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Achieving Child-Health-Related Millennium Development Goals: The Role of Infrastructure

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Summary. — This paper provides an empirical analysis of the determinants of three child-health outcomes related to the Millennium Development Goals: the infant mortality rate, the child mortality rate, and the prevalence of malnutrition. Using data from Demographic and Health Surveys, the paper goes beyond traditional crosscountry regressions by exploiting the variability in outcomes and explanatory variables observed within countries between asset quintiles. The findings suggest that apart from traditional variables (income, assets, education, and direct health interventions), better access to basic infrastructure services has an important role to play in improving child-health outcomes.

Key words — Millennium Development Goals, infant mortality, malnutrition, infrastructure

1. INTRODUCTION

In September 2000, the 189 member states of the United Nations unanimously adopted the Millennium Declaration. The Declaration outlines key development challenges, proposes a response to these challenges, and defines a series of targets and progress measures. There are eight broad goals (the so-called Millennium Development Goals, or MDGs hereafter), with 15 targets that are to be monitored through a set of 48 indicators. [1] The aim is to achieve these targets by 2015.

The setting of human development goals is not new to the development literature. Many in the early 1980s viewed the development challenge through the optic of basic human needs, a series of necessities that the donor community was to commit itself to provide the poor. [2] Today, the development challenge is no less daunting than it was two decades ago. In the intervening years, global growth has surged, a few primarily Asian countries have broken through the poverty barrier, and some significant progress in trade opening has occurred. These developments notwithstanding, and despite some gains in reducing the demographic explosion, the number of poor people has increased dramatically. Hence, the attraction to the MDGs as a way to re-ignite development efforts.

To many, the goals encapsulate some of the key development challenges facing governments and international donors. To others, goals 2 through 8 seem superfluous as long as the first—eradication of extreme poverty and hunger—is tackled. Since improvements in most indicators of development are highly correlated with gains in per capita income, they argue, why bother with specific aims in health and education?

The answer to this first question is that economic growth should help, but will not be sufficient to achieve the MDGs. [3] Performance in health, education, and gender equity are clearly

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Table 1. *Selected indicators for the MDGs by income level*

Income group	GDP per capita, PPP (current international $)	Malnutrition prevalence		Maternal mortality ratio	Infant (per 1,000 live births)	Under-5 (per 1,000)	School enrollment, primary (% net)	Literacy rate, youth female (% of females ages 15–24)
		Height for age (% of children under 5)	Weight for age (% of children under 5)	Modeled estimate (per 100,000 live births)				
Low income	1,900		43.7	656.7	83.5	128.3	78.1	65.5
Lower middle income	4,620	17.3	11.4	111.7	34.5	42.4	91.3	96.9
Middle income	5,180	25.0	11.3	105.7	32.7	40.1	91.6	96.9
Upper middle income	9,690			67.0	19.6	23.2	93.2	97.1
High income	26,960			13.5	5.8	7.0	97.4	

Source: Author's computations from the World Bank's WDI indicators. In some cases, average values are omitted due to few data points in group.

influenced by income levels. Table 1 shows, for example, that maternal mortality rates in middle income countries are a fraction (1/7th) of what they are in low income countries. The same observation can be made for the prevalence of malnutrition among children and child mortality rates, both of which drop as income rises. Similarly, school enrollment rates and ratios of female to male literacy rates are much lower in low income countries.

However, within income categories, large differences in outcomes suggest that income is not the sole determinant of the indicators used in the MDGs. Other factors and policies could be effective in improving well-being, For example, as suggested by Jayasuriya and Wodon (2003), GDP per capita is only one of several key inputs entering the "production function" for the MDGs. Beyond these inputs, there are also issues regarding the efficiency with which countries use their available resources to achieve these goals, and the key determinants of this efficiency. This point is clearly made in Figure 1, which illustrates the wide range of outcomes in child mortality and nutritional status of children within income categories in developing countries. Thus, some of the poorest countries outperform upper middle income countries in infant mortality rates and in nutritional status of children.

Beyond the risk of emphasizing income growth to the detriment of other policy interventions, a second question is whether in the urgency to meet individual targets, the development community is at risk of losing sight of the multisectoral nature of interventions and development outcomes such as the MDGs. Again, the emphasis on linkages among sectors is not new to the development literature. [4] But we argue here that the MDGs will be useful tools only if they are not seen as narrow objectives with uni-dimensional interventions. To be concrete, it would be counterproductive if the goal of universal primary education were to be equated with higher spending on primary education. Primary education improvement in a particular country may well depend on better transportation networks in rural areas, in the same way that lower infant mortality may depend crucially on clean water, or gender equality in school enrollment may hinge on access to piped water (facilitating girl child school attendance).

The role of multisectoral linkages in the achievement of MDG-like goals has long been recognized (see, for example, Crosswell, 1981; De Melo, 1981; Lewis, 1981), but it deserves renewed emphasis since they are key to reaching the MDGs, and doing so at a potentially lower cost. There are clear gains from multisectoral interventions such as maternal and child health interventions (health, nutrition, and family planning), as well as from water, sanitation, and shelter and other bundled interventions. The effectiveness of multiple interventions in infrastructure, for example, can be shown to yield economies of delivery (Chong & Hentschel, 2003). Yet intersectoral connections are often underplayed when designing the average health, education, or infrastructure project. For this reason, a renewed emphasis on multisectoral factors that affect MDGs is useful.

Some of the biggest improvements are, in fact, likely to come from combining interventions. For example, it is well known that the health impact of improved water and sanitation is much greater when it is accompanied by

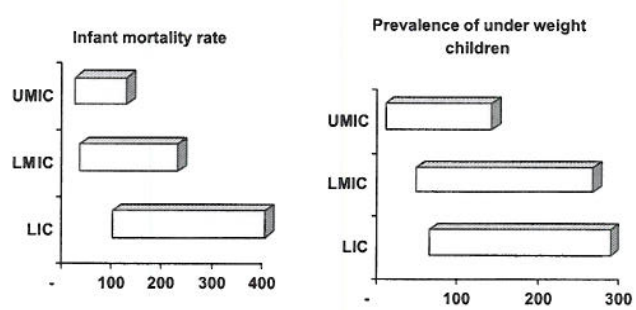

Figure 1. *Infant and child mortality by income group. Source: Author's calculations from World Bank's WDI. Note: Rates are normalized such that the sample average is set at 100. LIC, LMIC, and UMIC are, respectively, low income countries (27 countries), lower middle income countries (19 countries), and upper middle income countries (28 countries) for a total sample of 74 developing countries.*

behavioral changes interventions particularly as they pertain to hygiene—this is the motivation of the Public–Private Partnership for Handwashing with Soap, a global initiative to promote handwashing with soap to reduce diarrhea. [5] Similarly, Jalan and Ravallion (2001) argue for the need to combine infrastructure interventions with effective public action to promote health knowledge: Their research on India shows that diarrhea is much less prevalent and severe among young children in households with piped water, but that this gain largely bypasses children in poor households, particularly when the mother is poorly educated.

