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I) Introduction:

Few health issues are as common and insidious as diarrhea. Every year, there are more than 4 billion episodes that account for around 20% of children deaths. Yet, the pervasive effects of this malady do not stop with deaths: diarrhea can lead to malnutrition, stunting and wasting, especially if episodes are frequent. Moreover, long episodes of diarrhea weaken the immune system and make children more vulnerable to other diseases.

Diarrhea is a symptom rather than a disease. There are several illnesses that can cause diarrhea but mostly it signals a gastrointestinal infection. Among the leading agents are cholera, typho, shinghella. Most of these agents have a common element: they can spread through contaminated water.

Children in developing countries suffer on average three of such episodes each year (Kosek et al 2003). Although diarrhea related mortality has declined, it still represents the second largest single cause of child deaths. Evidence has shown that diarrhea causes malnutrition and more worryingly, this leads to a vicious circle where malnutrition leads to longer episodes of diarrhea[1].

This paper is the second of a series of documents where we analyze the impact of water and sanitation on human development. While the companion paper looks at the effects of water and sanitation infrastructures on mortality, the aim of this study is to look at what can be termed an intermediate route through which poor water and sanitation infrastructure can have adverse effects on child survival. For this effect, we use a large set of Demographic and Health Surveys for 24 countries. We use statistical techniques extensively used in the medical research literature and in choice modeling.

Specifically, this study tries to understand the linkages between different types of water sources and sanitation facilities and diarrhea incidence. This relationship has long been suggested. The WHO estimates that around 88% of all diarrhea deaths are water and sanitation related. A common mechanism of transmission, for instance, is septic tanks contaminated with human feces; thus the importance of both water infrastructure and sanitation facilities to limit this problem.

This paper provides a cross country overview with comparable datasets. Our results are consistent with previous findings, though are more recent and of wider scope. The paper is divided in six sections. Section 2 briefly outlines the framework, section 3 discusses the methodology, Section 4 describes the data, section 5 presents the results and section 6 concludes.

[1] Although the nutritional status does not seem to have an effect on the incidence of diarrhea diseases.

II) Framework and literature review

We use a variation of the Mosley and Chen framework to estimate the impact of water and sanitation in the incidence of diarrhea. This framework is usually applied to studies on mortality. As discussed in detail in Fuentes et al. (2006a), community, household and individual socio-economic factors influence children's health through proximate determinants, such as maternal fertility, environmental contamination, nutrient deficiency, injury and personal illness control that represent underlying mechanisms. We follow this logic to study morbidity instead of mortality. More specifically, we estimate the impact that this particular type of infrastructure (water and sanitation) has on illness and do not focus on the mechanism through which this effect occurs –although it is accepted that personal hygiene is the key determinant to lower incidences of diarrhea, and access to cleaner sources of water just impact this incidence as long as personal hygiene improves.

The significance of water and sanitation in public health is widely recognized. Several empirical studies have analyzed the problem and have found strong links between health status and access to water and sanitation. Esrey et al (1991) conducted a very comprehensive meta-study reviewing the impact of water and sanitation on several diseases that are pervasive in the developing world, including ascariasis, diarrhoeal diseases, dracunculiasis, schistosomiasis, and trachoma. Four basic aspects were considered: sanitation, water quality, personal hygiene, and domestic hygiene. Every disease is affected by one or more of these interventions. The review was restricted to studies that presented data on the effect of water and sanitation conditions on one of the six diseases. In particular, the authors updated a previous review of 67 studies on diarrhoeal morbidity, nutritional status, and mortality by including 17 more recent studies. The results include:

- Sanitation was examined in 30 studies and 21 reported health improvements. Overall, a 22% reduction in morbidity was calculated for 11 of the 30 studies, whereas the reduction determined using data from five of 18 rigorous studies was 36%.
- Water quality and quantity: in most of the studies reviewed, it was difficult to determine whether the differences in health conditions were due to increased amounts of water, improvements in its quality, or both. Sixteen studies examined the health impacts of pure versus contaminated water supplies (water quality). Of the seven studies for which calculations could be made, a median reduction in the prevalence of diarrhea of 17% was found. Of the studies that examined the effect of increased amounts of water specifically and independently of water quality (water quantity), all but one reported a positive impact. The median reduction for seven studies for which this could be calculated was 27%.
- Hygiene: only six studies reporting on the impact of hygiene interventions on diarrhoeal morbidity were found. All were rigorous, and the median reduction was 33%. Some studies focused specifically on hand-washing. In Burma, a 30% reduction in diarrhea was reported when mothers and children were provided with soap and encouraged to wash their hands after defecation and before preparing meals. Other studies have examined not only handwashing, but combination of handwashing and

other hypienic behaviors such as suitable disposal of waste and faeces and handwashing.

However, the issue at hand has received more attention in country case studies in recent years. Wodemicael (2001) for instance, examines the effect of some environmental and socioeconomic factors that determined childhood diarrhea in Eritrea using a logistical model. The results show that the risk of diarrhea peaks at age 6-11 months and then decreases as the child grows older. The low risk of diarrhea during the age 0-5 months indicates the protective effect of exclusive breastfeeding in the first months of life.

Sastry and Burgard (2002) examine the trends and differentials in diarrhea prevalence and treatment in Brazil between 1986 and 1996. One of the goals is to investigate whether the apparent decline in diarrhea mortality over this period was accompanied by a decrease in diarrhea incidence, which helps to understand the factors responsible for the decline in mortality due to diarrhea. A large decline in diarrhea morbidity would suggest a more limited contribution of oral rehydration therapy (ORT) towards reducing mortality due to diarrhea, given that ORT does little to prevent diarrhea disease. The second goal is to identify the social, economic, and behavioral factors that were associated with diarrhea and its treatment using a multivariate logit. The authors find that declining diarrhea incidence was not the driver in the decline in deaths caused by diarrhoea, simply because the decline in prevalence was so meager.

Chekley et al (2004) assess the impact of water and sanitation on children nutritional status in a cohort of Peruvian children. The findings show that nutritional status is related to the quality of water and sanitation interventions and highlights the need to improve sanitation in developing countries. More reliable water sources diminish the risk of contaminated water, decrease diarrhoeal incidence, and improve linear growth in children.

Jalan and Ravallion (2001) constructed a behavioural model for children, where health status depends on access to piped water, parental spending on private inputs to child health, and a vector of personal and environment characteristics. The authors use Propensity-score matching methods to estimate the causal effects of piped water on child health in a cross-sectional sample. Among the findings are a significantly lower prevalence and duration of the disease for children living in households with piped water compared to a comparison group of households matched on the basis of their propensity scores.

III) Methodology

To capture the effect of water and sanitation we use a logistic model. Logit estimations are used when the outcome variable takes two possible states, hence the name binary models. Although these models have been used in economic literature to gauge the probability of choosing one option over another—taking the bus versus the train for instance—we use it to capture the probability of occurrence of a particular event. In a traditional econometric setting, logit model are used to capture choice behavior. For this reason, they are often referred to as “behavioral models”; see Train (2003) for an extensive discussion. In such a case, a random utility framework is used to derive the logit probabilities. In our case, diarrhea is not really a choice that children make as economic agents. However, logit models are standard probability models and have been reviewed extensively in the economics and biostatistics literature.

In particular, the outcome of interest takes two possible states: (Y=1) if the child had an episode of diarrhea in the two weeks prior to the survey and (Y=0) otherwise. Parameters in logit regressions can be interpreted as the change in probability associated with a unit increase in the independent variables. The resulting parameters thus show the change in probability of a diarrhea episode conditional on different individual, household and community characteristics. Formally

$Prob(Y=1)= F(\mathbf{x}, \boldsymbol{\beta})$ and $Prob(Y=0)=1- F(\mathbf{x}, \boldsymbol{\beta})$

Where $\mathbf{x}$ is a vector of characteristics, $\boldsymbol{\beta}$ is the vector of parameters to be estimated and F is the distributional form. For the logit model

$F(x,B) = \exp(\mathbf{x_i}'\boldsymbol{\beta})/ [1+ \exp(\mathbf{x_i}'\boldsymbol{\beta})]$

The parameters are estimated using maximum likelihood methods.

The results are presented as odds ratios. These are the exponentiated parameters and in our analysis represent the relative risk associated to the change in a particular characteristic. An odds ratio of one means full statistical independence. Thus values lower than one imply a decrease in the relative risk.

We take as comparison category a household with the poorest living conditions. This means that the changes in relative risk will represent the improvement of a child living in a poor household given the impact of a specific variable (piped water, toilet facility, etc).

IV)<u>Data:</u>

As mentioned above, the main database is the set of Demographic and Health surveys conducted my Macro International. The DHS are part of a program funded by USAID. Theses surveys gather information on the health status of all children in the household at the time of the interview; they also collect information on the characteristics of the dwelling and particularly, on women aged 15-49. The main advantage of working with the DHS is the identical framework with which they are carried out. The standard design of the questionnaires provides a valuable opportunity to compare indicators across countries.

For this study, we focus on children under five at the time of the interview, and the main variable of interest is the incidence of diarrhea, defined in the DHS questionnaire as whether the child had a diarrhea episode in the two weeks prior to the survey or not. We exclude from our sample those respondents with non available information and the information on dead children.

