHS, a widely accepted alternative proposed by Filmer & Pritchett (1999) is the use of household wealth indexes to instrument for incomes and consumption expenditures. They argue that household assets and housing characteristics are closely related with socio-economic status, and work better as a proxy for the long-run financial capacities of the household. In addition, they define poor conditions more meaningfully among countries, and there are less likely to be errors in measurement.⁶ This paper uses household assets and housing conditions to instrument for incomes and expenditures but does not weight them. There are three reasons for this. First, there is no obvious a priori economic or social reason to weight one variable more than another; second, unweighted variables allow for different effects on malnutrition from each asset without having to fix that significance in advance, in the form of an index; third, the individual inclusion of wealth variables allows us to test implicitly a particular transmission effect that could be of policy interest, for instance, whether exposure to public campaigns (disseminated through household assets such as TV or radio) is relevant.

Finally, some variables are selected based on the expectation that they will have lower measurement errors – which would be another reason to use wealth instead of incomes or expenditures, even if the latter were available. This criterion also determines the choice of weight at birth rather than height at birth as a dependent variable and its specification as a *Z*-score rather than in a continuous form. As mothers are asked to report their *perception* of the height of the newborn rather than *actual* length at birth, this variable is believed to be measured with insufficient precision.

There is a different technique altogether to deal with the endogeneity of supply interventions (input) and the observed CMN rates (outcomes). These methods are known as matching techniques. Within a family, ‘propensity score matching’ as developed by Rosenbaum & Rubin (1983, 1985) and Heckman *et al.* (1997, 1998) is used frequently in the context of social programme evaluation. The propensity score matching technique groups sample observations by estimating individual probabilities of participating in the programme. These probabilities are calculated in the form of propensity scores for each observation – that is, $P(M)$, where $P(M) = \text{Prob}(d=1 | M)$ is the probability of participation in a programme conditional on a set of variables, M . Propensity scores are estimated using standard probits (logits or semi- or non-parametric methods). The technique thus creates ‘pairs’ of observations that are matched by a number of variables ‘ M ’, common for both groups. The only difference between each pair of observations is that one benefits from the intervention (treated group) while the other does not (control group). This technique then compares the impact of the intervention on the target group in comparison to the control group. The average treatment effect of the intervention is the average difference of the impacts by each pair of (treated and control) observations.

This analysis interprets malnutrition at birth as a criterion that categorizes households into treated and control groups. Households with well-nourished newborns constitute the treatment group; households with malnourished newborns, the control group. The effect of water and sanitation on CMN is then estimated as the average impact that its provision has on pairs of matched households whose only difference is the presence of malnourished newborns. Methodologically, both measurement errors and omitted variable biases may also affect the quality of estimates under this method. The same solutions proposed above to deal with these caveats in the regression analysis are applied to the matching score technique.

Data

The Choice of Data Source

The few existing studies on CMN in the Philippines mentioned above have made use of the Cebu Longitudinal Health and Nutritional Surveys (CLHNS) that tracked a sample of 3289 children born between 1 May 1983 and 30 April 1984, with subsequent follow-up rounds in 1991–92, 1994–95 and 1998–99. The main advantage of these longitudinal data is their great detail, which allows the construction of a

comprehensive nutritional profile of children. The surveys allow for a comparison of the health and nutritional status of the same children at the ages of 2, 8, 11 and 15. A major criticism of the CLHNS, however, is its limited coverage. Adair (1999) questions how representative results from Metropolitan Cebu can be for the rest of the country: this is a rapidly growing area, with economic development exceeding the national average, and high income disparities. At best, CLHNS results should be interpreted very cautiously, given wide regional differences in economic development, health and nutritional indicators.

An alternative source of data is the Department of Health, which conducted countrywide National Demographic and Health Survey (NDHS) in 1988, 1993 and 1998. The last survey gathered information on 13,983 women aged 15–49 in all regions of the country (DoH, 1999). These surveys include comprehensive information on the health conditions of mothers and children. They also provide background characteristics regarding the household; women's reproductive history, behaviour and fertility preferences; their knowledge and use of contraception; availability of family planning services; and maternal mortality. Importantly, the surveys provide information on characteristics of newborns, as well as infant and child mortality and morbidity. Health-related behaviours and public service supplies are captured at a nationwide representative level. Relevant community and regionally-based characteristics (such as, for instance, community indexes of ante- and post-natal care) can be readily estimated. Typically, demographic and health surveys also overcome the problem of international comparability of relevant malnutrition questions. The main caveat to using the NDHS is the precision with which nutritional information is gathered. It also has two important drawbacks: first, the same children cannot be followed at different ages; and second, information on children's weight and height is not reported, although the weight of newborns is accurately recorded. As for newborns' length, the survey asks mothers' perceptions rather than the actual length at birth.

Using the available nutritional data in the Philippines thus requires the familiar trade-off between detail and coverage, which is observed in longitudinal and cross-section surveys. This analysis opts in favour of the NDHS in order to achieve national representation and relevant information on malnutrition and its determinants. However, this choice implies using nutritional measures for newborns instead of the usual indicators of children's nutrition at different ages. The following section details the choice of variables used in the study.

The Choice of Variables in the Analysis

The choice of dependent variables, explanatory factors and estimating techniques is governed by the availability of data. The malnutrition status of children is approximated by the probability that their households report stunted newborns (that is, birthweight exceeding -1 standard deviation from the mean birthweight). Households are asked to report the birthweight of all their live births in the last five years.

Birthweight is originally provided in grams, from which a distribution of Z-scores can be readily obtained (see Figure 2 above). Additional definitions of malnutrition are also constructed (see Table 4). Thus, birthweight categories are further divided into ‘no weight stunting’ (above -1 standard deviation from the mean birthweight), ‘mild stunting’ (between -1 and -2 standard deviations around the mean), and ‘moderate to severe stunting’ (beyond -2 standard deviations). Z scores are used as a discrete dependent variable instead of a continuous form. There are three reasons for this strategy. First, it focuses the analysis on what interventions may reduce weight stunting at birth rather than on increasing Z-scores of the distribution of newborns or the average impact of a determinant. Second, alternative definitions of the discrete specifications permit the exploration of two magnitudes of stunting – mild and severe. Third, the repercussions of possible measurement errors are minimized when considering a discrete definition with few categories, as individuals are less likely to be misclassified according to their nutritional status (see the following section).