The objective of this paper is to explore the gains to be achieved from multisectoral interventions. In Section 2, we provide a brief review of the literature on the determinants of children's health outcomes—a key component of the MDGs—and discuss what we know of the role of infrastructure and other nonhealth related interventions. Section 3 outlines a simple reduced form model for estimating the determinants of child-health outcomes using crosscountry quintile-level data. We then present our empirical results for the estimation of this model in Section 4 and conclude in Section 5.

2. DETERMINANTS OF CHILD HEALTH: A BRIEF LITERATURE REVIEW

This paper provides an empirical analysis of the determinants of child health. In doing so, it makes the case for the importance of multisectoral interventions, including access to basic infrastructure services, in order to meet several of the core targets of the MDGs (malnutrition and infant/child mortality).

A number of studies have looked at the determinants of child (and maternal) health using crosscountry data. These studies typically find a large impact of income (or proxies for income), with elasticity estimates ranging from 0.5 to 0.8, with the causality clearly running from wealthier to healthier (Pritchett & Summers, 1996). The relationship with inequality is less clear, however. Filmer and Prichett (1999) find that both income and its distribution matter, while Anand and Ravallion (1993) and Waldmann (1992) conclude that inequality is most important. Finally, Easterly (1999) finds a positive and robust relationship between income (both level and growth) and child mortality and nutritional status.

A few other key variables are typically found to be important determinants of child health and nutrition. Thus, Filmer and Prichett (1999) find that 95% of crosscountry variations in infant or child mortality can be explained by just five variables—GDP per capita, income distribution, female illiteracy rates, ethno-linguistic fractionalization, and the predominant religion of a country. They argue that cross-country studies on the topic can be summarized as follows: (a) socioeconomic characteristics explain nearly all the variation in mortality rates across countries and (b) public expenditure on health has much less impact on average health status than expected or hoped for. The latter point is explored in Filmer, Hammer, and Pritchett (1997) who emphasize the importance of understanding the health seeking behavior of individuals, as well as the incentives facing health care providers in order to design health programs that are efficient and effective.

Two recent studies based on aggregated household data from demographic and health surveys (DHS) provide additional crosscountry evidence. Rutstein (2000) finds the strongest determinants of child mortality to be, in decreasing order of importance, the percentage of births that are the mother's fourth or more, the percentage of children born to mothers younger than 18, the percentage of children born to underweight mothers, and the percentage of households with drinking water from a surface source. The regressions do not include income variables however. Wang (2003) who combines DHS and World Development Indicators (WDI) data for a sample of 41 developing countries finds that the child mortality rate decreases with a higher GDP per capita, higher rural share of the population, vaccination, and greater access to electricity. For infant mortality rates, public expenditure on health and access to improved sanitation were also found to be significant. The work of Wang suffers from several limitations, however, including the small sample size and the absence of income or inequality variables.

There has also been increased interest in recent years on the impact of environmental health factors on child and maternal health. Thus, according to the WHO's, 2002 World Health Report, unsafe water, poor sanitation, and hygiene are the cause of 4–8% of the overall burden of diseases in developing countries and nine-tenths of diarrheal diseases. Given the importance of infrastructure—particularly water and sanitation, transport, and electricity—to environmental health, we review the literature on this topic, which tends to rely more on household level data.

The clearest link to emerge from microhousehold studies are those between water, sanitation, and hygiene (WSH) and health. Esrey, Potash, Roberts, and Shiff (1991) reviewed 49 studies showing an average 22% reduction in diarrheal morbidity from improved water and sanitation. Some of the most convincing evidence comes from a natural experiment that occurred in Argentina as a result of privatization of about 30% of the country's municipal utilities, covering 60% of the country's population. This was studied by Galiani, Gertler, and Schargrodsky (2005) who found, using the variation in ownership of water provision (and the associated increase in coverage and improvement in quality of water services), that child mortality fell 5–9% in areas that privatized their water services. The effect was largest in poorer areas. The authors check the robustness of these results in a number of ways and clearly establish that privatization is associated with significant reductions in death from infectious and parasitic diseases, but is uncorrelated with deaths from causes unrelated to water conditions.

In addition, in his exhaustive review of the links between infrastructure and poverty, Brenneman (2002) also highlights some of the relationships identified in the literature between health and transport and electricity. He finds evidence reported in various studies that better transport contributes to easier access to health care as well as easier staffing and operation of clinics. Moreover, improved transport policy can reduce air pollution, notably particulates and lead that are particularly harmful to children.

As to electricity, its impact is less direct. It is rarely used for cooking in developing countries (South Africa is one exception) and as such does not directly displace the use of traditional fuel, which is well known to have a significant and negative impact on health. [6] However, electrification has been shown to be associated with a switching from traditional to modern fuels that reduces indoor air pollution (Barnes, Krutilla, & Hyde, 2005; ESMAP, 2003). In addition, electricity allows for refrigeration. More generally rural electrification is associated with a reduction in fertility (attributed not only to higher economic prospects, but also to the increased reliance on mechanization and the associated reduced need for additional household members) and an improved functioning of clinics. [7]

Finally, basic services affect school attendance, as well as educational performance, which in turn may be linked with health outcomes. The literature quoted in Brenneman (2002) shows that electricity allows for more studying, transport promotes easier establishment of schools and higher attendance because of reduced transit time and safer passage to schools, and access to piped water frees girls to go to school and contributes both to higher achievement and attendance by promoting better health.

3. MODELING CHILD-HEALTH OUTCOMES USING CROSSCOUNTRY QUINTILE DATA

Figure 2 shows a conceptual framework which is consistent with current understanding as well as the literature presented above. [8] Two components of disease are shown: exposure to pathogens and severity of infection. The former is a function of the infrastructure variable (as effect modified by the mother's education, breastfeeding, and immunization), and the latter is a function of nutritional status as revealed by the markedly different case-fatality rate of malnourished children.

Note, however, that diarrhea can cause secondary malnutrition, when people cannot benefit fully from food because frequent stools prevent adequate absorption of nutrients. We therefore show that the exposure to pathogens also affects malnutrition.

Even if children are sick and malnourished, access to quality health care can save their lives (oral rehydration solutions or ORS, antibiotics, rehabilitative feeding, antimalarials, etc.). Thus, these "medical care variables" are shown here as effect modifiers of the synergism between exposure to disease and malnutrition.

Household income or wealth is a partial determinant of many of these variables. It affects malnutrition (through food security and women's time constraints), access to infrastructure, and access to curative health services (*via* both greater access and greater propensity to access such services).