Fuentes et al. (2006a) extensively describes the data used in this paper. Briefly, the variables used as controls in the multivariate exercise are:

Individual level control variables: education of the mother, age of the mother at birth of child, length of birth interval, sex of child, whether the child was ever breastfed, mother's knowledge of oral re-hydration therapy (ORT) and in some cases religion of the mother.

Household level control variables: access to electricity, access to media, type of floor in dwelling, type of water facility, type of sanitation facility and position in the wealth distribution.

It is worth expanding in this last variable. Since the main interest of our study is to capture the effect of water and sanitation infrastructure on diarrhea, we had to construct a wealth index that would exclude these variables. We followed the standard procedure for the construction of wealth indices as indicated in the annex to this paper. We include in each case between eight and ten different household asset indicators to calculate the first principal component. With this information we construct a standardized index using principal component analysis. Households are then subdivided into quintiles based on their asset score. A more detailed discussion is provided in the appendix.

Community level controls: whether the household is located in an urban or rural center and season of birth

A brief explanation of the variables related to water and sanitation will clarify the terms used in the study. In the estimations of the models we used the definitions that are explained below:

Safe Water: We followed the Joint Monitoring Program (JMP) definition of improved water with the exception of rain water. It corresponds to a household having access to piped water or a covered well.

Independent Water: Indicates whether a household has access to a private water source or whether that source is shared with other households.

Flush Toilet: Indicates whether a household has a flush toilet.

Pit Toilet: Indicates whether a household has a pit latrine.

Improved Toilet: Indicates whether a household has a flush toilet or an improved pit latrine.

Traditional Toilet: Indicates whether a household has an unimproved/traditional pit latrine. This term is generally used in contrast to Improved Toilet, while the pair Improved/Traditional Toilet is used interchangeably with the pair Flush/Pit Toilet.

Toilet Facility Indicates whether a household has any toilet facility at all. This term is used when not enough observations are available to distinguish between toilet types.

Some of the summary statistics are presented in table 1. Each column shows the percentage distribution of children. In the Dominican Republic, only 37.7% of children have access to safe water. Kenya, Mozambique and Mali also show very low proportion, with respectively 38.5%, 40.1% and 40.3%. Egypt shows the largest proportion with near universal access of 98%. Access to sanitation is equally skewed across countries but with a larger number of countries showing relatively high proportions. Again Egypt has the highest proportion of children with access at 98.1%, contrasting with Benin at 24.6%.

Column 3 shows the proportion of children whose mother has no education. In general, Latin American countries show a large proportion of children with educated mothers, with the exception of Haiti and Nicaragua. Sub-Saharan Africa shows a wide dispersion across countries, ranging from 8% in Zambia to a high 84.6% in Mali. Asia also shows a relatively wide dispersion with 2.2% in the Philippines and 74% in Nepal. In India, only 53% of children have an educated mother.

Sex ratios are evenly distributed, with Egypt and India being the only exceptions. In those countries, girls represent about 48% of the sample and nearly a quarter of the children are infants in all of the countries.

The last two columns of the table show the distribution of children between the poorest and the richest quintiles of the wealth distribution. The poorest quintiles have the highest proportion of children, with Benin Mali and Zimbabwe showing nearly even distribution. The biggest differences are found in Latin America with a 16 percentage point difference in Nicaragua.

Table 2 shows the difference in access to safe water stratified by the position in the wealth distribution for a selected number of countries. The biggest differences are found in Kenya and Haiti, but all of the selected countries show wide differences in access between the children living in the poorest and the richest quintiles. This is significant because if wealth turns out to be a factor, then reducing inequalities could help indirectly reduce diarrhea infection rates. These hypotheses will be tested in the multivariate exercise below.

IV) Results:

Diarrhea episodes are very common. However tragic, in statistical terms, this event allows for a better analysis of the determinants of diarrhea and the linkages between water facilities and illness than would a rare event like mortality, an issue that the companion paper deals with at length.

As explained above, we estimate the risk of children suffering a diarrhea episode in the two weeks prior to the survey using a standard probability model (logit regression). We use six different specifications for all the countries in our sample. The specifications differ in the definition of water source and toilet facilities.

In the first one, for instance, we include four different types of water: piped, covered, surface and other and three different sanitation services: flush toilet, pit latrine and none. We also estimate the model using the definition of safe water (piped plus covered water) and independent water (this means that the water source is not shared) to test for the possible presence of externalities.

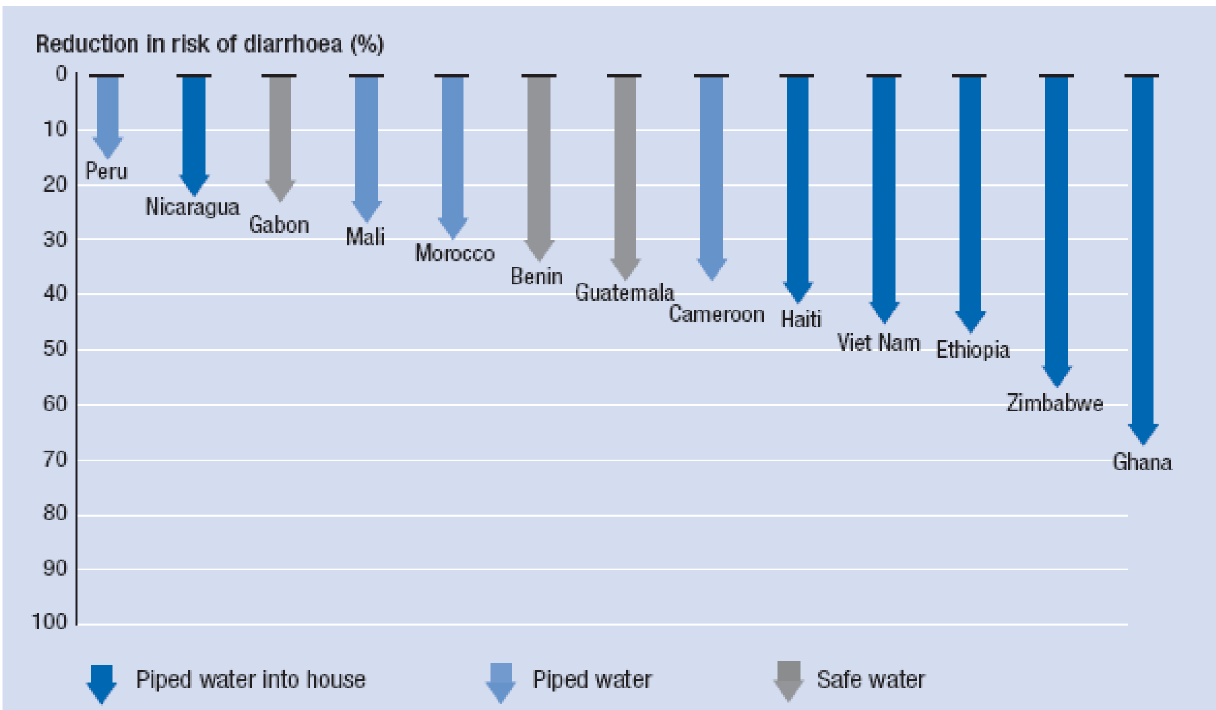
Overall, the results are very significant. The regression tables are presented on the back of this paper. For ease of interpretation, the consolidated results are presented graphically in the figures below for water and sanitation. In Benin, Cameroon, Malawi, Morocco and Vietnam the chances of diarrhea incidence are reduced significantly if the source of water is piped. In most of these countries the effect is larger than 30%. In Benin, Gabon, Malawi, Namibia and Zimbabwe the presence of safe water (piped water plus covered wells) reduce the risk of diarrhea by around 20 %. In Indonesia, bottled water (undeniably the safest source of water, but also the most expensive) reduces the risk of illness by 43 % relative to any other source of drinking water.