In addition to birthweight-related definitions, the length of live newborns is also considered. An anticipated problem with this definition is that – as mentioned above – the NDHS does not inquire about the actual length of the newborn but asks only for the mother’s perception of the newborn’s length. The intrinsic subjectivity of perceptions, and differences in individual ideas of what constitutes ‘short’ or ‘long’, inevitably play a role in the answers. It is unlikely that mothers have sufficient knowledge of national birth-length standards, and there is no reason to assume that possible biases are uniform across the country.

In this analysis, safe water sources include piped water and protected wells (the former, typically, are publicly-provided and community-based). Doubtful water sources include unprotected wells, springs, rivers, streams, ponds, lakes, dams and rainwater. Sanitary facilities available to the household include flush toilets, latrines (either open or closed) and drop/overhang disposal. Interaction effects of water and sanitation services with maternal education levels act as controls for complementarities or substitution between basic infrastructure and education.

Medical factors are divided into health services demanded by households during pregnancies, on the one hand, and general public provision of health services at the community level, on the other. The former are related directly to the birth history of each woman in the last five years, and include whether she received some form of ante-natal care (from either a doctor, nurse, midwife or a traditional birth attendant); the number of ante-natal visits she received during pregnancy; the average number of tetanus injections she received while pregnant; and the average interval between pregnancies.

Similarly, the supply of medical provision is controlled at the community level, that is, among *barangays*. As argued above, community-based health supply controls for possible endogeneity of health inputs and outputs. It is very unlikely that any given household can effectively alter the public (or private) provision of health services and, therefore, cause endogeneity biases in the household-level estimates. The analysis

Table 4. Statistical descriptives NDHS 1998

	Mean	St. Deviation
Birth Malnutrition		
Birthweight stunting	0.0240	0.1531
Mild birthweight stunting	0.0201	0.1405
Moderate to severe birthweight stunting	0.0038	0.0620
Z-score of birthweight	0.0044	0.7084
Perception of low or very low length at birth	0.0479	0.2137
Mother's education:		
(a) No education	0.0261	0.1596
(b) Incomplete primary	0.1184	0.3231
(c) Complete primary	0.1683	0.3741
(d) Incomplete secondary	0.2134	0.4097
(e) Complete secondary	0.1957	0.3965
(d) Tertiary	0.2781	0.4480
Woman reads easily	0.8174	0.3862
Partner's education		
(a) No education	0.0299	0.1703
(b) Incomplete primary	0.1938	0.3953
(c) Complete primary	0.1798	0.3836
(d) Incomplete secondary	0.1398	0.3468
(e) Complete secondary	0.1894	0.3919
(d) Tertiary	0.2618	0.4396
Water Services		
Household has access to safe water		
Household has access to community safe water	0.4749	0.4993
Household has a point source of water	0.4760	0.4994
Household purchases water from peddler or bottled water	0.0491	0.1607
Water facilities within the household premises	0.1255	0.3313
Sanitation Services		
Household has access to sanitary facilities		
Household has flush toilet	0.7123	0.4526
Household has latrine	0.1395	0.3465
Household sanitation is drop-overhang	0.0321	0.1762
Household has no sanitation facilities		
Household Wealth		
Household has TV and radio	0.6116	0.4873
Household has a car	0.1325	0.4801
Household's floor is made of natural material	0.4383	0.4961
Household Location		
Rural	0.5187	0.4996
Metropolitan Manila	0.1065	0.3085
Biological and Risk Variables		
Age of mother	29.4237	9.8409
Household size	6.2422	2.5683
Household has lived in community at least 5 years	0.7577	0.4284
Pregnant outputs of household's women	3.2802	2.6222
Household's women have maternal mortality antecedents	0.0094	0.0996

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Table 4. Statistical descriptives NDHS 1998 (*Continued*)

	Mean	St. Deviation
Number of stillbirths of household's women	0.3206	0.6800
Household has antecedents of multiple births	0.0565	0.3499
Community level health provision		
Vaccination score of children in the <i>barangay</i>	5.3159	3.2535
Score of the medical treatment of diarrhoea in the <i>barangay</i>	0.9561	0.8256
Score of delivery in public facilities in the <i>barangay</i>	0.2701	0.3792
Medical treatments of pregnant women in the household		
Household's pregnant women had some ante-natal care	0.9663	0.1802
Number of ante-natal visits of household's pregnant women	3.8833	5.8961
Mean of tetanus injections for household's pregnant women	0.6376	1.0537
Mean of birth intervals among household's pregnant women	25.4652	22.8848
Interaction effects:		
Community water source and access in premises	0.0100	0.0999
Community water source and household women read easily	0.4778	0.4947
Point source water access and women read easily	0.3498	0.4769
Flush toilet and women read easily	0.6387	0.4803
Latrine and women read easily	0.0936	0.2913
Drop/overhang and women read easily	0.0171	0.1296

Source: DoH (1999).

Note: Descriptives refer to sample means and standard deviations.

considers three community-based health supply variables: vaccination in the first year of life; medical treatment of diarrhoea for under-5 year olds; and delivery in public health centres. These variables are calculated as scores (given that the total population of each *barang* is not reported in the NDHS), that is, as the ratio of affected individuals benefiting from each service over those individuals failing to do so. Despite its limitations, the NDHS provides sufficient information to control for socio-economic, biological and health provision. Table 4 summarizes the main statistical descriptives for a set of relevant variables.

Results

The Effects of Water and Sanitation Services on Birthweight Stunting

Table 5 indicates that access to water and sanitation has, consistently, the expected results on birthweight. Such effects, however, are not found to be statistically significant. Having controlled for socio-economic, biological and health provision, access to safe water sources reduces the probability of low birthweight or birthweight stunting (see Column 1). Similarly, access to any sort of sanitary facility decreases the probability of birthweight stunting compared to no sanitary facilities being available to the household (Column 1). There is, however, no evidence of statistical significance in these relations.