The education of the mother is depicted as an effect modifier in three places: in mediating the relation between income/wealth and malnutrition; in mediating between access to

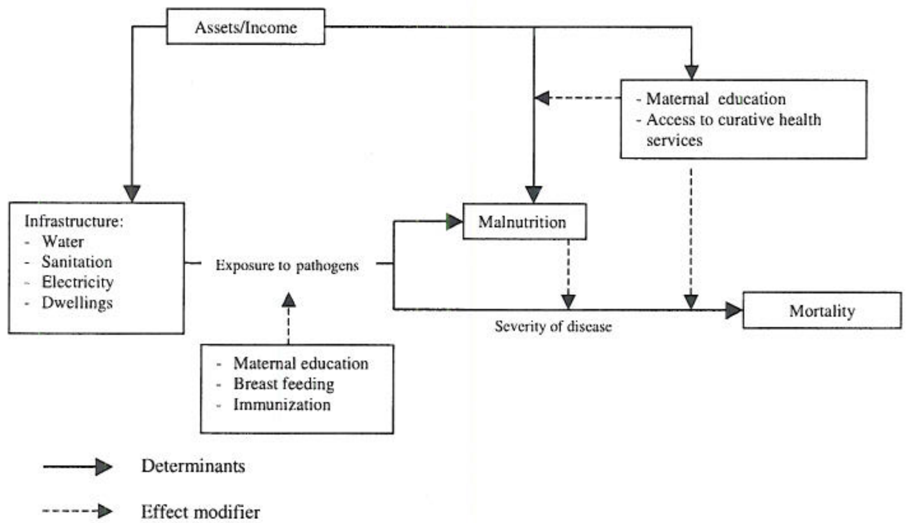

Figure 2. *Modeling the determinants of child mortality. Source: Authors, adapted from a suggestion by an anonymous referee.*

infrastructure and exposure to pathogens; and in mediating between infectious disease and mortality (a better educated mother is more likely to know how/when to administer ORS, seek appropriate medical care, and administer follow-up care).

In order to assess the determinants of child health, we use a database constructed by Gwatkin, Rutstein, Johnson, Pande, and Wagstaff (2000) from a DHS conducted in 39 developing countries. [9] The data are broken down by asset quintiles, based on a principal component analysis of various asset variables available in the surveys. The use of asset quintiles follows from the fact that DHS data do not include income or consumption. [10] The advantage of using these data is that we are able to go beyond traditional crosscountry regressions by exploiting some of the variability in outcomes and explanatory variables observed within a country. In addition, using quintile-level data substantially increases the sample size for the regressions.

However, these type of data require the use of multilevel regressions to account for possible nonindependence among data points. [11] Observations within each country (at the quintile level) tend to be more similar than between countries, which is a violation of the OLS basic assumption. Residuals and significance test of the coefficients may be overestimated in OLS models when individual characteristics are more similar within a group than between groups and the inclusion of country-level variables is not sufficient to correct for this nonindependence. Instead, these types of data require using hierarchical analysis (Hox, 1995; Snijders & Bosker, 1999) in which quintiles are the first level and countries the second. This method takes into account the fact that several observations are available for each country, while still allowing estimation of the effects of variables available at both the national and quintile levels.

The asset quintiles are defined at the country level, yet the extent of deprivation confronted by a household in the poorest quintile in a very poor and very unequal country is likely to be worse than that faced by a household in a richer, more equal country. More generally, the dispersion across quintiles will also be affected by country characteristics. We therefore include a number of country-level variables, and we interpret the quintiles as "mediators" of the national aggregate variables. Following Filmer and Prichett (1999), we include national GDP per capita, a measure of ethno-linguistic fractionalization, a measure of income inequality (the Gini coefficient), and the urbanization rate since in developing countries, health care tends to be much less easily accessible in rural areas than in cities (Jayasuriya & Wodon, 2003). These variables are from the WDI complemented by data from Milanovic (2002) for countries with missing Ginis, except for ethno-linguistic fractionalization which is from Easterly and Levine (1997).

Our measures of child-health outcomes are the rate of infant mortality, the rate of child mortality, and the rate of malnutrition within each quintile. [12] For malnutrition, we use the height-for-age *z*-score (HAZ), a measure of stunting or chronic malnutrition.

The household infrastructure variables are the shares of a household within each asset quintile with a sand or pounded earth floor, with access to piped water, without improved sanitation, and with access to electricity. [13] Given that infrastructure is a broad proxy for exposure to pathogens, we use a principal component index that includes all these variables. [14] This infrastructure variable is related to the measure of overall assets, although the latter does also include consumer durables and more information on the quality of the dwelling (quality of roof and walls).

Although DHS surveys do generally have information on mothers' education, our database by asset quintiles does not. We therefore use the national female literacy rate from the WDIs as an alternative proxy.

As a proxy for access to health care at the quintile level, we use a principal component index that includes the share of children with full vaccination, the share of pregnancies for which there was antenatal care, and the share of births attended medically. [15]

Given that we use data from 39 countries with five asset quintiles by country, we have a theoretical maximum of 195 observations. When explanatory variables are missing, the variable is set to zero and a dummy variable equal to 1 is included in that regression. The multilevel models were estimated using GLLAMM for STATA developed by Rabe-Hesketh, Skrondal, and Pickles (forthcoming), which uses maximum likelihood for the two levels model: quintile and country. Independence of observations is tested by the significance of country random effects in every model to prove the requirement for multilevel estimation. Models were estimated using random intercepts but not random coefficients (the latter could improve efficiency but would not change signs or significance).

4. EMPIRICAL RESULTS

Detailed definitions on the data used as well as summary statistics are provided in Appendix A, and Appendix B provides results for intermediate model specifications. We focus here on the discussion of the final models presented in Table 2, with hierarchical models estimated in levels. The key difference between the first three regressions and the last three is that the last three include an interaction term between the health and infrastructure explanatory variables. Starting with regressions 1 through 3, we find that infrastructure is a statistically significant determinant of both stunting and child mortality, but not of infant mortality. The reason for the lack of impact of access to basic infrastructure on infant mortality is probably the fact that infant mortality is more affected by the quality of care received by the mother and the child before and after delivery (including vaccination), than by access to infrastructure *per se*. By contrast, after the first year, infrastructure access plays a larger role. However, stunting and access to health care impact both infant and under-five mortalities. This suggests that infrastructure may still have an impact on infant mortality, but in an indirect way, *via* malnutrition.

Many national-level variables appear to be strong determinants of both infant and child mortality (regressions 1 and 2), suggesting that they do have a role to play in mediating the impact of the quintile variables. GDP per capita, ethno-linguistic fractionalization, inequality, and female illiteracy all have the expected impact on infant and under-five mortalities. Urbanization is positive and significant in regressions 1 and 2, implying that correcting for wealth, access to health care, infrastructure, and child mortality are (somewhat surprisingly) higher in urban areas. This could potentially capture the public health effect of crowding and pollution.

The effect of national-level variables on malnutrition (regression 3) is weaker—only GDP per capita and urbanization matter, both of which with a negative sign implying that higher income and higher urbanization result in lower chronic malnutrition.