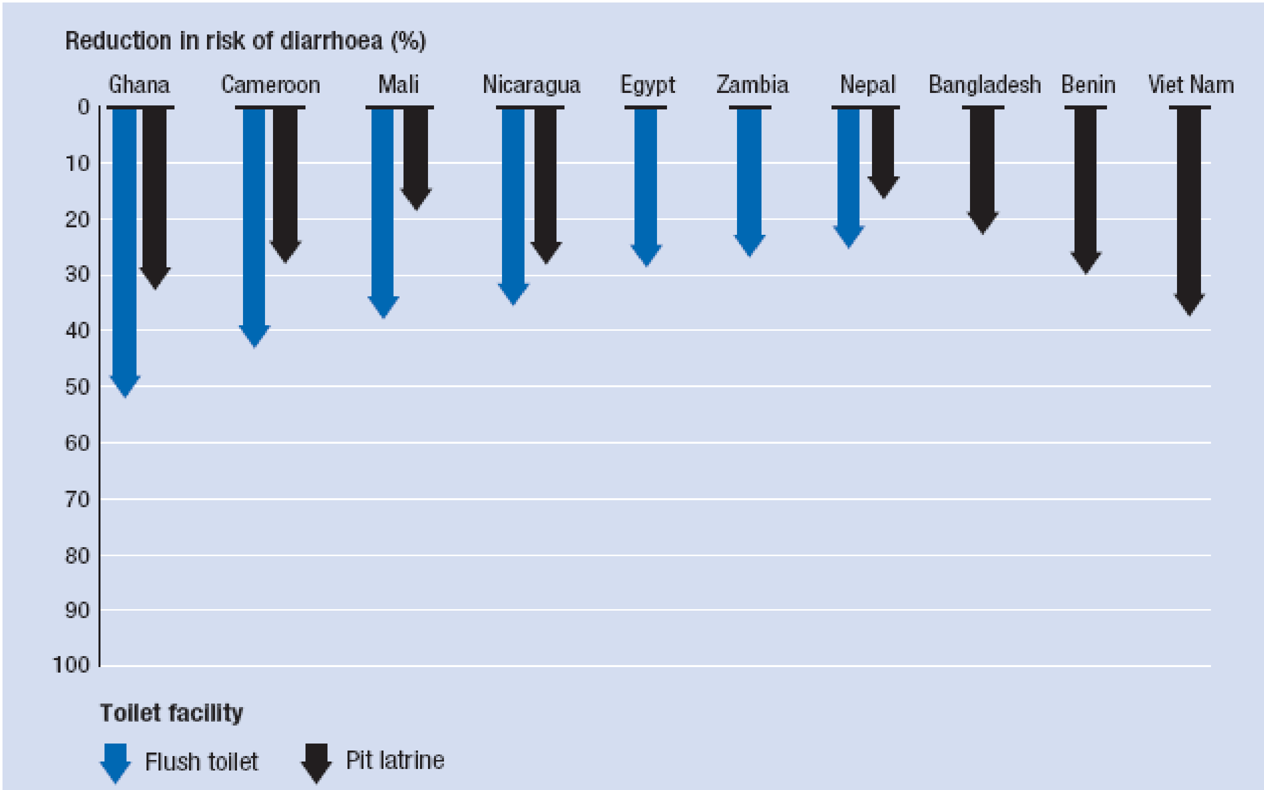
In Zambia and Zimbabwe, by contrast, non-shared sources of water reduce the risk of diarrhea by 28% and 23 % respectively. This suggests that there are negative externalities involved in shared water sources. This is the classic problem of common goods. Indeed there is a cost associated with maintaining the source that people will not internalize. Even if ownership is established and one has to pay to gain access, households simply do not have an incentive to keep the place clean. For operators, constant monitoring is an extra cost that they will not be willing to incur, especially if they have a certain degree of market power. That specific channel is potentially a source of pathogens.

In some countries, the evidence points a reduction in diarrhea incidence if the household has access to a water source in the dwelling. Such is the case in Ethiopia, Ghana, Guatemala, Haiti, Namibia, Vietnam and Zimbabwe. This might indicate a wealth effect, given that only the richest households will have this type of facility, but the effect remains after controlling for position in the social ladder (with the inclusion of wealth quintiles in the estimation). It might also capture the transmission effect of some of the diarrhea related diseases: children in households with water into the house are less exposed to ill children, and thus less likely to be to be infected.

Sanitary conditions also have a big impact on diarrhea incidence. Using as a comparison category a situation with no facility; the effects are large in some cases: in Mali, for instance, access to a flush or a pit toilet reduces the risk of diarrhea by respectively 39% and 18%. In Ghana, a flush toilet would cut in half the probability of diarrhea. The general results are intuitive: a flush toilet would reduce risk by a larger amount than a pit latrine where we found significant effects. We also found that for a couple of countries, namely Peru and Zimbabwe, the existence of a pit latrine increases the chances of a diarrhea episode. This result, although counterintuitive at first, might signal poor quality of latrines (and unfortunately, we have no means to test for this hypothesis with the data at hand).

Finally, we decided to pool the whole set of countries and use the same specification. The result of water sources and sanitation facilities on diarrhea are not as large as in the country analysis. This is expected however since we include all countries with available data, even if we found no correlation at the country level. Nevertheless, we found that in the pooled analysis, the presence of piped water lowers the risk of diarrhea by more than 10 %. We also found a similar effect for pit latrines. In the case of a flush toilet, the reduction is 13 %. In the specification using the independent water variable, the effect is about 6 %.





Other than water and sanitation facilities, mother's education has a big impact on the risk of having diarrhea. In Haiti, for instance, children whose mother has no education face a risk that is more than 80 % higher than children whose mother have higher education. In India and Indonesia the associated relative risk is respectively 40 % and 55%. This result was found in prior research which has shown that mother's education also plays an important role as "software" to some infrastructure improvements. Namely, educated mothers are more likely to engage in practices, such as boiling or filtering water, that could help reduce health risks.

Another consistent element in the analysis is the age of the child. Children in the first year of life are more likely to suffer diarrhea than children older than 12 months. The estimated parameters indicate that infants are between 30% and 70 % more likely to have diarrhea than non-infants.

The wealth status is not as important as expected, but this might be explained by the fact that we control for several other elements, such as area of residence, mother's education and access to media. However, in some cases the risk of having a diarrhea episode drops significantly for richer households. This is the case in Colombia and the Dominican Republic for instance.

V) Conclusions

This paper was written as part of a two documents series analyzing the effects of water and sanitation facilities on child health, specifically on infant and neonatal mortality and diarrhea incidence.

Our main goal was to estimate the size of water and sanitation interventions in the reduction of diarrhea incidence, the second largest cause of child deaths. The results are highly significant and large. Access to a clean water source represents one of the major interventions to reduce illness, along with mother's education. These results are consistent with several other academic findings, as described in section II of this document. However, the size of the impact varies largely by country. Moreover, in some cases only piped water into the house had a significant effect in reducing morbidity.

We often observe a step-ladder effect, where better infrastructure (piped water into the house, for instance) has the largest impact on the risk of having diarrhea. The same is true for sanitation infrastructure. Indeed, the costs associated with providing household connections are higher than those of providing a public standpipe and poor people may not be able to provide connection fees up front, making cost recovery highly unlikely. The same is true for sanitation infrastructure; providing a pit latrine may be more cost effective than providing a flush toilet. However as we have seen in this paper, the health benefits associated with a reduction in the incidence of illness can be substantially higher for households that have access to such infrastructure. Incidentally, a reduction in morbidity puts less pressure on public health systems, especially in developing countries, providing valuable savings in the medium to long term.

This has profound consequences for public health provision and cost benefit analyses of specific projects to provide water and sanitation, with possible applications of this principle for Millennium Development Goal costing exercises. The general discussions centers around provision in general. But as we have seen in this paper, policy makers have to weight which type of provision is more optimal and that is most likely going to be location specific.

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Table 1: Summary Statistics: Percentage of Children

Country	Safe Water	Toilet Facility	Mother has no Education	Child female	Child Infant	Poorest Quintile	Richest Quintile
Sub-Saharan Africa							
Benin	57.60%	26.10%	74.50%	49.60%	23.20%	17.70%	17.50%
Cameroon	52.80%	92.00%	26.00%	50.20%	22.10%	22.10%	17.90%
Egypt	98.00%	98.10%	37.90%	47.80%	20.80%	24.90%	16.20%
Ghana	59.30%	59.40%	47.50%	49.10%	21.60%	26.80%	12.90%
Kenya	38.50%	75.90%	20.20%	49.90%	22.90%	23.70%	13.10%
Malawi	66.90%	82.90%	30.10%	50.20%	24.20%	17.50%	18.00%
Mali	40.30%	75.60%	84.60%	49.70%	24.40%	17.90%	19.40%
Morocco	66.30%	75.80%	65.20%	49.60%	19.50%	25.90%	17.00%
Mozambique	40.10%	54.60%	41.20%	50.50%	23.00%	18.60%	18.60%
Namibia	72.40%	43.30%	17.60%	50.10%	24.20%	23.50%	13.60%
Uganda	54.80%	86.60%	24.00%	50.30%	22.90%	23.20%	12.80%
Zimbabwe	45.30%	69.40%	15.30%	50.20%	22.20%	17.40%	18.90%
Zambia	77.30%	63.30%	8.00%	49.20%	21.00%	23.90%	16.60%
Asia							
India	75.60%	39.70%	49.00%	47.30%	34.40%	21.10%	18.40%
Indonesia	55.50%	81.90%	4.50%	48.60%	20.00%	22.40%	18.50%
Nepal	73.10%	24.60%	74.30%	50.20%	18.80%	20.60%	14.00%
Philippines	76.60%	83.00%	2.20%	49.70%	20.10%	25.70%	14.60%
Vietnam	73.10%	78.90%	7.90%	47.00%	34.30%	26.80%	17.70%
Latin America							
Colombia	73.20%	89.50%	3.50%	49.50%	25.10%	25.00%	13.60%
Dominican Republic	37.70%	89.20%	6.10%	49.40%	20.00%	21.50%	15.60%
Haiti	48.30%	50.90%	42.70%	50.30%	21.00%	21.60%	13.00%
Nicaragua	79.80%	74.70%	25.40%	48.50%	18.40%	29.60%	13.70%
Peru	60.40%	65.90%	9.40%	49.40%	18.30%	23.80%	11.90%

Table 2: Difference in access to safe water for children in the richest and poorest quintiles