Table 5. Estimated effects of water and sanitation services, socio-economic factors, biological risk and health provision on the household probability of birthweight stunting

	(1) Birthweight Stunting Aggregated	(2) Birthweight Stunting Disaggregated	(3) Birthweight Stunting (Z-scores)	(4) Birthweight Stunting Interaction Effects	(5) Birthweight Stunting Interaction Effects	(6) Birthweight Stunting Mild	(7) Birthweight Stunting Moderate or Severe	(8) Perceived Length At Birth Interaction Effects	(9) Perceived Length At Birth Interaction Effects
Constant	-4.1151 (0.4544)***	-4.0107 (0.4930)***	-8.7031 (0.3872)***	-3.9800 (0.4943)***	-4.0070 (0.4946)***			-3.4170 (0.0380)***	-3.4309 (0.3803)***
Mother's education	-0.0254 (0.0248)	-0.0228 (0.0249)	0.1139 (0.0194)***	-0.0356 (0.0289)	-0.0382 (0.0284)	-0.0018 (0.0007)***	0.0001 (0.0003)	-0.0635 (0.0226)***	-0.0580 (0.0222)***
Partner's education	0.0591 (0.0197)***	0.0596 (0.0197)***	0.1672 (0.0152)***	0.0603 (0.0197)***	0.0592 (0.0197)***	0.0011 (0.0006)*	0.0006 (0.0002)***	0.0385 (0.0155)**	0.0381 (0.0155)**
Household has access to safe water	-0.0032 (0.0758)		-0.3138 (0.0620)***			-0.0024 (0.0026)	0.0001 (0.0009)		
Household has access to community safe water		-0.0616 (0.1914)		-0.0466 (0.2294)	-0.0687 (0.1926)			0.0972 (0.1817)	0.0658 (0.1583)
Household has a point source of water		-0.0240 (0.1935)		-0.1240 (0.1050)	-0.0356 (0.1948)			-0.0208 (0.1686)	0.0536 (0.1591)
Household has access to sanitary facilities	-0.0245 (0.0785)		0.5825 (0.1058)***			-0.0016 (0.0026)	-0.0014 (0.0013)		
Household has flush toilet		(0.0953)		(0.0957)	(0.1272)			(0.0719)**	(0.0958)
Household has latrine		-0.0933 (0.1069)		-0.1050 (0.1074)	-0.4170 (0.1826)**			-0.0357 (0.0769)	-0.1576 (0.1076)
Household sanitation is drop-overhang		-0.1596 (0.1838)		-0.1621 (0.1842)	-0.1822 (0.2623)			-0.2125 (0.1350)	-0.1233 (0.1760)
Household has TV and radio	-0.1278 (0.0627)**	-0.1261 (0.0624)**	-0.3926 (0.0429)***	-0.1290 (0.0623)**	-0.1297 (0.0623)**	-0.0061 (0.0022)***	0.0002 (0.0007)	-0.1105 (0.0493)**	-0.1087 (0.0493)**

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Table 5. Estimated effects of water and sanitation services, socio-economic factors, biological risk and health provision on the household probability of birthweight stunting (*Continued*)

	(1) Birthweight Stunting Aggregated	(2) Birthweight Stunting Disaggregated	(3) Birthweight Stunting (Z-scores)	(4) Birthweight Stunting Interaction Effects	(5) Birthweight Stunting Interaction Effects	(6) Birthweight Stunting Mild	(7) Birthweight Stunting Moderate or Severe	(8) Perceived Length At Birth Interaction Effects	(9) Perceived Length At Birth Interaction Effects
Household has a car	-0.0248 (0.0671)	-0.0246 (0.0666)	0.0460 (0.0548)	-0.0220 (0.0665)	-0.0217 (0.0663)	-0.0001 (0.0024)	0.0003 (0.0006)	0.0048 (0.0517)	0.0038 (0.0518)
Household's floor is made of natural materials	0.0141 (0.0675)	0.0117 (0.0682)	-0.5054 (0.0533)***	0.0113 (0.0681)	0.0104 (0.0681)	0.0009 (0.0021)	0.0005 (0.0008)	0.1382 (0.0541)**	0.1379 (0.0541)**
Rural	0.0152 (0.0650)	0.0102 (0.0655)	-0.0784 (0.0596)	0.0105 (0.0655)	0.0102 (0.0655)	0.0015 (0.0020)	0.0008 (0.0007)	-0.0380 (0.0526)	-0.0392 (0.0526)
Metropolitan Manila	-0.2231 (0.1330)*	-0.2190 (0.1350)*		-0.2186 (0.1352)*	-0.2275 (0.1356)*	-0.0059 (0.0028)**	-0.0006 (0.0012)	-0.0922 (0.1030)	-0.0968 (0.1029)
Age of mother	0.1563 (0.0260)***	0.1556 (0.0260)***	0.6915 (0.2004)***	0.1573 (0.0261)***	0.1584 (0.0261)***	0.0061 (0.0007)***	0.0007 (0.0003)**	0.1664 (0.0196)***	0.1657 (0.0196)***
Age square of mother	-0.0024 (0.0004)***	-0.0024 (0.0004)***	-0.0114 (0.0003)***	-0.0024 (0.0004)***	-0.0024 (0.0004)***	-0.0001 (0.00001)***	-0.0001 (0.00000)**	-0.0025 (0.0003)***	-0.0025 (0.0003)***
Sex of household head	-0.0990 (0.1023)	-0.0976 (0.1023)	-0.64234 (0.0648)***	-0.0974 (0.1024)	-0.0977 (0.1026)	-0.0018 (0.0031)	-0.0034 (0.0019)*	-0.1727 (0.0830)**	-0.1736 (0.0831)**
Household size	-0.0318 (0.0155)**	-0.0317 (0.0155)**	-0.0704 (0.0152)***	-0.0323 (0.0152)***	-0.0321 (0.0155)***	-0.0010 (0.00046)**	-0.0002 (0.0001)	-0.0289 (0.0123)**	-0.0290 (0.0123)**
Household has lived in community at least 5 years	-0.0478 (0.0653)	-0.0454 (0.0654)	-0.3390 (0.047)***	-0.0439 (0.0655)	-0.0462 (0.0655)	-0.0021 (0.0021)	0.0011 (0.0006)	-0.0930 (0.0524)*	-0.0939 (0.0524)*
Pregnant outputs of household's women	-0.0226 (0.0361)	-0.0227 (0.0361)	0.0514 (0.0338)	-0.0231 (0.0361)	-0.0222 (0.0361)	0.0009 (0.0011)	-0.0002 (0.0004)	-0.0022 (0.0294)	-0.0012 (0.0294)
Squared pregnant outputs of household's women	0.0051 (0.0029)*	0.0051 (0.0029)*	0.0033 (0.0033)	0.0052 (0.0029)*	0.0051 (0.0029)*	0.00002 (0.0001)	0.00004 (0.00003)	0.0015 (0.0025)	0.0015 (0.0025)