As to the quintile dummies, we expect them to be positive and increasing in magnitude from quintile 4 to quintile 1 (since the omitted dummy is quintile 5 accounting for the wealthiest segment of the population). This is indeed the case for malnutrition, and generally so for mortality regressions. The odd exception is given by the relatively low coefficient on quintile 1 (the poorest). This perhaps could suggest that after accounting for the direct impact of the (higher level of) deprivation of the poorest in terms of access to health care, infrastructure, and good

Table 2. *Determinants of child-health outcomes*

	1 IMR	2 U5MR	3 Stunting	4 IMR	5 U5MR	6 Stunting
Constant	75.53	161.86	57.65	73.35	96.32	37.03
	(7.48)*	(10.74)*	(14.60)*	(7.16)*	(6.00)*	(9.99)*
Malnutrition – Stunting	0.22	0.37		0.19	0.52	
	(2.51)**	(2.91)*		(2.21)**	(3.83)*	
Infrastructure PC index	−0.34	−3.32	−1.96	1.79	−14.79	0.91
	(0.38)	(2.45)**	(4.66)*	−0.78	(4.05)*	(1.06)
Health PC index	−9.54	−18.01	−3.76	−8.74	−15.78	−0.83
	(8.70)*	(11.84)*	(10.02)*	(6.48)*	(7.57)*	(1.67)
Health PC index * Infrastructure PC index				−0.42	2.23	−0.58
				(1.00)	(3.36)*	(3.72)*
GDP per capita	−0.01	−0.03	−0.002	−0.01	−0.01	−0.002
	(10.39)*	(23.07)*	(6.33)*	(10.55)*	(11.65)*	(8.02)*
Ethno-linguistic fractionalization	8.56	21.85	−0.83	8.48	3.83	4.95
	(2.49)**	(4.59)*	(0.61)	(2.51)**	−0.74	(4.12)*
Gini index of inequality	0.24	1.21	−0.02	0.24	−0.14	0.23
	(4.82)*	(15.86)*	(0.68)	(4.86)*	(1.68)	(11.88)*
Female illiteracy rate	0.58	0.41	−0.02	0.58	1.56	0.01
	(12.00)*	(5.24)*	(0.89)	(11.96)*	(20.45)*	(0.50)
Urbanization rate	0.19	0.53	−0.11	0.20	0.85	−0.33
	(4.85)*	(9.31)*	(5.57)*	(5.00)*	(12.81)*	(19.47)*
Asset quintile 1	9.93	6.16	6.96	9.44	23.47	9.87
	(2.40)**	(0.99)	(3.95)*	(2.28)**	(3.60)*	(6.37)*
Asset quintile 2	13.78	14.62	5.21	13.04	29.67	6.87
	(3.87)*	(2.72)*	(3.43)*	(3.60)*	(5.19)*	(5.03)*
Asset quintile 3	12.00	12.43	4.15	11.15	25.70	5.11
	(3.85)*	(2.64)*	(3.16)*	(3.47)*	(5.06)*	(4.20)*
Asset quintile 4	10.11	11.89	3.36	9.46	20.08	3.59
	(3.86)*	(2.98)*	(3.09)*	(3.52)*	(4.68)*	(3.49)*
R-square level 1	0.76	0.80	0.81	0.76	0.78	0.83
R-square level 2	0.74	0.65	0.51	0.73	0.64	0.50
Variance at level 1	105.12	245.76	17.77	104.36	270.69	15.67
	10.93	24.94	1.86	10.82	27.61	1.60
Variance at level 2	312.34	1491.09	58.30	320.26	1546.73	59.46
	34.55	106.09	5.21	35.68	124.97	4.46

Source: Authors' estimation using multilevel regression with country random effects. Absolute value of *z* statistics in parentheses.
* Significant at the 1% level.
** Significant at the 5% level.

nutrition, the very poor do manage perhaps better than slightly better-off groups in coping with their difficult situation.

The magnitude of many impacts is large. Table 3 gives the impact of improving access to infrastructure and health care from the average value for the poorest quintile to that of the richest, keeping all else constant. Raising preventive health access from quintile 1 to quintile 5 levels would imply a 26–27% reduction in infant and child mortalities, and a 10% decline in stunting. Similarly, improving infrastructure access from quintile 1 to quintile 5 levels would result in an 8% decline in under-five mortality, and a 14% decline in stunting. Finally, reducing the incidence of chronic malnutrition from quintile 1 to quintile 5 levels would result in a 30–40% decline in infant and child mortalities.

The effect of health and infrastructure interventions are particularly significant when compared to that of national-level variables. Thus, we estimate that tripling GDP per capita for countries in the sample's poorest decile would only reduce infant mortality by 13% and child

Table 3. *Comparing the impact of per capita GDP to health and infrastructure access*

	Actual Quintile 1 value	Estimated Q1 value if tripled GDP per capita from sample's poorest decile value (US$768)[a]	Estimated value with improved access to health and infrastructure (using Quintile 5 instead of Quintile 1 levels)		
			Infrastructure	Health	Stunting
IMR	93.4	77.4	92.1[b]	67.5	88.5
Percent change		−17	−1	−28	−5
U5MR	152.3	136.4	140.2	103.8	144.0
Percent change		−10	−8	−32	−5
Stunting	40.9	37.8	35.0	31.5	Not applicable
Percent change		−8	−14	−23	

Source: Authors' estimations. Effects are calculated using the relevant values from Table 5 combined with the coefficients from regressions 1–3 in Table 2. Effects include both the direct effect and the indirect one (*via* stunting).
[a] The GDP per capita sample average is US$2,220 in 1995 constant values, so tripling the bottom decile's income per capita would bring it to about that sample average.
[b] Only indirect effect included since coefficient on infrastructure is not significantly different from zero in regression 1, Table 2.

mortality by 5%. (However, this does not account for indirect effects through other determinants that could improve with a higher income.)

As mentioned in the introduction, we expect the impact of infrastructure on child health to be higher if combined with health and education interventions. Our lack of quintile-level education variable precludes testing for that particular hypothesis, but we can test for the complementarity between health and infrastructure by introducing an interaction term between the infrastructure and health indices. This is done in regressions 4–6 in Table 2.

In the case of infant mortality (regression 4), we find once again that the health variable

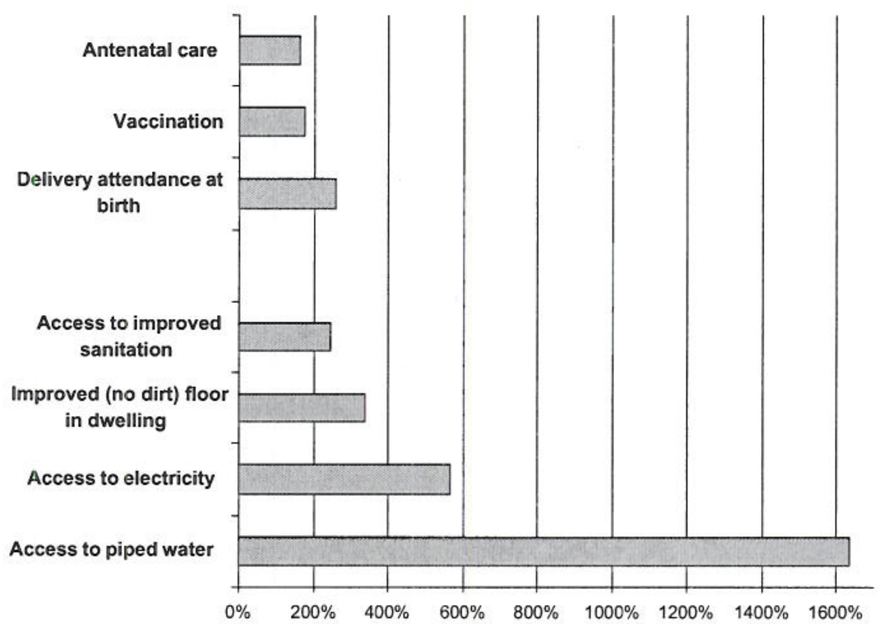

Figure 3. *Inequality in access to services is higher for infrastructure services. Source: Authors' estimation. Bars represent sample average for quintile 5 as a proportion of sample average for quintile 1, based on the data presented in Table 5.*

dominates, and that neither the infrastructure variable nor the interactive term has any statistically significant impact. In the case of child mortality (regression 5), the interactive term is in fact positive, suggesting that preventive health interventions and infrastructure could be substitutes, rather than complements. It is only with respect to malnutrition that we find the interactive term to be both significant and with the expected sign (suggesting health interventions and infrastructure to be complements). On the other hand, the coefficient on infrastructure is no longer significant, while that on the health variable is barely so.