Country	Quintile	Quintile
Benin	43.60%	81.90%
Cameroon	39.10%	79.20%
Colombia	55.60%	87.60%
Haiti	32.00%	86.40%
India	69.90%	82.30%
Indonesia	30.60%	73.50%
Kenya	19.30%	84.40%
Morocco	36.80%	91.80%

Bangladesh				
Household source of water and type of toilet facility				
piped water			1.452	
			(0.117)	
surface water			0.719	
			(0.315)	
safe water		1.458		
		(0.114)		
independent water				1.471
				(0.219)
pit toilet	0.762*	0.761*	0.765*	0.768*
	(0.071)	(0.068)	(0.075)	(0.08)
flush toilet	0.767	0.701	0.708	0.765
	(0.288)	(0.163)	(0.177)	(0.305)
Mother's education level				
Primary	1.155	1.164	1.164	1.157
	(0.246)	(0.223)	(0.223)	(0.242)
Secondary	0.982	0.995	0.994	0.982
	(0.902)	(0.971)	(0.968)	(0.903)
Post-secondary	0.78	0.788	0.792	0.782
	(0.407)	(0.426)	(0.438)	(0.412)
Other characteristics of interest				
child female	0.95	0.951	0.95	0.95
	(0.628)	(0.63)	(0.631)	(0.628)
infant child	1.054	1.053	1.054	1.057
	(0.683)	(0.691)	(0.682)	(0.669)
urban	0.941	0.865	1.051	0.938
	(0.659)	(0.333)	(0.327)	(0.644)
Observations	6370	6370	6370	6370

Robust p-values in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Benin

Household source of water and type of toilet facility

piped water	0.635***		0.637***				
	(0.001)		(0.001)				
covered water	0.938		0.938				
	(0.633)		(0.635)				
surface water	0.779		0.78				
	(0.115)		(0.115)				
other water source	1.297		1.297				
	(0.165)		(0.164)				
safe water		0.786**		0.786**		0.767***	
		(0.012)		(0.013)		(0.006)	
private source of water							0.989
							(0.913)
has toilet facility			0.663***	0.637***			
			(0.003)	(0.001)			
pit toilet	0.661***	0.635***			0.618***		0.619***
	(0.003)	(0.001)			(0.001)		(0.001)
flush toilet	0.825	0.749			0.707		0.709
	(0.696)	(0.553)			(0.475)		(0.480)
Mother's education level							
Primary	1.012	0.986	1.014	0.987	0.97	0.951	0.97
	(0.927)	(0.914)	(0.917)	(0.921)	(0.814)	(0.700)	(0.818)
Secondary	0.735	0.714	0.743	0.72	0.695	0.646*	0.696
	(0.181)	(0.142)	(0.191)	(0.147)	(0.111)	(0.054)	(0.114)
Post-secondary	1.313	1.244	1.468	1.351	1.201	1.16	1.204
	(0.730)	(0.780)	(0.592)	(0.674)	(0.814)	(0.835)	(0.812)
Other Characteristics of interest							
child female	1.065	1.06	1.065	1.06	1.06	1.057	1.06
	(0.471)	(0.500)	(0.468)	(0.498)	(0.500)	(0.518)	(0.503)
infant child	1.048	1.05	1.048	1.05	1.044	1.054	1.044
	(0.651)	(0.638)	(0.651)	(0.638)	(0.679)	(0.614)	(0.678)
urban	0.974	0.922	0.975	0.922	0.905	0.846	0.906
	(0.831)	(0.501)	(0.836)	(0.504)	(0.410)	(0.167)	(0.420)
Observations	4443	4443	4443	4443	4443	4443	4443

Robust p-values in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Cameroon

Household source of water and type of toilet facility

piped water	0.646***		0.642***				
	(0.003)		(0.002)				
covered water	1.022		1.022				
	(0.862)		(0.861)				
surface water	0.609***		0.609***				
	0.000		0.000				
other water source	0.251**		0.250**				
	(0.026)		(0.025)				
safe water		1.217**		1.214**		1.209**	
		(0.020)		(0.021)		(0.024)	
private source of water							1.336***
							(0.001)
has toilet facility	0.730**	0.690***			0.694***		0.697**
	(0.023)	(0.008)			(0.009)		(0.010)
pit toilet	0.629*	0.560**			0.572**		0.510**
	(0.093)	(0.035)			(0.043)		(0.014)
flush toilet	0.818**	0.703***	0.819**	0.703***	0.701***	0.675***	0.735***
	(0.042)	0.000	(0.043)	0.000	0.000	0.000	(0.001)
Mother's education level							
Primary	0.724**	0.598***	0.721**	0.594***	0.600***	0.573***	0.633***
	(0.011)	0.000	(0.010)	0.000	0.000	0.000	0.000
Secondary	0.217**	0.178**	0.206**	0.164**	0.183**	0.159**	0.188**
	(0.043)	(0.021)	(0.034)	(0.015)	(0.023)	(0.013)	(0.026)
Post-secondary	0.871*	0.878*	0.871*	0.878*	0.879*	0.879*	0.874*
	(0.060)	(0.076)	(0.060)	(0.075)	(0.077)	(0.076)	(0.067)
Other characteristics of interest							
child female	1.021	0.925	1.021	0.924	0.973	0.906	0.976
	(0.838)	(0.440)	(0.837)	(0.432)	(0.784)	(0.328)	(0.809)
infant child	1.019	1.016	1.019	1.017	1.011	0.983	1.014
	(0.864)	(0.885)	(0.862)	(0.881)	(0.920)	(0.879)	(0.902)
urban	1.220**	1.240**	1.219**	1.239**	1.228**	1.227**	1.234**
	(0.030)	(0.019)	(0.031)	(0.020)	(0.024)	(0.025)	(0.022)
Observations	6424	6424	6424	6424	6424	6424	6424

Robust p-values in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Egypt							
Household source of water and type of toilet facility							
piped water	1.906		1.915				
	(0.216)		(0.212)				
covered water	1.895		1.906				
	(0.226)		(0.222)				
other water source	2.45		2.46				
	(0.142)		(0.140)				
safe water		0.976		0.978		0.984	
		(0.928)		(0.936)		(0.953)	
private source of water							0.560***
							0.000
has toilet facility			1.08	1.143			
			(0.809)	(0.677)			
pit toilet	1.174	1.246			1.243		1.34
	(0.666)	(0.556)			(0.559)		(0.431)
flush toilet	1.069	1.132			1.129		1.305
	(0.833)	(0.701)			(0.704)		(0.413)
Mother's education level							
primary	1.415***	1.415***	1.413***	1.412***	1.414***	1.417***	1.462***
	(0.007)	(0.007)	(0.007)	(0.007)	(0.007)	(0.006)	(0.003)
secondary	1.539***	1.540***	1.536***	1.537***	1.539***	1.541***	1.619***
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
post-secondary	1.322	1.318	1.32	1.315	1.318	1.318	1.394*
	(0.114)	(0.118)	(0.116)	(0.120)	(0.118)	(0.117)	(0.060)
Other characteristics of interest							
child female	0.849**	0.849**	0.849**	0.849**	0.849**	0.848**	0.851**
	(0.042)	(0.041)	(0.041)	(0.041)	(0.041)	(0.039)	(0.044)
infant child	2.210***	2.203***	2.209***	2.202***	2.204***	2.203***	2.193***
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
urban	0.847*	0.846*	0.847*	0.846*	0.846*	0.846*	0.878
	(0.080)	(0.075)	(0.079)	(0.074)	(0.073)	(0.074)	(0.167)
Observations	5954	5954	5954	5954	5954	5954	5954

Robust p-values in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Ethiopia

Household source of water and type of toilet facility

piped into household	0.524**
	(0.044)
pit toilet	1.048
	(0.674)
flush toilet	0.773
	(0.693)
Mother's education level	
Primary	0.899
	(0.301)
Secondary	0.777
	(0.213)
Other characteristics of interest	
child female	0.956
	(0.496)
infant child	1.225***
	(0.01)
urban	0.854
	(0.44)
Observations	9066

Robust p-values in parentheses

* significant at 10%; ** significant at 5%;

Gabon

Household source of water and type of toilet facility

piped water	0.81		0.78				
	(0.662)		(0.608)				
covered water	2.874**		2.796**				
	(0.045)		(0.049)				
surface water	1.091		1.083				
	(0.858)		(0.868)				
other water source	1.776		1.851				
	(0.501)		(0.494)				
safe water		1.142		1.103		1.083	
		(0.606)		(0.702)		(0.757)	
private source of water							0.578
							(0.196)
has toilet facility			0.729	0.753			
			(0.512)	(0.581)			
pit toilet	0.537	0.539			0.56		0.572
	(0.144)	(0.175)			(0.201)		(0.199)
flush toilet	0.422	0.41			0.428		0.44
	(0.119)	(0.121)			(0.138)		(0.138)
Mother's education level							
primary	0.586	0.584	0.609	0.609	0.583	0.617	0.602
	(0.232)	(0.219)	(0.266)	(0.255)	(0.219)	(0.266)	(0.251)
secondary	0.867	0.817	0.878	0.828	0.816	0.833	0.84
	(0.755)	(0.649)	(0.774)	(0.669)	(0.647)	(0.679)	(0.696)
post-secondary	1.124	1.097	0.989	0.947	1.087	0.952	1.116
	(0.911)	(0.929)	(0.991)	(0.958)	(0.936)	(0.962)	(0.916)
Other characteristics of interest							
child female	0.969	0.999	0.98	1.01	0.998	1.012	0.996
	(0.886)	(0.996)	(0.925)	(0.961)	(0.993)	(0.957)	(0.985)
urban	1.831**	1.327	1.841**	1.337	1.378	1.341	1.396
	(0.015)	(0.235)	(0.015)	(0.225)	(0.182)	(0.222)	(0.164)
Observations	872	872	872	872	872	872	872