Household's women have maternal mortality antecedents	-0.0423 (0.2877)	-0.0271 (0.2870)	0.2533 (0.3577)	-0.0150 (0.2864)	-0.0211 (0.2900)	-0.0107 (0.0124)	0.0019 (0.0021)	-0.3009 (0.2630)	-0.3091 (0.2629)
Number of stillbirths of household's women	0.0686 (0.0381)*	0.0683 (0.0382)*	-0.0917 (0.0429)**	0.0682 (0.0382)*	0.0690 (0.0383)*	0.0012 (0.0012)	0.0006 (0.0004)	0.0571 (0.0306)*	0.0574 (0.0302)*
Household has antecedents of multiple births	0.0770 (0.0682)	0.0780 (0.0680)	0.0452 (0.0973)	0.0786 (0.0680)	0.0813 (0.0682)	0.0021 (0.0019)	-0.0003 (0.0010)	-0.0128 (0.0620)	-0.0136 (0.0621)
Vaccination score of children in the barang	-0.0020 (0.0113)	-0.0022 (0.0113)	0.0111 (0.0139)	-0.0025 (0.0113)	-0.0030 (0.0114)	-0.00002 (0.0003)	-0.00004 (0.0001)	0.0200 (0.0087)**	0.0198 (0.0087)**
Score of the medical treatment of diarrhoea in the barang	0.0621 (0.0348)*	0.0623 (0.0349)*	-0.0455 (0.0477)	0.0629 (0.0349)*	0.0642 (0.0349)*	0.0012 (0.0010)	0.0004 (0.0004)	-0.0027 (0.0281)	-0.0021 (0.0281)
Score of delivery in public facilities in the barang	0.4160 (0.2421)*	0.4308 (0.2438)*	0.8089 (0.3664)**	0.4375 (0.2439)*	0.4275 (0.2441)*	0.0080 (0.0076)	0.0049 (0.0023)**	-0.0624 (0.2123)	-0.0745 (0.2124)
Household's pregnant women had some ante-natal care	-0.3027 (0.1332)**	-0.3012 (0.1332)**	-2.5438 (0.0872)***	-0.3141 (0.1336)**	-0.3077 (0.1344)**	-0.0184 (0.0108)*	-0.0120 (0.0079)	-0.5195 (0.0925)***	-0.5149 (0.0924)***
Number of ante-natal visits of household's pregnant women	0.0191 (0.0048)***	0.0191 (0.0048)***	0.1368 (0.0036)***	0.0192 (0.0048)***	0.0190 (0.0048)***	0.0004 (0.0001)***	0.0004 (0.00005)	0.0118 (0.0042)***	0.0116 (0.0042)***
Mean of tetanus injections for household's pregnant women	0.1906 (0.0242)***	0.1906 (0.0242)***	0.4620 (0.0182)***	0.1904 (0.0242)***	0.1903 (0.0243)***	0.0059 (0.0008)***	0.00088 (0.00032)***	0.1953 (0.0199)***	0.1962 (0.0198)***
Mean of birth intervals among household's pregnant women	-0.0021 (0.0014)	-0.0021 (0.0015)	-0.0080 (0.0014)***	-0.0021 (0.0015)	-0.0021 (0.0015)	-0.0001 (0.00005)**	0.0000 (0.00002)	-0.0006 (0.0011)	-0.0007 (0.0011)

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Table 5. Estimated effects of water and sanitation services, socio-economic factors, biological risk and health provision on the household probability of birthweight stunting (*Continued*)

	(1) Birthweight Stunting Aggregated	(2) Birthweight Stunting Disaggregated	(3) Birthweight Stunting (Z-scores)	(4) Birthweight Stunting Interaction Effects	(5) Birthweight Stunting Interaction Effects	(6) Birthweight Stunting Mild	(7) Birthweight Stunting Moderate or Severe	(8) Perceived Length At Birth Interaction Effects	(9) Perceived Length At Birth Interaction Effects
<i>Interaction effects:</i>									
Community water source and access in premises				-0.2135 (0.3176)	-0.2176 (0.3179)			0.0593 (0.2152)	0.0625 (0.2147)
Community water source and household women read easily				-0.0072 (0.1453)				-0.0263 (0.1076)	
Point source water access and women read easily				0.1263 (0.2109)				0.1064 (0.0776)	
Flush toilet and women read easily					0.0179 (0.1202)				-0.0174 (0.0931)
Latrine and women read easily					0.4494 (0.1911)**				0.1990 (0.1163)*
Drop/overhang and women read easily					0.0524 (0.3384)				-0.1836 (0.2496)
Number of observations	10,789	10,789	10,789	10,789	10,789		9,1110	10,789	10,789
Chi2(n)	248.34***	248.34***	6,825.19***	252.02***	256.67***		345.57***	430.03***	432.02***

Log likelihood	-1,101.32	-1,101.32	-3,128.20	-1,099.48	-1,097.16	-1,123.12	-1,874.91	-1,874.08
H ₀ : IIA for no birth stunting						Chi2(26)=130.51***		
H ₀ : IIA for mild stunting						H ₀ rejected		
H ₀ : IIA for moderate or severe stunting						Chi2(26)=1.34.		
						H ₀ accepted		
						Chi2(26)=1.34.		
						H ₀ accepted		

Source: DOH (1999).
 Notes: Estimates report probit coefficients except for the multinomial logit column, which reports marginal effects evaluated at the mean of each variable. Standard errors are reported in brackets. ** indicates significance at 1% level; * indicates significance at 5%; and * indicates significance at 10%. Hausman specification tests are conducted for the null hypothesis of Independence of Irrelevant Alternatives, that is, for the hypothesis that a multinomial specification produces efficient estimates of weight at birth (in detriment of the alternative hypothesis that *probit* estimates are efficient).

