RESEARCH REPORT

Estimating inequities in sanitation-related disease burden and estimating the potential impacts of pro-poor targeting

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Sanitation and Hygiene Applied Research for Equity

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Executive summary

Background

There is growing attention to disparities in progress improving access to sanitation. Recent work by UNICEF and the WHO/UNICEF Joint Monitoring Programme (JMP) has shown significant variations in progress in improving access to sanitation across quintiles in many low-income settings (UNICEF 2010; WHO and UNICEF 2011). UNICEF has argued that this is not only 'unfair' but also potentially acts as a 'brake' to progress across all the MDGs (UNICEF 2010).

The role of international aid flows (OECD-DAC 2009; WHO 2010) and national policy and planning (World Bank 2011; WHO 2010) in this have been explored. Work in this area has suggested that certain groups are being marginalized by current strategies and investments.

Less work though has been carried out to understand how sanitation-related disease burden and impacts vary by wealth status in low-income settings. Work in other areas of public health has shown significant variance in disease burden and impacts across socio-economic groupings (Rheingans *et al*. 2011; Barros *et al*. 2010; Fenn *et al*. 2007; Kruk *et al*. 2011; Wirth *et al*. 2008). A stronger understanding of how sanitation-related risks and impacts are distributed across populations has the potential to improve the effectiveness and efficiency of sector investments.

Objectives and strategy

The objectives of this study are to model for 10 low-income countries[1] in sub-Saharan Africa and South Asia:

1. The distribution of sanitation-related health burden by wealth quintile
2. The distribution of health benefits for targeting different wealth quintile groups
3. The spatial distribution of sanitation-related health burden and benefits

This work used existing household survey data from the Demographic and Health Surveys for the 10 countries to estimate disparities in sanitation-related services, exposures, susceptibility, burden and impact of infrastructure improvements.

[1] Four of the 10 countries (Zambia, Ghana, Nigeria and India) are categorized as 'lower middle income countries' and the remaining six as 'low income countries' by the World Bank (2011). For the purposes of this paper all 10 are described as 'low income'.

The key components of this analysis were the:

- Construction of an asset index to assess economic status which excluded water and sanitation as ‘assets’
- Assessment of ‘access to sanitation’ based on both household access to a private or shared facility and also the density of people without sanitation in the immediate vicinity
- Use of nutritional vulnerability measured by weight for age Z-scores, Vitamin A doses, and treating diarrhorea with oral rehydration solution (ORS) integrated into a measure of susceptibility for diarrhoeal mortality
- Use of children under five years of age, rather than the household, as the unit of analysis
- Comparison of outcomes among wealth quintiles within both urban and rural areas
- Estimation of sanitation-related burden of disease based on national diarrhoeal mortality estimates, pooled estimates of sanitation effectiveness, and the estimated distribution of sanitation-related risks (according to the Sanitation Risk Index developed)
- Estimation of the impact of improved sanitation (non-shared improved toilet) for each wealth quintile in urban and rural areas
- Development of interpolation maps in ArcGIS to explore the spatial patterns of disparities for two of the countries (Malawi and Kenya)

Key results

Although inadequate data and knowledge prevent definitive answers to the questions outlined in the objectives for this study, the results of this modeling exercise based on exisiting information suggest the following:

- The health burden of poor sanitation falls disproportionately on children living in the poorest households
- This increased health burden is the result of both greater exposure to infection and increased susceptibility among children in these households
- The increased exposure among these children is a function of their increased likelihood of having no access to a private facility, having to use shared facilities and being more likely to live in an area with a high density of people without sanitation
- Children in poor households are more likely to be susceptible (resulting from lower nutritional status) to diarrhoeal diseases and suffer higher mortality
- Improvements in sanitation for households in the poorest quintile may bring significantly greater health benefits than improvements in the richest quintiles
- The sanitation-related burden differs between rural and urban settings, but children in poor households in both settings consistently suffer disproportionately
- While rural populations generally have lower levels of access, the sanitation associated risk may be greater for the urban poor due to the increased likelihood of these households being in areas with a high density of people without sanitation

Conclusions

- There are important limitations of this study that must be highlighted: (1) the relative importance of the three exposure variables which are modeled as being equal; (2) the susceptibility index contains only three variables (nutritional vulnerability, Vitamin A dose, and ORS treatment); (3) only diarrhoeal mortality is considered in estimating the distribution of health impacts, and the total burden and its distribution would change if other sanitation-related health impacts were included