Overall, the results on the impact of infrastructure variables are both interesting and challenging. They are interesting in the sense that we find that we can explain a substantial portion of the difference in health outcomes between the rich and the poor through the difference in service coverage. This is good news because presumably, it is easier to aim for universal (or at least widespread) access to water, sanitation, and electricity than for universal wealth. But it poses a daunting development challenge in the sense that the efforts required are still huge—the difference in access to water, sanitation, electricity, and decent housing of the poor and the rich remains enormous (Figure 3). Significantly improving child-health outcomes will require massive increases in water and sanitation coverage of the poorer populations.

5. CONCLUSION

The importance of adequate, affordable, and universal (or at least widely accessible) health care is recognized as essential to improving child-health outcomes. It is also well understood that mothers' education is a key determinant of the well-being of children—whether by reducing fertility or by facilitating the adoption of good nutritional and hygienic practices. What we have argued, however, is that achieving the health MDGs will require more than health and education interventions. In particular, infrastructure services have an important role to play, and a failure to recognize this in planning MDG strategies will risk undermining success. After a quick review of the literature as it pertains to the achievement of the child-health MDGs, we outlined and estimated a simple reduced form model for analyzing the determinants of child-health outcomes using crosscountry quintile-level data. The use of such data enabled us to go beyond traditional crosscountry regressions by exploiting some of the variability in outcomes and explanatory variables observed between asset quintiles within countries.

We find that at the national level, a higher GDP per capita, lower inequality, lower female illiteracy, and lower ethno-linguistic fractionalization all reduce infant and child mortalities. Urbanization has a positive effect, suggesting that for a given level of wealth, access to health care and infrastructure, children exhibit poorer health outcomes in urban areas. At the quintile level, the households' asset levels (which are used to define the quintiles), the prevalence of malnutrition, access to infrastructure, and preventive health also affect child mortality, and all these variables except infrastructure affect infant mortality. The impact of infrastructure on infant mortality appears small and indirect, *via* its impact on malnutrition. Note, however, that infrastructure is likely to have an additional effect through growth in per capita GDP over time, among others. In addition, some of the impact of infrastructure might already be partially captured through the asset quintile index, since infrastructure variables represent a large part of the index.

Chronic malnutrition is strongly affected by both health care and infrastructure access as well as household asset level. Higher national GDP per capita and urbanization lower chronic malnutrition.

We do not find evidence of a strong complementarity between health care and infrastructure. Instead, at least in the case of child mortality, they appear to be substitutes, rather than complements. The lack of quintile-level education variable precluded from testing the widely held belief that education, particularly maternal education, is an important complement to both access to health care and infrastructure services. More work would, however, be required before reaching strong conclusions on these interaction effects (or lack thereof).

One important finding is that GDP per capita becomes less important once a more complete set of explanatory variables is used for analyzing the determinants of health outcomes. Instead, variables such as female literacy, access to basic health care, and infrastructure, which are certainly easier to affect than the GDP per capita, are found to be the key.

NOTES

1. The eight goals are to eradicate extreme poverty and hunger, achieve universal primary education, promote gender equality and empower women, reduce child mortality, improve maternal health, combat HIV/AIDS, malaria and other diseases, ensure environmental sustainability, and develop a global partnership for development. For more information, see http://www.developmentgoals.org/. For a review of the progress on the International Development Goals, see www.paris21.org/betterworld.

2. See, for example, Hicks (1979), Hicks and Streeten (1979), and Leipziger (1981).

3. Simulations suggest that many countries may not in fact achieve the targets put forward in the MDGs unless they substantially change their policies. For Latin America, see, for example, Hicks and Wodon (2002).

4. A generation of development economists labored over general equilibrium models of development trying to clearly specify the interactions between policy interventions and development outcomes. Recall the path breaking work of Adelman and Robinson (1975), Adelman (1975), and the consolidation of this line of inquiry by Dervis, de Melo, and Robinson (1982).

5. A recent review in The Lancet Infectious Diseases Journal (http://www.infection.thelancet.com) suggests that a surprising 42–47% of all diarrhea could be prevented if people washed their hands with soap, thereby saving close to one million lives. There is growing evidence that hand washing also works to prevent acute respiratory tract infections, which are the biggest infectious killers in the world today. For more information on the Partnership, see http://www.globalhandwashing.org/.

6. Traditional biomass fuels are well known to be a significant source of indoor air pollution with a particularly negative impact on children's health. In addition, a study in South Africa where electricity is indeed used frequently for cooking has shown that electrification is associated with a reduction in household accidents such as paraffin poisoning and burns associated with other commonly used fuels (Community Health Research Group, 1995 as quoted in Brenneman, 2002).

7. Candles or kerosene lights make it difficult to safely perform an operation or even adequately examine a patient at night. In addition, vaccines require continuous and reliable refrigeration to retain their effectiveness. Alternatives to electricity exist, but they are more costly. Finally, anecdotal evidence suggests it is much more difficult to staff clinics that do not have electricity, particularly at night. For a discussion of these issues and a review of the literature, see Brenneman (2002).

8. We are grateful to an anonymous reviewer for helping frame this conceptual framework.

9. The list of countries is given in Table 4.

10. Filmer and Prichett (1998) show that an asset index, calculated as it is here, using principal component techniques, is an excellent proxy for household income.

11. We are grateful to an anonymous referee for pointing this out and for suggesting the use of multilevel regressions.

12. We are aware of the fact that infant mortality accounts for the greater share of child mortality (65–70% in many developing countries), and so it would make sense to separate infant, or even neonatal, from child (1–5 years) mortality. Unfortunately the data are not available to do so. Also, the mortality figures are based on births in the 10 years prior to the survey. The implication is that historical mortality rates are being explained with current covariates. This is a common issue in the literature on child mortality since many countries lack reliable vital registration systems and rely instead on household surveys which calculate mortality based on past births.

13. For the Dominican Republic and Turkey, we relied on ownership of a television as a proxy.

14. The infrastructure principal component index is equal to -0.43626 (no improved sanitation) $+ 0.52431$ (piped water) $- 0.46814$ (dirt floor) $+ 0.56181$ (electricity).

15. The health principal component index is equal to 0.61059 (antenatal care) $+ 0.60875$ (delivery attendance) $+ 0.50656$ (vaccination rate).

REFERENCES

Adelman, I. (1975). Development economics—A reassessment of goals. *American Economic Review, 65*(2), 302–309.

Adelman, I., & Robinson, S. (1975). *Income distribution policy in developing countries: A case study of Korea*. Oxford, UK: Oxford University Press.