Robust p-values in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Ghana

Household source of water and type of toilet facility							
piped water	0.838		0.807				
	(0.369)		(0.280)				
covered water	0.962		0.962				
	(0.815)		(0.816)				
surface water	0.818		0.816				
	(0.266)		(0.259)				
other water source	0.918		0.885				
	(0.849)		(0.786)				
safe water		1.039		1.032		1.031	
		(0.740)		(0.786)		(0.790)	
private source of water							0.854
							(0.441)
has toilet facility			0.700***	0.691***			
			(0.004)	(0.003)			
pit toilet	0.709***	0.703***			0.703***		0.701***
	(0.006)	(0.004)			(0.004)		(0.004)
flush toilet	0.440**	0.422**			0.423**		0.451**
	(0.024)	(0.017)			(0.018)		(0.031)
Mother's education level							
primary	1.300*	1.299*	1.300*	1.297*	1.300*	1.15	1.293*
	(0.074)	(0.076)	(0.076)	(0.078)	(0.074)	(0.322)	(0.082)
secondary	1.185	1.177	1.183	1.172	1.18	1.027	1.179
	(0.242)	(0.259)	(0.251)	(0.276)	(0.253)	(0.843)	(0.255)
post-secondary	0.253	0.245	0.221	0.211	0.246	0.179*	0.255
	(0.188)	(0.178)	(0.147)	(0.134)	(0.179)	(0.098)	(0.191)
Other characteristics of interest							
child female	0.926	0.918	0.926	0.917	0.918	0.923	0.918
	(0.459)	(0.406)	(0.458)	(0.401)	(0.405)	(0.438)	(0.409)
infant child	0.826	0.825	0.83	0.829	0.825	0.838	0.824
	(0.127)	(0.123)	(0.137)	(0.133)	(0.122)	(0.155)	(0.120)
urban	1.115	1.075	1.098	1.037	1.083	0.985	1.114
	(0.504)	(0.632)	(0.574)	(0.810)	(0.593)	(0.920)	(0.478)
Observations	3412	3412	3412	3412	3412	3412	3412

Robust p-values in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Guatemala

Household source of water and type of toilet facility			
piped water	0.732*		
	(0.048)		
covered water	0.707		
	(0.13)		
other water source	1.731*		
	(0.083)		
safe water		0.617***	0.622***
		(0.001)	(0.001)
pit toilet	1.038	1.06	
	(0.781)	(0.668)	
flush toilet	0.955	1.082	
	(0.847)	(0.74)	
Mother's education level			
primary	1.334**	1.329**	1.335**
	(0.028)	(0.029)	(0.27)
secondary	0.869	0.936	0.949
	(0.612)	(0.821)	(0.85)
post-secondary	1.385	1.57	1.592
	(0.644)	(0.504)	(0.486)
Other characteristics of interest			
child female	0.908	0.896	0.897
	(0.443)	(0.387)	(0.389)
infant child	1.367	1.142	1.142
	(0.392)	(0.375)	(0.373)
urban	1.096	1.107	1.118
	(0.607)	(0.56)	(0.505)
Observations	4563	4584	4584

Robust p-values in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Haiti

Household source of water and type of toilet facility

piped water	1.324		1.316				
	(0.245)		(0.256)				
covered water	1.326		1.314				
	(0.303)		(0.319)				
surface water	1.711**		1.700**				
	(0.026)		(0.027)				
other water source	0.986		0.975				
	(0.974)		(0.956)				
safe water		0.887		0.886		0.878	
		(0.303)		(0.301)		(0.265)	
private source of water							0.574***
							(0.002)
has toilet facility			0.933	0.915			
			(0.586)	(0.486)			
pit toilet	0.934	0.916			0.903		0.937
	(0.593)	(0.491)			(0.426)		(0.609)
flush toilet	0.575	0.57			0.561		0.737
	(0.178)	(0.172)			(0.159)		(0.464)
Mother's education level							
primary	0.985	0.975	0.986	0.976	0.966	0.973	0.968
	(0.895)	(0.830)	(0.903)	(0.837)	(0.770)	(0.815)	(0.782)
secondary	0.868	0.864	0.854	0.851	0.851	0.843	0.88
	(0.511)	(0.505)	(0.459)	(0.455)	(0.463)	(0.427)	(0.563)
post-secondary	0.181**	0.170**	0.159**	0.149***	0.176**	0.148***	0.178**
	(0.019)	(0.014)	(0.011)	(0.008)	(0.015)	(0.008)	(0.016)
Other characteristics of interest							
child female	0.909	0.898	0.909	0.898	0.897	0.897	0.896
	(0.355)	(0.296)	(0.356)	(0.297)	(0.295)	(0.291)	(0.287)
infant child	1.783***	1.779***	1.777***	1.774***	1.770***	1.777***	1.755***
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
urban	1.182	1.123	1.177	1.118	1.085	1.098	1.094
	(0.259)	(0.436)	(0.271)	(0.452)	(0.568)	(0.509)	(0.529)
Observations	5771	5771	5771	5771	5771	5771	5771

Robust p-values in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Mali

Household source of water and type of toilet facility							
piped water	0.896		0.888				
	(0.535)		(0.505)				
covered water	1.059		1.05				
	(0.809)		(0.837)				
surface water	1.562**		1.575**				
	(0.025)		(0.023)				
safe water		0.905		0.896		0.896	
		(0.541)		(0.499)		(0.500)	
private source of water							0.686**
							(0.028)
has toilet facility			0.917	0.904			
			(0.533)	(0.469)			
pit toilet	0.928	0.916			0.917		0.944
	(0.592)	(0.530)			(0.536)		(0.681)
flush toilet	0.641	0.617			0.606		0.628
	(0.302)	(0.265)			(0.248)		(0.306)
Mother's education level							
primary	1.128	1.114	1.124	1.109	1.119	1.114	1.102
	(0.551)	(0.592)	(0.563)	(0.606)	(0.582)	(0.596)	(0.632)
secondary	1.208	1.228	1.18	1.197	1.197	1.19	1.22
	(0.633)	(0.611)	(0.675)	(0.655)	(0.666)	(0.666)	(0.642)
post-secondary	0.68	0.674	0.578	0.566	0.653	0.562	0.662
	(0.698)	(0.695)	(0.597)	(0.588)	(0.675)	(0.584)	(0.705)
Other characteristics of interest							
child female	0.809	0.806	0.809	0.806	0.808	0.808	0.805
	(0.169)	(0.160)	(0.169)	(0.160)	(0.166)	(0.162)	(0.154)
infant child	1.363**	1.366**	1.361**	1.364**	1.369**	1.361**	1.373**
	(0.036)	(0.033)	(0.037)	(0.034)	(0.030)	(0.035)	(0.028)
urban	0.497***	0.481***	0.487***	0.471***	0.470***	0.459***	0.532***
	(0.003)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.007)
Observations	2368	2368	2368	2368	2368	2368	2368

Robust p-values in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Morocco

Household source of water and type of toilet facility

piped water	0.704**		0.704**				
	(0.036)		(0.035)				
covered water	1.085		1.085				
	(0.652)		(0.653)				
surface water	0.79		0.791				
	(0.147)		(0.144)				
other water source	0.499**		0.499**				
	(0.015)		(0.015)				
safe water		0.967		0.967		0.962	
		(0.784)		(0.784)		(0.752)	
private source of water							0.906
							(0.382)
has toilet facility			1.001	0.966			
			(0.992)	(0.783)			
pit toilet	0.993	1.017			1.011		1.009
	(0.982)	(0.956)			(0.970)		(0.977)
flush toilet	1.002	0.96			0.955		0.964
	(0.987)	(0.756)			(0.720)		(0.775)
Mother's education level							
primary	1.197	1.191	1.197	1.191	1.191	1.189	1.192
	(0.163)	(0.178)	(0.163)	(0.179)	(0.179)	(0.183)	(0.176)
secondary	1.262	1.248	1.262	1.248	1.248	1.247	1.253
	(0.141)	(0.163)	(0.141)	(0.164)	(0.164)	(0.165)	(0.156)
post-secondary	1.472	1.43	1.472	1.429	1.431	1.428	1.436
	(0.129)	(0.160)	(0.129)	(0.161)	(0.159)	(0.162)	(0.156)
Other characteristics of interest							
child female	1.145	1.142	1.145	1.141	1.141	1.142	1.142
	(0.122)	(0.131)	(0.122)	(0.131)	(0.131)	(0.131)	(0.129)
infant child	1.362***	1.368***	1.362***	1.368***	1.369***	1.367***	1.370***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
urban	1.125	0.991	1.125	0.989	0.979	0.984	1.006
	(0.446)	(0.946)	(0.446)	(0.934)	(0.860)	(0.902)	(0.962)
Observations	5717	5717	5717	5717	5717	5717	5717