- More effective targeting strategies to reach children in the poorest households are required to both protect those children and households most at risk and to maximize the potential impact of sanitation investments. Although the study did not directly consider the relative costs associated with reaching the poorest households, the results suggest that targeting the poorest households could yield substantially higher health returns and may also bring greater economic returns
- Better use of available information on the distribution of sanitation-associated risk and health burden could strengthen planning and resource allocation
- Current monitoring indicators at the national and global levels fail to incentivise targeting the areas of greatest need and potential greatest impact. Existing limitations in monitoring efforts include a focus on household coverage rather than child coverage; the use of household access, not community level exposure measures; no direct targets for focusing improved access on the poorest; and, in some settings, the under counting of the most vulnerable urban populations
- Additional information on the relative risk of shared facilities and density of population without sanitation would allow for better identification of priority areas and targeting of interventions

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1. Introduction

There is growing attention to disparities in global and national progress in improving access to sanitation. Recent work by UNICEF (2010) and the WHO/UNICEF (2011) Joint Monitoring Programme (JMP) has shown significant variation in progress in improving access to sanitation across quintiles in many low-income settings. UNICEF (2010) has argued that this is not only ‘unfair’ but also potentially acts a ‘brake’ to progress across all the MDGs.

At the policy level, a number of important questions arise concerning the ‘equity’ of sanitation investments and progress. Are the poorest populations necessarily the most at risk? Are current investments targeting and/or reaching the populations in areas of greatest possible impact? If more progress were to be more equitable, would the returns on investment (measured by health impact) be greater among low-income groups versus wealthier groups? If so, what are the explanatory variables that explain this beyond household facilities?

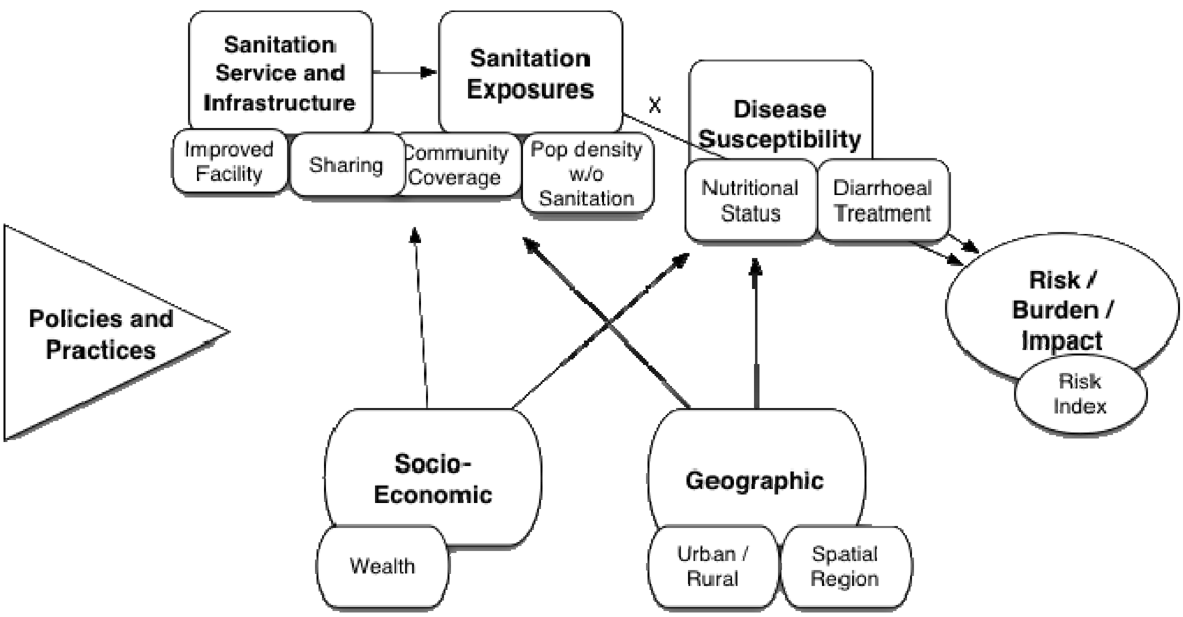
There is a general awareness that poor sanitation is generally associated with poverty (UNDP 2006) and some measures of economic status directly include sanitation access as an asset or proxy for wealth. Recent efforts by UNICEF and others have repeatedly pointed out the connection between poor coverage and economic status (UNICEF 2010). Nevertheless there is a concern that sector investments and improvements in sanitation do not always directly confront these underlying disparities. The MDG target on sanitation does not directly prioritize improvements for the poor. Often sector investments are primarily used for infrastructure, such as urban wastewater treatment, that is not likely to disproportionately benefit the poor.