Anand, S., & Ravallion, M. (1993). Human development in poor countries: On the role of private incomes & public services. *Journal of Economic Perspectives, 50*, 7–133.

Barnes, D. F., Krutilla, K., & Hyde, W. F. (2005). *The urban household energy transition: Social & environmental impacts in the developing world*. Baltimore, MD: John Hopkins University Press.

Brenneman, A. (2002). Infrastructure & poverty linkages: A literature review. Background Report, The World Bank, Washington, DC.

Chong, A., & Hentschel, J. (2003). Bundling of basic services & household welfare in developing countries: The case of Perú. Background Report, The World Bank, Washington, DC.

Community Health Research Group (1995). *Electrification & health: The interface between energy, development & public health*. Tygerberg, South Africa: Medical Research Council.

Crosswell, M. (1981). Growth, poverty alleviation & foreign assistance. In D. M. Leipziger (Ed.), *Basic needs & development* (pp. 1–28). Cambridge, MA: Oelgeschlager, Gunn & Ham.

De Melo, M. (1981). Modifying the effects of alternative approaches to basic human needs: Case study of Sri Lanka. In D. M. Leipziger (Ed.), *Basic needs & development* (pp. 137–180). Cambridge, MA: Oelgeschlager, Gunn & Ham.

Dervis, K., de Melo, J., & Robinson, S. (1982). *General equilibrium models for development policy*. Cambridge, NY: Cambridge University Press.

Easterly, W. (1999). Life during growth. Policy Research Working Paper No. 2110, The World Bank, Washington DC.

Easterly, W., & Levine, R. (1997). Africa's growth tragedy: Policies and ethnic divisions. *Quarterly Journal of Economics, 50*, 112–1203.

ESMAP (Joint UNDP/World Bank Energy Sector Management Assistance Program) (2003). Household energy use in developing countries—A multicountry study. ESMAP Technical Paper No. 042-03. Available from http://wbln0018.worldbank.org/esmap/site.nsf/pages/042-03.

Esrey, S. A., Potash, J. B., Roberts, L., & Shiff, C. (1991). Effects of improved water supply & sanitation on ascariasis, diarrhea, dracunculiasis, hookworm infection, schistosomiasis, & trachoma. *Bulletin of the World Health Organization, 89*(5), 609–621.

Filmer, D., Hammer, J., & Pritchett, L. (1997). Health policy in poor countries: Weak links in the chain. Policy Research Working Paper No. 1874, The World Bank, Washington, DC.

Filmer, D., & Prichett, L. (1998). Estimating wealth effects without expenditure data or tears. Policy Research Working Paper No. 1994, The World Bank, Washington, DC.

Filmer, D., & Prichett, L. (1999). The impact of public spending on health: Does money matter? *Social Science & Medicine, 49*, 1309–1323.

Galiani, S., Gertler, P., & Schargrodsky, E. (2005). Water for life: The impact of the privatization of water services on child mortality. *Journal of Political Economy, 113*(1), 83–120.

Gwatkin, D. R., Rutstein, S., Johnson, K., Pande, R., & Wagstaff, A. (2000). Socio-economic differences in health, nutrition, & population. HNP and Poverty Country Reports, HNP/Poverty Thematic Group, The World Bank, Washington, DC. Available from http://www1.worldbank.org/hnp.

Hicks, N. (1979). Growth versus basic needs: Is there a tradeoff? *World Development, 7*(10/11), 985–994.

Hicks, N., & Streeten, P. (1979). Indicators for development: The search for a basic needs yardstick. *World Development, 7*(6), 567–580.

Hicks, N., & Wodon, Q. (2002). Reaching the Millennium Development Goals in Latin America: Preliminary results. En Breve, 8, The World Bank, Washington, DC. Available from http://www.worldbank.org/en_breve.

Hox, J. J. (1995). *Applied multilevel analysis*. Amsterdam, The Netherlands: TT-Publikaties.

Jalan, J., & Ravallion, M. (2001). Does piped water reduce diarrhea for children in Rural India? Policy Research Working Paper No. 2664, The World Bank, Washington, DC.

Jayasuriya, R., & Wodon, Q. (2003). Efficiency in reaching the Millennium Development Goals. World Bank Working Paper No. 9, The World Bank, Washington, DC.

Leipziger, D. M. (1981). Policy issues & the basic human needs approach. In D. M. Leipziger (Ed.), *Basic needs & development* (pp. 107–136). Cambridge, MA: Oelgeschlager, Gunn & Ham.

Lewis, M. (1981). Sectoral aspects of a basic human needs approach: The linkages among population, nutrition & health. In D. M. Leipziger (Ed.), *Basic needs & development* (pp. 29–106). Cambridge, MA: Oelgeschlager, Gunn & Ham.

Milanovic, B. (2002). True world income distribution, 1988 & 1993: First calculations, based on household surveys alone. *Economic Journal: The Journal of the Royal Economic Society, 112*(476), 51–92.

Pritchett, L., & Summers, H. L. (1996). Wealthier is healthier. *Journal of Human Resources, 31*(4), 841–868.

Rabe-Hesketh, S., Skrondal, A., & Pickles, A. (forthcoming). Maximum likelihood estimation of limited and discrete dependent variable models with nested random effects. *Journal of Econometrics*.

Rutstein, S. O. (2000). Factors associated with trends in infant & child mortality in developing countries during the 1990s. *Bulletin of the World Health Organization 2000, 78*(10), 1256–1270.

Snijders, T. A. B., & Bosker, R. J. (1999). *Multilevel analysis: An introduction to basic & advanced multilevel modeling*. London, UK: Sage Publishers.

Waldmann, R. J. (1992). Income distribution & infant mortality. *The Quarterly Journal of Economics, 107*, 1283–1302.

Wang, L. (2003). Determinants of child mortality in LDCs: Empirical findings from demographic & health surveys. *Health Policy, 55*, 277–299.

WHO (World Health Organization) (2002). *The World Health Report 2002, Reducing risks, promoting healthy life*. Geneva. Available from http://www.who.int/pub/en/.

APPENDIX A. DATA SOURCES, VARIABLE DEFINITIONS, AND SAMPLE OF COUNTRIES

Most national-level data are from the World Bank's WDI (http://www.worldbank.org/data/), complemented in the case of the inequality measure with data from Milanovic (1999.) The index of ethno-linguistic fractionalization for 1960 measures the probability that two randomly selected persons from a given country will not belong to the same ethno-linguistic group, as reported in Easterly and Levine (1997). The quintile-level data are from Gwatkin *et al.* (2000). The methodology used to develop the asset quintiles is discussed at http://www.worldbank.org/poverty/health/data/index.htm. For information on Demographic and Health Surveys, see http://www.measuredhs.com/.

List of variables and definitions:

GDP per capita: In 1995 US dollars, from the WDI.

Gini: Gini coefficient, mostly WDI, complemented with data from Milanovic (1999).

Urbanization rate: Share of the country's population living in urban areas (WDI).

Female illiteracy rate: Share of females of ages 15 and above who cannot, with understanding, read and write a short, simple statement on their everyday life (WDI).