When estimates are disaggregated by categories of service provision, similar results are found in terms of both signs and statistical significance (Column 2). Access to community-based sources of water – piped water – reduces the probability of stunting among newborns in comparison to bottled water and water bought from peddlers (taken as reference source). Wells and natural sources of water (doubtful sources) also reduce the probability of birthweight stunting in comparison with purchased water. Quantitatively, the relation between community (piped) water and birthweight is more than double that between point source water and birthweight.⁷ As with aggregate estimates, none of these relations is statistically significant. Household access to flush toilets, latrines or drop/overhang disposal also reduces the probability of birthweight stunting compared to no sanitation facilities. The improvement in birth conditions is greater for flush toilets than latrines, and greater for latrines than for drop/overhang disposal. These effects, again, are not statistically significant.

Significant results are found, however, when the birthweight is specified as a continuous variable of the most recent newborn's weight as a Z-score (Column 3). But access to safe water does not have the expected sign: it appears to decrease the Z-score of the most recent newborn's weight. In contrast, access to sanitation has the expected sign vis-à-vis birthweight. As there are no obvious reasons for the unexpected sign of safe water access (nor for the TV and car ownership variable), it is possible that measurement errors from the originally reported birthweight are fully transmitted to the continuous Z-score definition. If that is the case, the significance of basic service provision will be biased. This appears to support the theoretical argument (mentioned above) that a discrete birthweight variable is a preferred specification that minimizes original measurement errors.

Interaction variables in Columns 4 and 5 allow us to compare our findings on the significance of nutritional interaction effects between maternal education and community basic infrastructure in the Philippines with those of Barrera (1990). Estimates in Table 5 suggest that there is an additional reduction in the probability of birthweight stunting as education increases in mothers able to access community-based piped water.⁸ Mothers who read easily benefit from an additional reduction in the probability of birthweight stunting when they have access to piped water sources. In this sense, the provision of community water services and maternal education has a substitutive effect. The relation between water point source services and maternal reading is of a different nature: mothers unable to read easily (or at all) find extra benefits from their access to point source water (vis-à-vis peddler's or bottled water). Education and point source water provision are thus complementary. A possible reason for the different nature of these interaction effects is that access to point source water does not entail direct service costs, whereas piped water, peddler's and bottled water do. Poorer households (which are likely to have mothers with lower reading abilities) may then benefit relatively more from access to point source water than from more expensive alternative forms of water provision.

The interaction between access to safe water and the location of such services within household premises is found to be negative (see Columns 4 and 5). There is thus an additional reduction in the probability of birthweight stunting when safe water sources are located within the premises of the household. However, this effect is not statistically significant.

The interaction effects between sanitation and maternal education on birthweight are complementary. This complementary nature is found consistently among the three categories of sanitary facilities, although its magnitude varies. The reduction in the probability of birthweight stunting associated with access to sanitation services is smaller among households where mothers are able to read easily. It is greatest among illiterate mothers or mothers with reading difficulties in households with access to latrines (see Appendix 1).

These results confirm Barrera's (1990) expectations on relations between water connections and maternal education, and between toilet facilities and maternal education, in the Philippines. Water and toilet facilities bring different nutritional benefits to the community: "toilet connections" function primarily as a subsidization of health inputs. . . while "water source" functions primarily to improve the healthiness of the environment' (Barrera, 1990, p. 86). Thomas & Strauss (1992) also report complementary interaction effects between community sewerage connections and water installations, and maternal education in Brazil.

Although interaction effects are difficult to predict a priori, current estimates show that water and sanitation facilities have different interactions with nutritional outcomes at birth. While these effects are not found to be statistically significant for the status of newborns, this does not preclude that they may become significant among children at later stages. Thomas & Strauss's (1992) results support this conjecture. They report that, in Brazil, a greater presence of community water and sanitation services has a positive relation with children's height for age, but is only significant among children aged 5 to 9. The positive relation among younger children is not statistically significant. Reasons for this pattern are unclear.

Estimates in this study are robust to different specifications of birthweight. The systematic lack of significance is also observed for alternative definitions of birthweight. Columns 6 and 7 in Table 5 confirm the statistical insignificance of water and sanitation effects using a definition of birthweight stunting that separates mild from moderate to severe stunting. The signs of these effects are, however, somewhat different from the binary definition of birthweight stunting: the impact of access to safe water services is negative on mild stunting but positive on moderate and severe stunting. A possible reason for the latter unexpected sign may lie in the inappropriateness of a multiple definition of birthweight stunting. Hausman tests reported in Table 5 indicate that the core assumption underlying the efficiency of a multiple-category specification (that is, the independence of irrelevant alternatives; see Hausman, 1978) is not accepted for the multiple-category definition used. Other alternative definitions

produced similar results. As a consequence, the binary definition is the preferred specification.

Finally, statistically insignificant effects from water and sanitation services are also found when length at birth is used instead of weight. A striking difference is that such effects have the opposite signs to those found for birthweight (see Columns 8 and 9 in Table 5). Length at birth is not a preferred proxy for newborn's nutritional conditions. As we have seen, the NDHS does not report actual length at birth but the mother's perception of the newborn's length: the intrinsic subjectivity of perceptions and different understandings of 'average' length may explain the unexpected sign.