Lack of equity in access raises policy and ethical questions, however it also has implications for the efficiency and value for money of investments in the sector. Clearly, understanding differences in the health burden associated with sanitation or in returns on investment requires more than an understanding of coverage. These additional mechanisms for disparities can occur in terms of sanitation-related exposures and the susceptibility of the underlying population. For example, in addition to having poor household sanitation, poorer individuals are more likely to live in communities with poor access due to socio-economic clustering. In terms of susceptibility, poorer households may have a higher number of children under five, implying that impacts in these households may be greater because they reach a larger number of high-risk individuals. Similarly, poorer children may be more likely to be nutritionally compromised and susceptible to the most severe effects of poor sanitation. These factors are also likely to vary spatially, both between urban and rural areas and among geographic regions.

Towards a conceptual framework for sanitation-related risk and impacts

One conceptualization of these potential mechanisms for disparities is shown in Figure 1, although in reality these relationships are likely to be more complex. In this conceptual framework, sanitation-related burden is assumed to be a function of exposure and susceptibility. Exposure may be a function of the presence of a toilet that the household can use, whether or not it is shared, and the concentration of people without sanitation in the local environment. The exact relationship and relative importance of these factors is uncertain. Current indicators for improved sanitation within the JMP do not include shared facilities, but there is limited and mixed evidence on the impact of shared, compared to private, toilets (Biran *et al.* 2011; Joshi *et al.* 2011). Several studies have suggested that community coverage, rather than individual household coverage, may be the key risk factor for outcomes such as diarrhoeal disease (Barreto *et al.* 2010), but again there is limited information on the relative contributions to overall exposure. In terms of susceptibility, a number of factors may contribute to the likelihood that a given level of exposure results in an infection or that an infection results in mortality. Black and colleagues (2008) found that low weight for age was a significant predictor of diarrhoeal mortality. Other factors, such as breast-feeding practice for children under six months, are also predictors of case fatality rates, especially for diarrhoeal disease (Black *et al*. 2008).

Figure 1: A conceptual framework for disparities in sanitation-associated risk and impacts



Study objectives

Specifically, this study aims to estimate the following for 10 low-income countries:

1. The distribution of sanitation-related health burden by economic status
2. The distribution of health benefits for targeting sanitation improvements at different wealth quintile groups
3. The spatial distribution of sanitation–related health burden and benefits

The study uses data from national Demographic and Health Surveys (DHS) from 10 sub-Saharan African and South Asian countries (Table 1) to construct a model for estimating sanitation-related risk using proxy measures for exposure and susceptibility to develop a risk index. We then use a simulation approach to estimate the impact of sanitation investments at a national level and, within that, by rural and urban areas based on economic strata.

Currently there is insufficient information to fully estimate the combined effect of these factors on disparities in burden and impact with complete precision. In fact, there is still limited (albeit growing) rigorous evidence of the health impacts of sanitation and much less information on how these effects may differ between settings and within them. However, by elaborating a model for the potential distributional impact based on existing national datasets, we hope to demonstrate that:

1. Distributional impacts may be substantial

2. Discussions of cost-effectiveness are of limited value without more careful attention to distributional effects

3. Additional research and data are needed to refine these distributional estimates

2. Methods

2.1 Data sources

Data for this study come from the most recent round of Demographic and Health Surveys for 10 countries (Table 1). These surveys are representative national cluster surveys of households that are used alongside Multiple Indicator Cluster Surveys (MICS) and national censuses in the estimation of sanitation coverage by the JMP. The latest phase 6 survey questionnaire was introduced in 2008 by DHS; the surveys used here include phase 5, and 6 surveys.