Robust p-values in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Nepal

Household source of water and type of toilet facility							
piped water	0.765		0.766				
	(0.153)		(0.154)				
covered water	0.868		0.869				
	(0.442)		(0.446)				
surface water	0.612**		0.613**				
	(0.012)		(0.012)				
safe water		1.212**		1.212**		1.217**	
		(0.028)		(0.028)		(0.025)	
private source of water							0.984
							(0.864)
has toilet facility			0.858	0.820*			
			(0.152)	(0.056)			
pit toilet	0.863	0.823*			0.816*		0.816*
	(0.193)	(0.078)			(0.065)		(0.065)
flush toilet	0.83	0.804			0.809		0.811
	(0.340)	(0.257)			(0.276)		(0.282)
Mother's education level							
primary	0.997	0.995	0.998	0.995	0.987	0.956	0.987
	(0.981)	(0.964)	(0.985)	(0.966)	(0.908)	(0.685)	(0.904)
secondary	0.895	0.89	0.894	0.89	0.89	0.833	0.89
	(0.444)	(0.419)	(0.441)	(0.417)	(0.420)	(0.185)	(0.421)
post-secondary	0.789	0.781	0.783	0.778	0.781	0.71	0.782
	(0.563)	(0.553)	(0.549)	(0.544)	(0.551)	(0.404)	(0.553)
Other characteristics of interest							
child female	0.903	0.905	0.903	0.905	0.906	0.906	0.907
	(0.139)	(0.148)	(0.140)	(0.149)	(0.154)	(0.152)	(0.155)
infant child	1.557***	1.568***	1.557***	1.568***	1.572***	1.572***	1.572***
	0.000	0.000	0.000	0.000	0.000	0.000	0.000
urban	1.077	1.093	1.069	1.088	1.093	1.034	1.095
	(0.636)	(0.572)	(0.663)	(0.580)	(0.572)	(0.824)	(0.562)
Observations	5991	5992	5991	5992	5992	5992	5992

Robust p-values in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Nicaragua

Household source of water and type of toilet facility

piped water	1.015		1.015				
	(0.933)		(0.935)				
covered water	1.152		1.158				
	(0.400)		(0.383)				
other water source	0.783		0.753				
	(0.676)		(0.627)				
safe water		1.1		1.105		1.068	
		(0.534)		(0.513)		(0.661)	
private source of water							1.066
							(0.641)
has toilet facility			0.831	0.824			
			(0.205)	(0.183)			
pit toilet	0.834	0.827			0.839		0.833
	(0.210)	(0.190)			(0.222)		(0.204)
flush toilet	0.658	0.65			0.657		0.653
	(0.116)	(0.103)			(0.112)		(0.107)
Mother's education level							
primary	1.19	1.187	1.194	1.191	1.201	1.178	1.19
	(0.226)	(0.233)	(0.218)	(0.226)	(0.199)	(0.253)	(0.229)
secondary	0.861	0.852	0.843	0.833	0.862	0.821	0.852
	(0.436)	(0.402)	(0.381)	(0.348)	(0.439)	(0.307)	(0.411)
post-secondary	0.486*	0.480**	0.462**	0.455**	0.485*	0.449**	0.481**
	(0.055)	(0.049)	(0.040)	(0.035)	(0.053)	(0.032)	(0.050)
Other characteristics of interest							
child female	0.859	0.859	0.856	0.856	0.859	0.859	0.858
	(0.134)	(0.135)	(0.124)	(0.125)	(0.134)	(0.132)	(0.133)
infant child	1.299**	1.300**	1.296**	1.297**	1.299**	1.292**	1.298**
	(0.043)	(0.042)	(0.045)	(0.044)	(0.043)	(0.047)	(0.044)
urban	1.206	1.159	1.179	1.129	1.173	1.102	1.151
	(0.211)	(0.296)	(0.276)	(0.390)	(0.254)	(0.484)	(0.341)
Observations	4465	4465	4465	4465	4465	4465	4465

Robust p-values in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Peru

Household source of water

piped water	0.873		0.835*				
	(0.191)		(0.071)				
surface water	0.942		0.919				
	(0.589)		(0.436)				
other water source	0.582***		0.598***				
	(0.003)		(0.004)				
safe water		1.002		0.971		0.987	
		(0.973)		(0.668)		(0.85)	
private source of water							1.047
							(0.521)
has toilet facility			1.187**	1.205***			
			(0.015)	(0.008)			
pit toilet	1.235***	1.244***			1.244***		1.242***
	(0.003)	(0.002)			(0.002)		(0.002)
flush toilet	0.998	1.046			1.047		1.025
	(0.989)	(0.693)			(0.676)		(0.828)
Mother's education level							
primary	1.388***	1.387***	1.393***	1.393***	1.387***	1.403***	1.388***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)
secondary	1.291**	1.281**	1.281**	1.276**	1.281**	1.298**	1.280**
	(0.039)	(0.045)	(0.045)	(0.049)	(0.045)	(0.035)	(0.046)
postsecondary	1.017	1.011	0.997	0.996	1.011	1.017	1.009
	(0.914)	(0.945)	(0.982)	(0.977)	(0.945)	(0.916)	(0.954)
Other characteristics of							
child female	0.865**	0.864**	0.867**	0.866**	0.864**	0.864**	0.865**
	(0.018)	(0.017)	(0.019)	(0.018)	(0.017)	(0.017)	(0.017)
infant child	1.160**	1.163**	1.156*	1.159**	1.163**	1.161**	1.164**
	(0.048)	(0.045)	(0.053)	(0.05)	(0.045)	(0.046)	(0.044)
urban	1.129	1.041	1.072	1.004	1.041	1.027	1.043
	(0.178)	(0.648)	(0.423)	(0.967)	(0.647)	(0.754)	(0.627)
Observations	12589	12589	12589	12589	12589	12589	12589

Robust pvalues in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Vietnam

Household source of water and type of toilet facility

piped water	0.150***		0.150***				
	(0.001)		(0.001)				
covered water	0.338**		0.338**				
	(0.012)		(0.012)				
surface water	0.483		0.483				
	(0.129)		(0.129)				
other water sources	0.238***		0.238***				
	(0.006)		(0.006)				
safe water		0.749		0.747		0.722	
		(0.201)		(0.195)		(0.148)	
private source of water							0.777
							(0.264)
has toilet facility			0.668	0.643*			
			(0.139)	(0.097)			
pit toilet	0.669	0.648			0.633*		0.647
	(0.144)	(0.106)			(0.090)		(0.105)
flush toilet	0.665	0.581			0.552		0.579
	(0.409)	(0.274)			(0.229)		(0.270)

Mother's education level

primary	0.925	0.847	0.925	0.85	0.812	0.78	0.844
	(0.848)	(0.684)	(0.848)	(0.690)	(0.611)	(0.526)	(0.678)
secondary	0.844	0.732	0.844	0.732	0.665	0.618	0.724
	(0.707)	(0.476)	(0.707)	(0.476)	(0.350)	(0.248)	(0.463)
post-secondary	0.744	0.738	0.744	0.739	0.738	0.733	0.736
	(0.175)	(0.157)	(0.172)	(0.159)	(0.159)	(0.148)	(0.155)

Other characteristics of interest

child female	0.671	0.500	0.669	0.475**	0.480*	0.455**	0.497
	(0.328)	(0.111)	(0.266)	(0.043)	(0.090)	(0.031)	(0.107)
infant child	0.85	0.839	0.85	0.838	0.82	0.831	0.833
	(0.608)	(0.577)	(0.608)	(0.575)	(0.532)	(0.551)	(0.563)
urban	0.867	0.865	0.867	0.869	0.86	0.843	0.863
	(0.608)	(0.601)	(0.605)	(0.610)	(0.589)	(0.531)	(0.596)
Observations	1212	1212	1212	1212	1212	1212	1212

Robust p-values in parentheses
* significant at 10%; ** significant at 5%; *** significant at 1%

Zimbabwe

Household source of water and type of toilet facility

piped water	0.754		0.762				
	(0.261)		(0.264)				
covered water	0.702**		0.701**				
	(0.043)		(0.042)				
surface water	0.997		0.998				
	(0.991)		(0.993)				
safe water		0.721**		0.722**		0.752**	
		(0.026)		(0.026)		(0.045)	
private source of water							0.736**
							(0.023)
has toilet facility			1.246	1.258			
			(0.130)	(0.108)			
pit toilet	1.247	1.257			1.19		1.218
	(0.128)	(0.109)			(0.211)		(0.158)
flush toilet	1.396	1.446			1.349		1.4
	(0.504)	(0.439)			(0.521)		(0.478)
Mother's education level							
primary	0.856	0.845	0.857	0.846	0.856	0.854	0.853
	(0.440)	(0.407)	(0.444)	(0.410)	(0.437)	(0.438)	(0.432)
secondary	0.651*	0.644*	0.653*	0.645*	0.649*	0.658*	0.668*
	(0.060)	(0.051)	(0.060)	(0.051)	(0.053)	(0.063)	(0.072)
post-secondary	1.154	1.136	1.155	1.135	1.155	1.174	1.184
	(0.738)	(0.764)	(0.736)	(0.766)	(0.735)	(0.706)	(0.692)
Other characteristics of interest							
child female	0.92	0.918	0.919	0.918	0.914	0.918	0.92
	(0.478)	(0.468)	(0.477)	(0.466)	(0.446)	(0.468)	(0.478)
Infant child	1.171	1.174	1.169	1.172	1.178	1.174	1.169
	(0.270)	(0.263)	(0.274)	(0.267)	(0.252)	(0.263)	(0.274)
urban	0.683	0.702	0.743	0.786	0.675	0.815	0.706
	(0.384)	(0.427)	(0.252)	(0.234)	(0.368)	(0.311)	(0.433)
Observations	2937	2945	2937	2945	2945	2945	2945