Estimates from propensity score matching confirm the signs and significance of the effects of access to water and sanitary facilities.⁹ Table 6 shows that the aggregate impact of community and point sources of water has a negative impact on the probability of low birthweights in comparison to the reference category of peddler's or bottled water. Similarly, any form of sanitation facility has a negative impact on the probability of birthweight stunting. By separating nutritional effects of water and sanitation from maternal educational attainment, these effects are shown not to be uniform. This result is consistent with different interaction effects associated with maternal reading abilities. There are some differences, however. Consistent with reading ability results, there are additional reductions in the probability of birthweight stunting as maternal educational attainment rises in households with piped water. With probit estimates, the opposite effect occurs in those households whose water comes from point sources (see Columns 3 and 4 in Table 5 for comparison). Where results differ between the two estimating techniques is in the systematic complementarity of sanitation services and maternal education. A positive relation between sanitary services and maternal reading abilities is only observed in the case of latrines when matching procedures are used. Complementarities are only partially observed between drop and overhang disposal and maternal education, and unobserved for flush toilets and education.

The Effects of Household Socio-economic Characteristics, Biological Risk and Health Provision on Birthweight Stunting

If water and sanitation services do not have significant effects on the probability of the household's having stunted newborns, what other factors are likely to have significant impacts? Among socio-economic proxies, household possession of TV and radio sets has a statistically significant negative impact on the probability of birthweight stunting. This result is found systematically among all specifications of birthweight and length. The presence of TV and radio sets may indicate that wealthier households have lower probabilities of birthweight stunting. In addition, and importantly, the result may indicate that the media can play a crucial role in spreading knowledge on hygienic and health practices that affect the health status of household members.

As expected, increased maternal educational attainment reduces the probability of birthweight stunting in the household. The effect, however, is not statistically

Table 6. Effects of household access to water and sanitary facilities on the household probability of birthweight stunting

	Piped Water	Point Source	Peddler's or bottled water	Flush toilet	Latrine	Drop/Overhang disposal	Field/no sanitation facilities
No education	0.0444 (0.0292)	-0.0201 (-0.0155)	-0.0061 (0.0041)	0.0150 (0.0149)	0.0066 (0.0104)	-0.0072 (0.0043)*	-0.0071 (0.0050)
Primary incomplete	0.0004 (0.0070)	-0.0026 (-0.0102)	-0.0195 (0.0034)	0.0116 (0.0071)	-0.0143 (0.0069)**	-0.0009 (0.0170)	-0.0050 (0.0085)
Primary complete	0.0129 (0.0093)	-0.0178 (0.0112)	0.0065 (0.0226)	-0.0094 (0.0130)	-0.0129 (0.0085)	0.0091 (0.0238)	0.0171 (0.0124)
Secondary incomplete	-0.0048 (0.0056)	0.0002 (0.0051)	-0.0009 (0.0137)	-0.0064 (0.0053)	0.0056 (0.0072)	0.0154 (0.0212)	0.0127 (0.0111)
Secondary complete	-0.0113 (0.0070)	0.0037 (0.0093)	0.0230 (0.0204)	-0.0099 (0.0134)	0.0039 (0.0107)	-0.0322 (0.0036)***	0.0094 (0.0164)
Tertiary	-0.0035 (0.0057)	0.0056 (0.0065)	-0.0137 (0.0074)*	0.0014 (0.0085)	0.0111 (0.0122)	-0.0231 (0.0028)***	0.0185 (0.0312)
All	-0.0022 (0.0032)	-0.0028 (0.0033)	-0.0025 (0.0076)	-0.0027 (0.0043)	-0.0025 (0.0031)	-0.0047 (0.0075)	0.0051 (0.0046)

Source: DoH (1999).

Notes: Propensity score estimated from birthweight stunting probits using maternal age, sex of household head, material of household floor, household size and geographical location of the household. See Appendix 2. Average treatment effects on the respective water and sanitation facility are estimated using Kernel matching. Standard errors are reported in brackets. *** indicates significance at 1% level; ** significance at 5%; and * significance at 10%.

significant. Interestingly, the education of the mother's partner has a significant impact on the probability of birthweight stunting. The positive sign of this effect indicates that birthweight stunting is more likely among households with more educated partners. Given that income and wealth effects are already controlled for, partners' education may effectively control for intrahousehold bargaining. Newborns' weight fares worse in households where male partners are more educated (and, therefore, more likely to control the household's resources than the mother) than in households with less educated partners. It has been widely documented in the household literature that increases of incomes controlled by males are more likely to end up in low nutritional items (such as alcohol, tobacco, meals outside the household and even 'female companionship') than those controlled by females (Haddad & Hodinott, 1990). This may affect pregnant women's nutrition and, ultimately, the weight of their newborns. In contrast, evidence from matriarchal societies and from policy interventions targeting resources to women show an increase in health and nutritional expenditures for household children (Lundberg *et al.*, 1997; Quisumbing & Maluccio, 2003; Thomas, 1994).

Rural households have a greater probability of stunting even after controlling for biological, medical and socio-economic factors. In contrast, residence in Metropolitan Manila reduces this probability, an effect that is found statistically significant. The age of the mother at birth also has a significant impact, although different factors may be at play here, as the relation between maternal age and birthweight stunting probability is non-linear. As age increases, so do the chances of birthweight stunting. After a turning point at age 32, however, age increases are associated with a decreasing probability of low birthweight. As pure biological effects are already controlled for, this result may indicate that maternal experience plays a critical role during pregnancy – even more than education levels of the mother. This result may also indicate that mothers above that age are less likely to conduct work other than household chores or care activities within the household. Furthermore, both larger household size and a long-standing residence in the current location reduce the probability of birthweight stunting (although only the former effect is significant). These two variables suggest that experienced support available to pregnant women – either from extended families or long-acquainted neighbours and/or friends – are relevant for the newborn's health status. If competition for resources with other siblings or household members is an important factor determining infant and child malnutrition, this effect may not be as strong during pregnancy.