Table 1: DHS country data sets

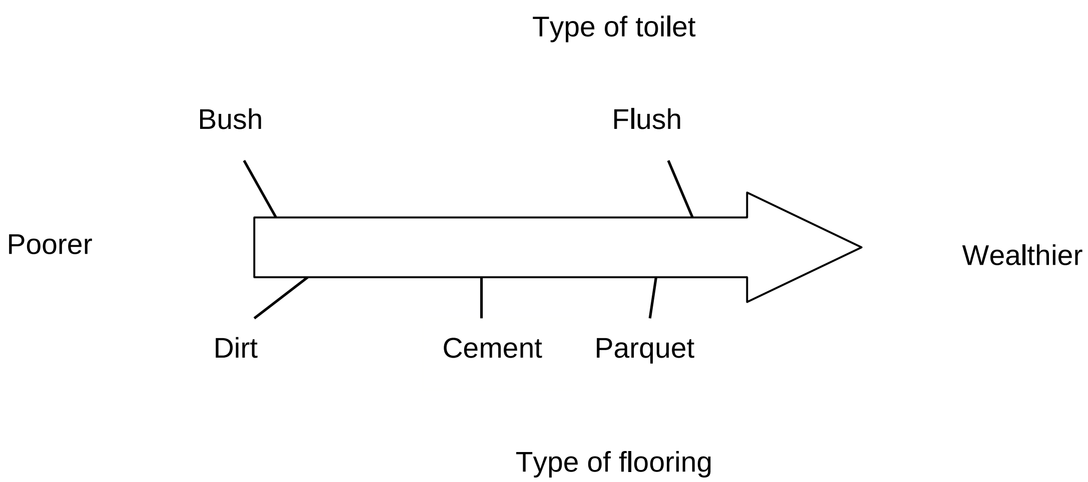
Data sources: Demographic and Health Surveys

Country	**Year**	**DHS phase**
Kenya	2008-9	6
Malawi	2010	6
Ethiopia	2005	5
Zambia	2007	5
Zimbabwe	2005	5
Ghana	2008	6
Nigeria	2008	6
Bangladesh	2007	5
India	2005-6	5
Tanzania	2010	6

2.2 Measures of economic status

For this study, disparities in sanitation exposure and risk are assessed based on economic status as measured by a wealth index and categorized by wealth quintile. DHS surveys include questions on household assets and home construction. These assets are used to construct an asset index using Principal Components Analysis (PCA) (Filmer and Pritcett 2001; Rutstein and Johnson 2004). This score is then converted into quintiles that rank households based on wealth.

Figure 2: Presumed relationship between sanitation and flooring and underlying scale of wealth



Adapted from Rutstein and Johnson (2004)

Default asset scores and quintiles are available in the DHS datasets for each country, however these defaults scores include drinking water supply and sanitation as household assets. Figure 2 above shows the presumed relationship between sanitation, flooring, and the underlying scale of wealth. The inclusion of these assets as part of this independent variable results in biased overestimates of sanitation or water distribution by wealth quintile.

In order to overcome this bias, for the purposes of this study we estimated a new asset index that excludes sanitation and drinking water supply. This approach is similar to that explored by other authors developing valid but more efficient asset indices (Houweling *et al.* 2003). In order to test for comparability, we compared the default and new index for each country using a Pearson rank correlation test. For all countries there was a high correlation between the two scores.

Typical analyses of disparities use national quintiles of wealth as categorical variables. Within the national population, urban households tend to be more skewed to the higher quintiles and rural households to the lower. However there are questions of whether a similar asset score (or quintile) is equally rich or poor in urban and rural settings (Filmer and Pritcett 2001). In addition, for sanitation in particular, there are concerns about how disparities might function differently in urban and rural populations.

We also explored the use of a separately estimated urban and rural asset index. We found that within urban and rural groups, national asset indices and separately estimated urban and rural indices resulted in similar rankings of household and similar grouping by quintile. As a result we used the asset score based on the national sample and the resulting national quintile assignment. However, in order to better understand disparities within urban and rural areas, we also divided the urban and rural population into separate urban and rural quintiles.

2.3 A Sanitation Risk Index: combining exposure and susceptibility measures

For this study we examine disparities associated with sanitation related to both exposure and susceptibility. These are combined to create a Sanitation Risk Index (SRI) to explore the distribution of sanitation-related health burden and potential impacts across wealth groups. This section describes how component measures of exposure and susceptibility are included in the SRI.