Robust p-values in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Zambia							
Household source of water and type of toilet facility							
piped water	1.027		1.002				
	(0.850)		(0.991)				
covered water	0.974		0.977				
	(0.788)		(0.818)				
surface water	0.974		0.971				
	(0.798)		(0.778)				
other water sources	0.646		0.629				
	(0.644)		(0.624)				
safe water		1.000		0.997		0.997	
		(0.996)		(0.970)		(0.974)	
private source of water							0.718**
							(0.012)
has toilet facility			0.881	0.882			
			(0.132)	(0.131)			
pit toilet	0.884	0.886			0.886		0.892
	(0.141)	(0.145)			(0.145)		(0.170)
flush toilet	0.648**	0.651**			0.651**		0.785
	(0.016)	(0.016)			(0.016)		(0.208)
Mother's education level							
primary	0.854	0.855	0.857	0.858	0.855	0.846*	0.854
	(0.106)	(0.108)	(0.115)	(0.117)	(0.108)	(0.085)	(0.105)
secondary	0.863	0.864	0.849	0.85	0.864	0.835	0.873
	(0.254)	(0.258)	(0.208)	(0.213)	(0.257)	(0.165)	(0.291)
post-secondary	0.203***	0.204***	0.186***	0.186***	0.204***	0.183***	0.212***
	(0.003)	(0.004)	(0.002)	(0.002)	(0.004)	(0.002)	(0.004)
Other characteristics of interest							
child female	0.972	0.972	0.974	0.974	0.972	0.974	0.974
	(0.689)	(0.694)	(0.712)	(0.712)	(0.693)	(0.707)	(0.713)
infant child	1.157*	1.157*	1.160*	1.160*	1.157*	1.161*	1.164*
	(0.085)	(0.085)	(0.079)	(0.079)	(0.085)	(0.077)	(0.073)
urban	1.363**	1.395***	1.321**	1.335**	1.395***	1.296**	1.447***
	(0.023)	(0.004)	(0.045)	(0.013)	(0.002)	(0.023)	(0.001)
Observations	5472	5472	5472	5472	5472	5472	5472

Robust p-values in parentheses

* significant at 10%; ** significant at 5%; *** significant at 1%

Appendix

Wealth Indices

I- Background on wealth indices

- **Income and consumption data versus asset ownership**

Microconometric studies generally attempt to measure some underlying relationship. A starting point for such studies involves a structural relationship between the outcome of interest and a set of other measured covariates. For most studies, a reduced form estimation is performed, involving the use of socio-economic status (SES) not only as a control variable but also as an outcome of interest. In the presence of appropriate data, income or consumption/expenditure data is usually the number one choice for researchers. The rationale for using these measures to control for SES is clear. Higher levels of income imply better standards of living as measured in the usual sense. For example richer households are able to spend more on sanitary amenities which can in turn affect child mortality.

A critique of this though is that current income does not necessarily proxy for permanent income which is a more relevant measure of living standards over time. Where credit and insurance markets are nonexistent or imperfect, the stock of wealth accumulated by the household provides a better measure of SES (World Bank, 2005, pp 90-99; Filmer and Pritchett, 1994). In this case, the stock of household durables can be a better estimator of SES than the arguably more inconsistent flow of income.

Another issue that arises is that survey measures of income usually rely on recall data (especially when it comes to expenditure or consumption data), which is susceptible to measurement error, introducing yet another source of endogeneity bias (violation of zero conditional mean assumption).

A more practical issue that arises is that not all surveys have an explicit measure of income. DHS and MICS surveys are examples of this. These surveys measure lots of household and individual characteristics, but have no direct measure of income. They do however incorporate a fairly extensive section on household ownership of durable and productive goods (in some cases). These questions can in turn be used to control for SES either by separately entering them as covariates in a regression or as part of an index that ranks households into wealth quintiles. For a more extensive discussion, see World Bank (2005).

- **The Filmer and Pritchet methodology**

Filmer and Pritchett (1994) use data from the National Family Health Surveys (NFHS) of India Collected between 1992 and 1993 to estimate the wealth effects of children’s educational enrollments. The NFHS consist of a large sample of 88,000 households and closely resembles the DHS surveys. In the absence of a specific measure of income, they make use of the asset ownership questions to construct an index. In their index, they use dichotomous indicators of whether the household owns a clock, bicycle, radio, television, sewing machine, motorcycle, refrigerator and a car. They also include the type of toilet facility, the source of drinking water, the number of rooms in the dwelling, whether the kitchen is in a separate room, the main source of lighting (electricity=1), household land ownership and whether the dwelling is made of high or low quality materials. They use Principal Component Analysis (PCA) to construct their index (also used in this exercise). The methodology of PCA and its potential pitfalls are reviewed below. For external coherence, they use the Living Standard Measurement Surveys (LSMS) of Nepal and Pakistan along with the Indonesian DHS (IDHS), which included a consumption module, and compare their computed indices with the more traditional consumption based poverty measure, adjusted for household size. They find that the results are generally comparable (except for Pakistan).

- **Alternative indicators**

Some alternative asset based wealth estimators are discussed in World Bank (2005), pp 90-99. As stated earlier, one can theoretically include these variables in a regression. In that case, the main issues of concern are dimensionality and autocorrelation. The former is moot because household surveys generally have a decent sample size, making the loss of degrees of freedom a marginal issue. The latter is more serious and has to be dealt with by excluding some variables from the analysis.

Another issue discussed in Filmer and Pritchett (1994) is that one is often interested in wealth effects. Entering these variables individually enables the researcher to control for wealth heterogeneity but provides no information on the marginal effect of wealth, which may be a relevant factor for policy makers.

Another way of controlling for wealth effects is to aggregate asset ownership (summation over the number of assets owned by the household). This method however lends itself to criticism because either the summation is linear across asset classes (not all assets have the same marginal utility) or preferential weights are applied based on one’s own judgment.

II- What data is available and which variables to include

- **Data available in DHS surveys**

As stated earlier, DHS surveys do not include income, consumption or expenditure modules. The only information included representative of socio-economic status relates to household ownership of durable goods. Among the variables consistently included in virtually all DHS country surveys are radio, television, motorcycle, bicycle, car and telephone ownership, the type of toilet facility, whether the household has electricity the source of drinking water and main floor materials. The type of cooking fuel used is included in all but 6 countries (Gabon, Guatemala, Guinea, Kazakhstan, Kyrguistan and Vietnam), for the most recent surveys (year 2000 to present). In the previous surveys, this variable wasn’t included. In these cases, “Main Wall” is included (where available) to add some variation to the computed scores. See table A1 for the list of variables used to construct each country’s index.

<u>Table A1: Variables included in index computation for each country</u>

Country	Dhs index	Index Computed	Electricity	Radio	Television	Refrigerator	Bicycle	Motorcycle	Car/Truck	Floor Material	Roof Material	Wall Material	Cooking fue
Benin 2001	yes	yes	x	x	x	x	x	x	x	x	no	no	no
Cameroon	no	yes	x	x	x	x	x	x	x	x	no	no	no
Colombia 2005	no	yes	x	x	x	x	no	x	x	x	no	no	x
Dom Rep 2002	no	yes	x	x	x	x	x	x	x	x	x	no	x
Egypt 2000	yes	yes	x	x	x	x	x	x	x	x	no	no	x
Gabon 2000	no	yes	x	x	x	x	x	x	x	x	no	no	x
Ghana 2003	no	yes	x	x	x	x	x	x	x	x	no	no	x
Haiti 2000	yes	yes	x	x	x	x	x	x	x	x	no	no	x
India 1998	yes	yes	x	x	x	x	x	x	x	x	no	no	no
Indonesia 02/03	no	yes	x	x	x	x	x	x	x	x	no	no	x
Kenya 2003	no	yes	x	x	x	x	x	x	x	x	no	no	x
Malawi 2000	no	yes	x	x	x	no	x	x	x	x	no	no	x
Mali 2001	yes	yes	x	x	x	x	x	x	x	x	no	no	x
Morocco 03/04	no	yes	x	x	x	x	x	x	x	x	no	no	x
Mozambique 2003	no	yes	x	x	x	x	x	x	x	x	no	no	x
Namibia 2000	no	yes	x	x	x	x	x	x	x	x	no	no	x
Nepal 2001	yes	yes	x	x	x	no	x	no	x	x	no	no	x
Nicaragua 2001	no	yes	x	x	x	x	x	x	x	x	no	no	x
Peru 2000	yes	yes	x	x	x	x	x	x	x	x	no	no	x
Philippines 2003	no	yes	x	x	x	x	x	x	x	x	no	no	no
Uganda 00/01	no	yes	x	x	x	x	x	x	x	x	x	no	x
Vietnam 2002	no	yes	x	x	x	x	x	x	x	x	no	no	no
Zambia 01/02	yes	yes	x	x	x	x	x	x	x	x	no	no	x
Zimbabwe 1999	yes	yes	x	x	x	x	x	x	x	x	no	no	x

- **Which variables to include**

Besides the problems of data availability, there is also the need to determine which variables to include in our indices. The indices constructed in DHS surveys (15 Countries) follow the Filmer and Pritchett (1994) methodology and include the same variables that the authors use to construct their index. Depending however on the relationship that one wants to measure (child mortality and access to water and sanitation in our case), it would be ideal to exclude those indicators (access to water and toilet facility) from the index and measure these effects separately. There is however a cost associated with such exclusion. The reduction of the number of variables to analyze implies that there will be fewer assets on which to discriminate among households, hence we will observe less variation in their wealth scores. A way to deal with this is to add a marginal value to the score of a randomly selected number of households that are at the threshold of one quintile (containing over 20% of the sample). See the attached Stata program for a more detailed explanation.