Because the NDHS 1998 survey does not report mother's height – the usual proxy for genetic risk – four biological risk variables (in addition to mother's age) are included: maternal mortality antecedents in the mother's family; the number of stillbirths by women in the household (from births in the last five years); antecedents of multiple births; and the average interval between births in the last five years. Estimates show that only the number of stillbirths is statistically significant (at a 10 percent level) and positively associated with the probability of birthweight stunting.

Longer intervals between births decrease the probability of birthweight stunting, but the effect is not significant.

Variables accounting for different forms of medical treatment during pregnancy show significant effects on birthweight on a systematic basis. Having received some form of ante-natal treatment (either by doctors, nurses, midwives or traditional birth attendants) decreases the probability of birthweight stunting. In contrast, other medical treatment controls, such as the average number of tetanus injections during pregnancies (in the last five years) and the number of ante-natal visits that pregnant women had (also during the last five years), both increase the probability of birthweight stunting. The demand for more medical attention during gestation may well indicate problems with the pregnancy (having already controlled for maternal biological risks). In this sense, these two variables do not account for the impact of medical treatment on health conditions as much as for problems during pregnancy.

As information on the number of hospital beds or medical personnel available by community is not included in the NDHS or readily available from other sources, three alternative variables are used as proxies for community health supply: the probability (in the form of scores)¹⁰ that any given child in the *barang* between 1 and 2 years of age was vaccinated in his or her first year; the score of medical treatment for diarrhoea among under-5s in the *barang*; and the score of deliveries carried out in public medical centres at the *barang*. The last two variables are found to be significant and positively related with the probability of birthweight stunting. In contrast, the vaccination score is negatively associated with birthweight stunting, although not significantly. As these variables are more likely to affect the morbidity and mortality of infants and children than newborns, their estimated effects may account for some endogenous relations between medical supply and health conditions relevant to newborns. Having controlled for biological and socio-economic factors, better public health facilities should perhaps be provided to *barangays* with poorer newborn conditions. Another possible explanation is that newborn conditions may be expected to improve when delivery takes place in private medical centres: whether this is a result of higher quality inputs available in private medical centres or an indication of the socio-economic status of the mother attending private facilities, is not obvious. The absence of information on health inputs in both private and public health centres prevents us from controlling fully for quality factors.

Conclusions

Using NDHS and birthweight stunting as nutritional proxy, this study confirms the negative effect of access to safe water and sanitary facilities on malnutrition in the Philippines, which has been found in previous studies using different data sources. Consistently, these effects are found to be not statistically significant, regardless of nutritional definitions, functional specifications and estimating techniques used. The negative effect that community-based provision of safe water (in the form of

piped water sources) has on the probability of birthweight stunting is larger than the effect caused by access to less safe water sources (that is, point sources). In terms of sanitation facilities, the probability of birthweight stunting is reduced most when households have access to flush toilets. In the absence of such facilities, access to latrines reduces the household probability of birthweight stunting more than drop or overhang disposal.

These and other estimates also provide valuable policy guidelines. Policy-makers in the Philippines should bear in mind six key results. First, water and sanitation provision has a positive effect on nutritional status (however measured). Second, this effect is neither uniform between water and sanitation services, nor among different provision modalities. Third, community-based piped water provision and flush toilets have the greatest potential to reduce malnutrition. Fourth, however, household access to point source water and latrines benefit marginally more those households that are poor (that is, with less educated mothers). Fifth, these effects are not substantial, which means that they cannot substitute for public interventions such as increasing health supply and the diffusion of good health practices, if the MDGs are to be achieved. Sixth, the generation of both relevant and rich datasets to monitor and evaluate nutritional progress is a priority: the NDHS is a good step in this direction but a precise measurement of various dimensions of health and nutrition and additional socio-economic information of the household are areas that still need improvement.

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Notes

1. According to the Department of Health, access to safe drinking water varies from 0.6 percent of households in the Autonomous Region of Muslim Mindanao (ARMM) to 96.3 percent in Central Luzon. In other poor regions such as Bicol, Western Mindanao and Eastern Visayas, household access reaches 60 percent to 65 percent, while in the more affluent regions of Ilocos and Southern Tagalog, 84 percent and 89 percent of households, respectively, have such access. In Metro Manila, only 62.7 percent of the population within the Metropolitan Waterworks and Sewerage System (MWSS) service area have access to safe drinking water (DoH, 1999).
2. These may be serious under-estimates, however, given the conservative assumptions made regarding yearly patient costs – ten-day morbidity for typhoid and paratyphoid and three days for diarrhoea, cholera and hepatitis A.
3. It also seems that better educated mothers are more likely to know the actual weight of their newborns. Mothers with secondary and tertiary education represent the categories with the lowest incidence of unknown birth-weights.
4. The database for the 1999 round was not available at the time of writing this paper.

5. The analysis of interaction effects is restricted to those related to basic services and parental education. This paper avoids either the mechanization of interaction effects (i.e. all possible interactions are considered regardless of their economic meaning), or their random inclusion. It provides an implicit test of whether results found for different age groups, samples, and surveys (cross-section and longitudinal) hold for the Philippines case. Specifically, it explores the robustness of their significance to the definition of malnutrition not only for children and infants but also for newborns.
6. Filmer & Pritchett (1999) propose the estimation of a weighted wealth index using all household assets and housing conditions reported by demographic and health surveys. As they acknowledge, the problem with these indexes is the weighting of the wealth variables. There is no obvious a priori economic or social reason for one variable to be weighted more than another. The solution that they propose is the use of principal component analysis. This weighting alternative has two main problems, however: first, it has a statistical but not a socio-economic basis; second, as Filmer & Pritchett also acknowledge, there are no obvious explanations to interpret the second and remaining principal components.
7. This comparison refers to the elasticity of each variable over low birthweight. Appendix 1 reports these elasticities.
8. Having tried alternative specifications of education, the ability of mothers to read exhibits the strongest interaction effect with birthweight.
9. The construction of propensity score matches using Kernel distributions required non-parsimonious specifications. As a result, a reduced set of variables was used for pairing sample observations: maternal age, sex of household head, floor material, household size and geographical location of the household. Appendix 2 reports the propensity scores of each water and sanitation facility.
10. This probability is estimated as a score of vaccinated children with respect to non-vaccinated children pertaining to the same *barang*.