Exposure measures

Disparities relating to three aspects of sanitation exposure are considered:

1. The presence of an improved latrine for households to use
2. The presence of a private toilet (ie. that is <u>not</u> shared)
3. The density of people without sanitation in the community. These are considered individually and combined into an exposure index

Level of sanitation access

The JMP currently defines 'improved' sanitation as a private facility that 'hygienically separates human excreta from human contact'. Although within the JMP 'sanitation ladder' approach, shared facilities that otherwise meet the criteria for 'improved' are considered as better than open defecation, they are still considered as 'unimproved'. The most recent definition excludes pit latrines without slabs or flush toilets that do not go to an appropriate site. The most recent DHS questionnaires (phase 6) include this distinction but the older phase 4 and 5 questionnaires do not. Therefore for those country surveys that used the older phase 4 and 5 questionnaires (Ethiopia, Zambia, Zimbabwe, Bangladesh and India) it is not possible to distinguish the type of slab or the destination of flush toilet waste. For these countries, it was assumed that all pit latrines and flush toilets were improved. This does not affect the overall estimates of sanitation-related burden, however it reduces our ability to distinguish between different levels of service. Consequently, it results in a likely underestimate of disparities in countries where we used the less precise definition.

While current JMP definitions of improved sanitation exclude shared facilities, there is ongoing debate about whether shared facilities offer the same or similar level of protection as private facilities. For our analysis we assumed that both shared and unshared facilities provide some protection and that unshared – or private – facilities are likely to be more protective of health.

Population density without sanitation

MDG targets and JMP measures focus on household access, however a number of studies suggest that community coverage is likely to be a more important determinant of sanitation-related health risks (Moraes *et al*. 2004). To investigate disparities in this dimension of exposure we estimated the density of population without sanitation for each household and child. For most of the countries (except Tanzania and India), GPS coordinates are available for each survey cluster. These locations were used to estimate population density using AfriPop (www.africpop.com) and Global Urban Rural Mapping Project (GRUMP) (http://beta.sedac.ciesin.columbia.edu/gpw/) databases. For each survey cluster we estimated the fraction of households with access to an improved toilet (whether shared or not) as a proxy for the fraction of the community's human waste entering the environment with little or no treatment. The cluster density and coverage were multiplied to estimate the density of population without sanitation (people/km^2). This provides a proxy measure for the amount of human waste being released into the nearby environment.

Two versions of this index were used in the analysis. One version simply used the product of the population density and the cluster level coverage. However this formulation of the index does not account for the fact that some household may be more 'vulnerable' to excreta in the environment. For example, in an informal settlement with limited drainage, informal housing structures, and households relying on unprotected water sources, the opportunity for child exposure to excreta in the environment may be much higher than in settings with multi-storey concrete structures, good drainage and infrastructure, and access to household tap water for drinking. In order to account for these differences we developed an environmental vulnerability score, which was used to adjust the population density without sanitation. We constructed this index using household data from the DHS surveys regarding housing and water sources. Each floor type and wall type was categorized into low, medium and high vulnerability (and scored 0, 1, and 2). These roughly corresponded with 'natural', 'rustic' and 'finished' materials. Similarly, water sources were grouped into the same levels, with household tap being low, other improved sources being 1, and unimproved being 2. The sum of the three scores divided by the total possible of 6 was used as a vulnerability score (ranging from 0-1). The vulnerability score was multiplied by the population density without sanitation as an adjustment.

Focusing on children as the unit of analysis

All exposure variables were estimated at the child level rather than the household because our main focus was on the distribution of exposures and risks and children bear the majority of that health burden (for diarrhoea and soil-transmitted helminths). Although the MDG sanitation targets focus on household access our approach is consistent with the MDG focus on child-level or population-level outcomes for other targets. Since richer households often have fewer members and fewer children, household-based approaches give disproportionate weight to better-off individuals.

Exposure index

In order to estimate the combined effect of these different exposure variables on disparities we developed an exposure index.

Exposure Index = No facility (0,1) + No Private Facility (0,1) + Population Density without Sanitation

Where 'No facility' is 1 if the child's household has no facility, 'No Private Facility' is an additional 1, and 'Population Density without Sanitation' is defined as above and normalized by dividing it by the national average density without sanitation. For the base-case analyses presented here, we use the adjusted population density without sanitation that takes into account household structure and infrastructure.