Infant mortality rate: Number of deaths to children under 12 months of age per 1,000 live births, based on births in the 10 years preceding the survey (DHS).

Under-five mortality rate: Number of deaths to children under five years of age per 1,000 live births. Figures are based on births in the 10 years preceding the survey (DHS).

Malnutrition: Share of children whose weight measurement is more than two standard deviations below the median reference standard for their age as established by the World Health Organization, the US Centers for Disease Control, and the US National Center for Health Statistics. The figures in the tables are based on a sample of living children under three, four, or five years of age, depending on the country (DHS).

Percent of mothers with low body mass index (BMI): Share of women whose BMI is less than 18.5, where BMI—an indicator of adult nutritional status—is defined as weight in kilograms divided by the square of height in meters. In some countries, BMI is presented for all sample women, while in other countries, the figure is available only for mothers of children under five years old (DHS).

Vaccination rate: Share of surviving children of age 12–23 months who received all vaccinations, namely BCG, three doses of DPT and oral polio, and measles (DHS).

Diarrhea prevalence: Share of surviving children under three, four, or five years old (depending on the country) who had diarrhea in the two weeks preceding the survey based on mothers' reports concerning the presence of loose stools (DHS).

Medical attendance: Share of children with diarrhea in the past two weeks who were taken to any medical facility for treatment, defined as a private doctor, mission/hospital clinic, other private hospital/clinic, pharmacy, or a public facility (DHS).

Acute respiratory infection (ARI) prevalence: Share of surviving children under three, four, or five years old (depending upon the country) who had a cough accompanied by rapid breathing in the two weeks preceding the survey, as defined and reported by the mother (DHS).

ARI medical attendance: Share of children with a cough and rapid breathing in the preceding two weeks who were taken to any medical facility for treatment (DHS).

Antenatal care: Share of births in the five years before the survey for which a woman received at least one antenatal care consultation from a medically trained person, defined as a doctor, nurse or nurse-midwife; at least one antenatal care consultation from a doctor; at least one antenatal care consultation from a nurse or nurse-midwife; two or more antenatal care consultations from a medically trained person (DHS).

Delivery attendance: Share of births in the five years prior to the survey that were attended to by a medically trained person, defined as a doctor, nurse, or nurse-midwife, a doctor, a nurse-midwife (DHS).

Dirt floor in dwelling: Share of dwellings that have a sand or dirt floor (DHS).

Access to piped water: Share of dwellings that have piped water in the residence (DHS).

Access to electricity: Share of households with electricity in the house (DHS).

No improved sanitation: Share of households without any kind of improved sanitation, with the definition varying across surveys but generally including unimproved latrines or use of fields and bushes (DHS).

See Tables 4 and 5.

Table 4. *Countries and years included in the sample*

Country	Year
Bangladesh	1996–97
Benin	1996
Bolivia	1998
Brazil	1996
Burkina Faso	1992–93
Cameroon	1991
Central African Republic	1994–95
Chad	1996–97
Colombia	1995
Comoros	1996
Côte d'Ivoire	1994
Dominican Republic	1996
Ghana	1993
Guatemala	1995
Uzbekistan	1996
Haiti	1994–95
India	1992–93
Zambia	1996
Kazakhstan	1995
Kenya	1998
Kyrgyz Republic	1997
Madagascar	1997
Malawi	1992
Mali	1995–96
Morocco	1993
Mozambique	1997
Namibia	1992
Nepal	1996
Nicaragua	1997–98
Niger	1998
Nigeria	1990
Pakistan	1990–91
Paraguay	1990
Peru	1996
Zimbabwe	1994
Tanzania	1996
Uganda	1995
Togo	1998
Turkey	1993

Source: Country sample in Gwatkin *et al.* (2000).

Table 5. *Summary statistics for variables used in the empirical analysis*

	Asset quintiles					Sample average
	1	2	3	4	5	
Infant mortality rate (per thousand)	93.4	90.2	83.6	74.0	53.9	79.1
Child mortality rate (per thousand)	152.3	146.1	133.3	116.4	83.0	126.2
Malnutrition (%)	40.9	35.7	32.0	27.2	18.6	30.9
Infrastructure PC index	2.0	2.5	3.2	3.9	5.0	3.3
No improved sanitation (%)	63.5	47.7	33.5	20.6	10.1	35.1
Access to piped water (%)	3.3	9.9	17.6	30.3	53.9	23.0
Dirt floor in dwelling (%)	72.7	60.2	42.1	25.9	7.3	41.6
Access to electricity (%)	13.8	23.6	32.9	49.1	78.2	39.5
Health PC index	3.4	4.0	4.4	5.1	5.9	4.5
Antenatal care (%)	56.0	65.6	71.3	81.1	91.5	73.1
Delivery attendance at birth (%)	31.8	42.1	50.6	65.1	83.1	54.5
Vaccination (%)	37.1	44.5	48.7	55.4	64.9	50.1
Health PC * Infrastructure PC[a]	7.3	10.9	14.8	20.6	29.8	16.7
GDP per capita (1995 US$)						2182.9
Ethno-linguistic fractionalization						0.5
Gini index of inequality						41.6
Female illiteracy (%)						46.7
Urbanization rate (%)						29.4

Source: Authors' estimation.
[a] Calculated as the average of the product, rather than the product of the averages.

APPENDIX B. MULTILEVEL MODEL INTERMEDIATE MODEL SPECIFICATION

See Tables 6–8.

Table 6. *Determinants of infant mortality, DHS data*

	1	2	3	4	5	6	7	8	9
Constant	81.76	46.03	115.59	59.13	103.17	47.66	81.73	75.53	73.35
	(28.68)*	(4.81)*	(12.48)*	(24.77)*	(9.71)*	(3.89)*	(9.49)*	(7.48)*	(7.16)*
Malnutrition – Stunting		1.34	0.41		0.43		0.54	0.22	0.19
		(8.34)*	(3.54)*		(4.22)*		(5.17)*	(2.51)**	(2.21)**
Infrastructure PC index		−3.46	−2.14		−1.17		−0.80	−0.34	1.79
		(3.06)*	(2.30)**		(0.89)		(0.85)	(0.38)	(0.78)
Health PC index			−9.70		−9.17		−9.88	−9.54	−8.74
			(8.37)*		(7.65)*		(7.88)*	(8.70)*	(6.48)*
GDP per capita						−0.01	0.00	−0.01	−0.01
						(3.50)*	(5.38)*	(10.39)*	(10.55)*
Ethno-linguistic fractionalization						5.81	−13.29	8.56	8.48
						(0.62)	(1.99)**	(2.49)**	(2.51)**
Gini index of inequality						0.21	0.36	0.24	0.24
						(1.41)	(3.72)*	(4.82)*	(4.86)*
Female illiteracy rate						0.69	0.45	0.58	0.58
						(6.58)*	(4.16)*	(12.00)*	(11.96)*
Urbanization rate						−0.01	0.15	0.19	0.20
						(0.10)	(3.42)*	(4.85)*	(5.00)*

(*continued next page*)