There are also some other variables that one needs to weight the use of. Generally as stated in World Bank (2005), all productive assets only have an indirect effect on children's conditions through their wealth effects, making their inclusion appropriate. A more thorny issue applies to those durable goods that can potentially affect the conditions of children, like main floor material and the type of cooking fuel.

Our analysis includes both variables for two reasons. The first one is simply because it is practical (due to data limitations), and is another potential source of variation. As it is, we are only using 10 variables to construct the indices. Eliminating these variables would reduce our list of variables to 6, making it difficult to have any variation.
Another reason why these variables have been included is that in hindsight, they don't really have an effect on mortality. The following table presents the results of the correlation between childhood mortality and the above mentioned variables.

Table A2- Correlation coefficients between incidence of death and household characteristics included in the index

Death	natural floor	rudimentary floor	finished floor	cooking fuel
Armenia	0.045	0.015	-0.026	-0.055
Colombia	0.010	0.046	-0.034	-0.005
Ghana	-0.026	0.061	-0.020	-0.010

III- Statistical procedures

- **Background on principal component analysis**

Principal Component Analysis (PCA) and more generally Principal Factor Analysis is a method used to reduce data dimensionality or to detect the structure of the data one wants to analyse. we will briefly discuss the methodology here and one can refer to http://www.statsoft.com/textbook/stfacan.html for a more extensive discussion. PCA is a way to decompose the correlation or the covariance matrix of a set of variables. From this decomposition, factors are extracted with the leading factor (principal component) accounting for the maximum variation in the data. Each successive factor (eigenvalue) accounts for less and less variation until the last factor, which accounts for the least and remaining variation.

Table A3- Principal component decomposition

Component	Eigenvalue	Difference	Proportion	Cumulative
Comp1	3.21474	2.02531	0.3215	0.3215
Comp2	1.18943	.142224	0.1189	0.4404
Comp3	1.0472	.0465329	0.1047	0.5451
Comp4	1.00067	.0356949	0.1001	0.6452
Comp5	.964976	.17286	0.0965	0.7417
Comp6	.792116	.0691922	0.0792	0.8209
Comp7	.722924	.110277	0.0723	0.8932
Comp8	.612647	.165328	0.0613	0.9545
Comp9	.447319	.439345	0.0447	0.9992
Comp10	.00797387	.	0.0008	1.0000

Table A3 presents the PCA analysis of the variables listed in the previous section for Bangladesh. This table indicates that the first component accounts for 32.15% of the variation. The second component accounts for 11.89% and so forth (Column 3). Since the primary value of this exercise is to reduce the dimensionality of the data, one must decide how many factors to extract. In the case of wealth indices, only the first factor is relevant because it incorporates the maximum possible variation.

After PCA, one calculates the scores of the components, creating a continuous variable with a wealth score for each household. From this continuous variable, households can be classified into wealth quintiles (5 in our case). An alternative to this parametrization is to use non-parametric linear splines to estimate the respective quintiles. The stata program of Bangladesh is included in the appendix.

- **Do we adjust for scale or not?**

An issue of concern with this analysis is whether we need to adjust for scale or the appropriate weights to use. World Bank (2005) argues that there is a need to control for household economies of scale. Conceptually, controlling for scale matters. Practically however, there are lots of potential pitfalls in such an exercise. The marginal utility of household durable goods should be taken into consideration. For example, certain household durables can be sold in the case of an adverse shock to household income. This is the case for a parcel of land or a car. The marginal utility of such an insurance good is necessarily different from that of having a good floor, which is not a tradable good per se. The weight associated with such good should be higher. Practically however, we would need to measure these marginal utilities per good and per country (even within a country, i.e. Urban/Rural) making it cumbersome at best and pure guess work at worse. Due to these difficulties, we won't proceed with these scale adjustments.

IV- Results and extensions

The results of this exercise compared to the actual indices computed in DHS surveys are presented in table A4. The table presents the correlations and spearman rank correlations between our estimates and those indices included in the DHS surveys. Also included is the stratification by Urban/Rural and the correlation coefficients with the actual indices, which could be of potential interest. The same amenities are not always available or do not have the same relevance to urban and rural households, making it worthwhile to explore the issue further.

Our estimates correlate fairly well with those computed by DHS surveys. Overall in 10 out of 39 countries, the correlation coefficients are higher than 80%, and in another 22 countries, the coefficients are higher than 90%.

Subsequently, we have proceeded to calculate these indices for all of the countries, providing a richer set of covariates for the econometric exercises to follow.

Table A4: Our Results Compared to DHS Estimates

Country	Whole Country		Urban		Rural	
	Correlation	Spearman	Correlation	Spearman	Correlation	Spearman
Armenia	77.29%	79.00%	80.96%	32.79%	53.37%	24.41%
Benin	89.29%	84.67%	89.18%	90.01%	81.18%	73.72%
Colombia	85.62%	82.93%	83.36%	76.50%	80.74%	82.30%
Egypt	83.43%	84.31%	80.07%	75.97%	81.19%	82.32%
Ethiopia	89.51%	73.87%	87.46%	90.00%	48.84%	35.97%
Mali	92.02%	48.56%	93.61%	66.02%	90.34%	18.95%
Peru	94.05%	93.27%	90.02%	88.72%	87.99%	76.72%
Zimbabwe	86.48%	85.87%	73.46%	73.27%	73.29%	67.73%
Guinea	88.67%	68.01%	92.38%	89.71%	69.60%	43.55%
Kazakhstan	55.23%	60.13%	43.14%	42.04%	52.36%	55.92%
Kyrguistan	59.80%	69.54%	53.04%	56.67%	60.14%	69.42%
Haiti	85.97%	78.33%	87.78%	90.73%	76.30%	55.93%
Namibia	93.22%	89.35%	91.42%	93.94%	90.64%	78.42%
Nepal	84.91%	78.39%	79.05%	78.69%	77.70%	71.84%
Zambia	91.61%	67.67%	93.85%	89.38%	85.16%	58.93%
Bangladesh A	96.88%	87.91%	96.50%	94.99%	94.73%	84.34%
Benin A	93.20%	93.85%	93.14%	92.24%	90.31%	92.23%
Namibia A	97.13%	94.44%	96.01%	96.19%	92.65%	87.12%
Nicaragua A	93.07%	91.73%	91.99%	91.47%	87.45%	78.52%
Nigeria	91.08%	92.77%	89.45%	89.59%	88.03%	88.42%
Peru A	95.31%	94.17%	93.42%	93.50%	85.95%	72.18%
Philippines A	93.94%	93.28%	93.51%	93.89%	93.54%	88.22%
Tanzania A	96.09%	80.62%	96.67%	95.43%	88.99%	59.81%
Tanzania B	97.41%	85.24%	97.11%	95.56%	94.79%	75.66%
Uganda A	93.93%	80.33%	92.14%	93.20%	88.39%	61.96%
Zimbabwe A	94.53%	93.94%	95.28%	95.69%	92.93%	89.15%
Colombia A	91.01%	90.49%	88.50%	89.55%	89.11%	90.03%
Dom Rep B	73.51%	85.34%	69.98%	81.54%	74.39%	82.65%
Guatemala A	96.78%	95.00%	96.41%	96.27%	95.29%	90.49%
Haiti A	96.31%	94.57%	95.29%	95.57%	89.77%	83.08%
India	90.81%	91.26%	90.49%	92.34%	88.44%	87.10%
Indonesia A	85.91%	85.55%	81.05%	79.45%	83.32%	83.70%
Kazakhstan A	87.25%	85.65%	87.91%	91.91%	69.51%	69.08%
Kenya A	96.99%	94.23%	97.09%	95.18%	95.22%	92.15%
Mali A	95.21%	78.95%	96.00%	93.49%	79.32%	62.73%
Morocco A	95.45%	96.42%	93.22%	92.28%	91.10%	91.90%

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