As an example, if a household has no sanitation facility, they would receive a '1' for each of the two first components of the index. If they have a toilet but it is shared then they would receive a '0' and '1' for the first two components. A household with a private toilet would receive a '0' for both components. If a household is located within a community with population density exactly equal to the national mean, they would receive '1' for the third element. If their community has a population density twice the national average then they would receive a '2' and if it is half the mean they would receive a '0.5'. For this third component, all non-negative numbers are possible, while the first two components can only take a '0' or '1'.

It is important to point out that this is just one potential formulation of an exposure index. In particular, there is uncertainty regarding the relative contribution of any particular facility to reducing exposure. There is also clearly uncertainty about the contribution of household domain variables and the community level variable of density of population without sanitation. The formula used here gives each factor roughly equal influence.

Susceptibility

In Figure 1, the distribution of sanitation-related burden is a function of disparities in exposure and in vulnerabilities. In this context we use vulnerability to reflect that, for the same level of exposure, some children may be more likely to become ill and/or more likely to die. A number of potential factors have been shown to be associated with vulnerability to sanitation related burden and diarrhoea more specifically. These include nutritional vulnerability (weight-for-age; Caulfield *et al*. 2004; Black *et al*. 2008), preventive zinc, access to treatment with zinc (Walker and Black 2010; *Yakoob et al.* 2011*)* or oral rehydration solution (ORS), Vitamin A supplementation (Imdad *et al*. 2010; Imdad *et al*. 2011; Mayo-Wilson *et al*. 2011), HIV/AIDS status, malaria, and others. Within the DHS data sets there is some information on a number of these variables, however the data are often not available for all countries or for all children within the sample. For this analysis we developed a susceptibility index based on nutritional vulnerability (specifically weight-for-age Z-score), ORS treatment, and Vitamin A supplements.

The susceptibility index was developed by accounting for three individual diarrhoeal risk factors: low weight-for-age, use of Vitamin A supplementation, and likelihood of receiving appropriate treatment for diarrhea. The index is constructed for each child as the product of the child's risk factors and the evidence-based relative risk associated with each factor (Eq. 1).

For weight-for-age, the risk is a based on the linearized relative risk based on z-scores calculated in Caulfield and colleagues (2004). Relative risks are in comparison to children with z-scores of greater than -1 (Eq. 2).

Meta-analyses and reviews of studies of Vitamin A supplementation have been shown to reduce incidents of mortality due to diarrhoea in children under five years of age (Imdad *et al*. 2010; Imdad *et al*. 2011; Mayo-Wilson *et al*. 2011). Mayo-Wilson and colleagues (2011) showed an overall rate reduction of 0.72, calculated from seven studies of effects of Vitamin A supplementation on diarrhoea-associated mortality. In calculations of susceptibility indices, a child was given a score of 0.72 if they had received a Vitamin A dose either by documentation on a vaccine card or if the mother reported them receiving a dose in the last six months (Eq. 4). If there was no record or report of Vitamin A supplementation, the child received a score of 1.

Interviewers gathering data for the DHS questionnaire ask respondents if any of their children have had diarrhoea within the last two weeks preceding the interview. If respondents indicated that their child had a case of diarrhoea, then respondents were asked follow-up questions regarding treatment. If the respondent indicated that they used ORS as a treatment, then the child was given a score of 1, if ORS was not received then they received a 0 score. Logistic regression on ORS treatment scores, including factors that effect the likelihood for health-seeking behaviors, were performed for each country. Maternal education level, place of residence (state-level), and wealth quintiles were included as predictive variables in logistic regression models of ORS treatments. The "predict" function in STATA 11.2 was used to impute a probability of receiving ORS treatment for each child. The imputed probabilities were assigned based on regression results and calculated based on each child's wealth, place of residence and mother's education level.

The final ORS probability was included in the susceptibility indices if they were significant in the logistic regression analyses. ORS scores were included in the susceptibility index calculations for Bangladesh, Ethiopia, India, Nigeria, and Tanzania. Logistic regression models were not significant and subsequently ORS scores were excluded for Ghana, Kenya, Malawi, Zambia, and Zimbabwe. In these countries, the susceptibility indices were calculated with Vitamin A and weight-for-age scores only.