Table 6—*continued*

	1	2	3	4	5	6	7	8	9
Health PC *									−0.42
Infrastructure PC									−1.00
Asset quintile 1				39.27	3.56			9.93	9.44
				(13.54)*	(0.75)			(2.40)**	(2.28)**
Asset quintile 2				35.61	8.75			13.78	13.04
				(12.27)*	(2.14)**			(3.87)*	(3.60)*
Asset quintile 3				28.89	8.14			12.00	11.15
				(9.96)*	(2.31)**			(3.85)*	(3.47)*
Asset quintile 4				19.27	7.65			10.11	9.46
				(6.64)*	(2.62)*			(3.86)*	(3.52)*
R-square level 1	0.00	0.58	0.68	0.58	0.71	0.09	0.72	0.76	0.76
R-square level 2	0.00	0.73	0.69	0.39	0.68	0.87	0.76	0.74	0.73
Variance at level 1	432.03	179.57	137.02	180.94	126.42	395.03	120.55	105.12	104.36
	45.34	19.97	14.47	17.95	13.24	43.31	13.12	10.93	10.82
Variance at level 2	1182.21	318.91	361.49	716.78	381.98	148.59	277.90	312.34	320.26
	267.39	62.05	44.22	51.21	51.71	51.20	51.00	34.55	35.68

Source: Authors' estimation. Absolute value of *z* statistics in parentheses.
* Significant at the 1% level.
** Significant at the 5% level.

Table 7. *Determinants of under-five mortality, DHS data*

	1	2	3	4	5	6	7	8	9
Constant	99.56	160.22	198.77	55.80	175.72	34.37	169.31	161.86	96.32
	(31.19)*	(9.80)*	(20.71)*	(14.43)*	(15.23)*	−1.07	(12.30)*	(10.74)*	(6.00)*
Malnutrition − Stunting		1.03	0.69		0.61		−0.02	0.37	0.52
		(3.54)*	(4.84)*		(4.51)*		(0.10)	(2.91)*	(3.83)*
Infrastructure PC index		−14.70	−3.31		−5.58		−6.99	−3.32	−14.79
		(7.43)*	(2.48)**		(3.71)*		(5.10)*	(2.45)**	(4.05)*
Health PC index			−17.82		−14.33		−19.66	−18.01	−15.78
			(13.35)*		(11.06)*		(11.64)*	(11.84)*	(7.57)*
GDP per capita						−0.01	−0.01	−0.03	−0.01
						(3.16)*	(7.13)*	(23.07)*	(11.65)*
Ethno-linguistic fractionalization						31.82	22.63	21.85	3.83
						(1.40)	(4.04)*	(4.59)*	(0.74)
Gini index of inequality						0.60	0.69	1.21	−0.14
						(1.47)	(7.93)*	(15.86)*	(1.68)***
Female illiteracy rate						1.48	0.58	0.41	1.56
						(5.73)*	(7.56)*	(5.24)*	(20.45)*
Urbanization rate						0.16	0.08	0.53	0.85
						(0.73)	(1.12)	(9.31)*	(12.81)*
Health PC *									2.23
Infrastructure PC									(3.36)*
Asset quintile 1				69.36	2.90			6.16	23.47
				(13.42)*	(0.50)			(0.99)	(3.60)*
Asset quintile 2				62.29	11.69			14.62	29.67
				(12.06)*	(2.24)**			(2.72)*	(5.19)*
Asset quintile 3				49.24	10.37			12.43	25.70
				(9.53)*	(2.17)**			(2.64)*	(5.06)*

Table 7—*continued*

	1	2	3	4	5	6	7	8	9
Asset quintile 4				32.04	10.26			11.89	20.08
				(6.20)*	(2.37)**			(2.98)*	(4.68)*
R-square level 1	0.00	0.60	0.75	0.54	0.74	0.09	0.73	0.80	0.78
R-square level 2	0.00	0.69	0.68	0.07	0.57	0.82	0.53	0.65	0.64
Variance at level 1	1257.64	499.67	308.99	573.91	323.87	1147.66	334.22	245.76	270.69
	131.19	55.43	32.04	55.81	33.08	127.25	34.13	24.94	27.61
Variance at level 2	4282.44	1327.61	1353.20	3989.08	1852.02	791.73	1995.47	1491.09	1546.73
	524.72	141.18	83.36	258.80	130.83	197.50	174.60	106.09	124.97

Source: Authors' estimation. Absolute value of z statistics in parentheses.
* Significant at the 1% level.
** Significant at the 5% level.
*** Significant at the 10% level.

Table 8. *Determinants of stunting, DHS data*

	1	2	3	4	5	6	7	8	9
Constant	30.21	53.75	59.22	15.63	40.19	22.48	65.83	57.65	37.03
	(20.44)*	(51.45)*	(51.39)*	(16.38)*	(18.42)*	(3.26)*	(24.24)*	(14.60)*	(9.99)*
Infrastructure PC index		−6.02	−3.47		−2.89		−3.08	−1.96	0.91
		(20.55)*	(10.97)*		(8.38)*		(9.52)*	(4.66)*	(1.06)
Health PC index			−3.86		−1.65		−4.28	−3.76	−0.83
			(10.98)*		(4.35)*		(11.16)*	(10.02)*	(1.67)***
GDP per capita						0.00	0.00	0.00	0.00
						(1.53)	(6.54)*	(6.33)*	(8.02)*
Ethno-linguistic fractionalization						6.39	−1.47	−0.83	4.95
						(1.15)	(1.05)	(0.61)	(4.12)*
Gini index of inequality						0.10	0.03	−0.02	0.23
						(1.03)	(1.14)	(0.68)	(11.88)*
Female illiteracy rate						0.17	−0.02	−0.02	0.01
						(2.62)*	(0.84)	(0.89)	(0.50)
Urbanization rate						−0.11	−0.09	−0.11	−0.33
						(1.44)	(5.30)*	(5.57)*	(19.47)*
Health PC * Infrastructure PC									−0.58
									(3.72)*
Asset quintile 1				22.29	9.37			6.96	9.87
				(19.66)*	(6.69)*			(3.95)*	(6.37)*
Asset quintile 2				17.16	6.86			5.21	6.87
				(15.14)*	(5.46)*			(3.43)*	(5.03)*
Asset quintile 3				13.40	5.54			4.15	5.11
				(11.81)*	(4.84)*			(3.16)*	(4.20)*
Asset quintile 4				8.60	4.05			3.36	3.59
				(7.58)*	(3.93)*			(3.09)*	(3.49)*
R-square level 1	0.00	0.69	0.77	0.73	0.80	0.00	0.79	0.81	0.83
R-square level 2	0.00	0.06	0.38	0.20	0.58	0.54	0.53	0.51	0.50
Variance at level 1	93.46	29.30	21.42	25.07	18.29	93.46	19.24	17.77	15.67
	10.39	3.04	2.22	2.73	1.98	10.65	2.03	1.86	1.60

(*continued next page*)

Table 8—*continued*

	1	2	3	4	5	6	7	8	9
Variance at level 2	118.56	111.09	73.95	94.97	49.23	54.53	55.18	58.30	59.46
	21.24	11.05	6.96	11.22	3.99	17.90	5.04	5.21	4.46

Source: Authors' estimation. Absolute value of z statistics in parentheses.
* Significant at the 1% level.
** Significant at the 5% level.
*** Significant at the 10% level.