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Appendix 1. Birthweight stunting Elasticities

	(1) Birthweight stunting Aggregated	(2) Birthweight stunting Disaggregated	(3) Birthweight stunting Interaction Effects	(4) Birthweight stunting Interaction Effects
Mother's education	-0.2076	-0.1860	-0.2908	-0.3128
Partner's education	0.4180	0.4213	0.4266	0.4196
Household has access to safe water	-0.0065			
Household has access to community safe water		-0.0710	-0.0538	-0.0794
Household has a point source of water		-0.0313	-0.1619	-0.0466
Household has access to sanitary facilities	-0.0488			
Household has flush toilet		-0.0698	-0.0943	-0.0498
Household has latrine		-0.0346	-0.0389	-0.1550
Household sanitation is drop-overhang		-0.0135	-0.0137	-0.0154
Household has TV and radio	-0.1936	-0.1911	-0.1956	-0.1970
Household has a car	-0.0074	-0.0074	-0.0066	-0.0065
Household's floor is made of natural materials	0.0163	0.0135	0.0131	0.0120
Rural	0.0206	0.0138	0.0143	0.0138
Metropolitan Manila	-0.0453	-0.0444	-0.0444	-0.0463
Age of mother	11.6748	11.6236	11.7667	11.8653
Age square of mother	-6.0004	-5.9706	-6.0332	-6.0891
Sex of household head	-0.2801	-0.2763	-0.2761	-0.2772
Household size	-0.4982	-0.4971	-0.5066	-0.5043
Household has lived in community at least 5 years	-0.0925	-0.0879	-0.0851	-0.0897
Pregnant outputs of household's women	-0.1901	-0.1905	-0.1941	-0.1870
Squared pregnant outputs of household's women	0.2325	0.2313	0.2356	0.2354
Household's women have maternal mortality antecedents	-0.0011	-0.0007	-0.0003	-0.0005
Number of stillbirths of household's women	0.0567	0.0564	0.0564	0.0571
Household has antecedents of multiple births	0.0113	0.0114	0.0115	0.0119

(Continued on next page)

Appendix 1. Birthweight stunting Elasticities (*Continued*)

	(1) Birthweight stunting Aggregated	(2) Birthweight stunting Disaggregated	(3) Birthweight stunting Interaction Effects	(4) Birthweight stunting Interaction Effects
Vaccination score of children in the <i>barang</i>	-0.0267	-0.0293	-0.0325	-0.0387
Score of the medical treatment of diarrhoea in the <i>barang</i>	0.1493	0.1499	0.1515	0.1548
Score of delivery in public facilities in the <i>barang</i>	0.2152	0.2229	0.2266	0.2217
Household's pregnant women had some ante-natal care	-0.7363	-0.7329	-0.7652	-0.7507
Number of ante-natal visits of household's pregnant women	0.1826	0.1823	0.1832	0.1816
Mean of tetanus injections for household's pregnant women	0.3091	0.3092	0.3091	0.3095
Mean of birth intervals among household's pregnant women	-0.1363	-0.1370	-0.1412	-0.1409
<i>Interaction effects:</i>				
Community water source and access in premises			-0.0060	-0.0061
Community water source and household women read easily			-0.0074	
Point source water access and women read easily			0.1210	
Flush toilet and women read easily				0.0289
Latrine and women read easily				0.1110
Drop/overhang and women read easily				0.0024

Source: DOH (1999)

Notes: Estimates report probit coefficients except for the multinomial logit column, which reports marginal effects evaluated at the mean of each variable. Standard errors are reported in brackets. *** indicates significance at 1% level; ** significance at 5%; and * significance at 10%.

Hausman specification tests are conducted for the null hypothesis of Independence of Irrelevant Alternatives, that is, for the hypothesis that a multinomial specification produces efficient estimates of weight at birth (in detriment of the alternative hypothesis that *probit* estimates are efficient).

Appendix 2. Propensity Score Probits

	Piped Water	Point Source	Peddler's or bottled water	Flush toilet	Latrine	Drop/overhang disposal	Field/no sanitation facilities
Household size	0.0059 (0.0043)			-0.0270 (0.0047)***	0.0038 (0.0056)	-0.0050 (0.0087)	0.0093 (0.0064)
Rural	-0.7841 (0.0231)***	-0.8115 (-0.0232)***	-0.3750 (0.0507)***	-0.6401 (0.0259)***	-0.4248 (0.0305)***	0.2620 (0.0508)***	0.5648 (0.0383)***
Sex of household head	0.1607 (0.0339)***	-0.2197 (0.0346)***	0.1305 (0.0614)**	-0.0745 (0.0389)*	-0.0202 (0.0451)	-0.3093 (0.0904)***	-0.1649 (0.0589)***
Home floor made of natural materials.	-0.4118 (0.0233)***	0.5391 (0.0233)***	-0.0809 (0.0505)	-0.9368 (0.0252)***	0.7236 (0.0297)***	0.8195 (0.0551)***	0.9570 (0.0382)***
Mother's age	-0.0009 (0.0011)	0.0018 (0.0011)	-0.0031 (0.0023)	0.0006 (0.0012)	0.0014 (0.0014)	-0.0044 (0.0023)*	0.0046 (0.0016)***
Constant	-0.2671 (0.0638)***	-0.5316 (0.0549)***	-1.8044 (0.1034)***	1.4851 (0.0725)***	-1.7835 (0.0840)***	-2.1070 (0.1464)***	-2.3186 (0.1049)***
Number of observations	13,983	13,983	13,983	13,983	13,983	13,983	13,983
Chi2(n)	2,091.75	2,563.53	92.14	2,850.26	1,140.88	417.00	1,358.77
Log likelihood	-8,628.82	-8,394.40	-1,666.47	-6,964.95	-5,081.95	-1,777.13	-3,593.72

Source: DoH (1999).

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