In a meta-analysis of studies of ORS effectiveness in preventing deaths due to diarrhoea in children under 5 years of age, Munos *et al*. (2010) estimated that ORS reduced diarrhoeal deaths by 93%. The ORS probabilities for each child were multiplied by 0.93 and then subtracted from 1 if they had a reported case of diarrhoea and subsequently received an ORS treatment (Eq. 3).

Eq. 1: Susceptibility Index = Weight-for-age (WFA) risk * ORS (oral rehydration solution) risk * Vitamin A risk

Where:

Eq. 2: WFA risk = -1.64-2.64 * WFA z-score if WFA z score ≤ -1

= -3.32-3.48 * WFA z-score if WFA z score ≤ -2

= -23.76-10.36 * WFA z-score if WFA z score ≤ -3

= 12.5 if WFA z score ≤ 3.5

Eq. 3: ORS risk = 1 – p(ORS treatment) * 0.93

Eq. 4: Vitamin A risk = 1 – 0.28 * Vitamin A supplement (0 or 1)

Alternative susceptibility indices that include nutrition, susceptibility to infection (e.g.. zinc preventive treatment) and access to treatment (e.g. distance to clinic) might provide a more accurate measure. However a multivariate index would require some assessment of the independent contribution of each of these elements.

The exposure index and susceptibility index were combined into a Sanitation Risk Index (SRI) in order to assess overall disparities. The SRI is defined as the product of the two other indices for each child.

Sanitation Risk Index = Exposure Index x Susceptibility Index

While there are a number of ways to combine susceptibility and exposure, using the SRI implies that children who have no exposure (as captured by the index) have no risk. It also assumes that a doubling of the exposure index has the same effect as doubling the susceptibility index. While there is uncertainty about the exact form of the relation between the three indices, the formula used can provide a starting point to be refined with additional research.

Estimating the distribution of sanitation-related health burden

SRI provides a proxy for the relative distribution of sanitation related health burden. In order to convert that into a more traditional measure of burden, we combined it with national estimates of diarrhoeal mortality burden (Black *et al*. 2010). WHO estimates of diarrhoeal mortality were converted to Disability-Adjusted Life Years (DALYs) using standard formulas from the Global Burden of Disease Study. These were combined with estimates of national population under five years of age to estimate the DALY burden per child.

In order to calculate the portion of diarrhoeal burden attributable to sanitation we used the 'Population Attributable Fraction' (PAF) method used by WHO and the Global Burden of Disease Study. PAF was calculated for each country using the following formula:

$$\textbf{PAF} = \frac{\sum_{i=1}^{n} P_i \; RR_i - \sum_{i=1}^{n} P_i' \; RR_i}{\sum_{i=1}^{n} P_i \; RR_i}$$

where P_i is the proportion of children under five with or without sanitation at baseline and RR_i is the relative risk for each condition. The relative risk for those with sanitation was assumed to be 1 and those without improved sanitation was estimated based on a potential risk reduction of 35% associated with receiving sanitation. This is much less than some model studies, but is consistent with estimates of risk reduction from meta-analyses (Esrey *et al*. 1991; Fewtrell *et al*. 2005; Waddington *et al*. 2009). P_i' is the proportion with or without improved sanitation in 'counterfactual' state, which in this case is universal coverage.

The overall sanitation DALY burden was then distributed based on the SRI. For urban and rural settings we estimated the burden per 1,000 children under five years of age by wealth quintile. The fraction of the DALY burden was based on the SRI for that subgroup divided by the average. The result is an estimated DALY distribution that is directly proportional to the SRI distribution.

Of course diarrhoea is not the only health outcome associated with sanitation (Prüss-Üstün *et al*. 2008). Poor sanitation contributes to soil-transmitted helminths infection, schistosomiasis, trachoma, cystocercosis, poor nutritional status, and other outcomes. As a result, the DALY burden estimates should be treated as a relative measure of the distribution of burden, rather than the absolute burden. It is likely that these estimates significantly underestimate the burden and may also underestimate disparities in the burden.

Estimating the distributional impact of improved sanitation

In addition to estimating disparities in the sanitation exposure and burden, we also examined the differential impact of improving sanitation coverage among different economic groups. The objective was to estimate the DALY improvement associated with providing improved private sanitation to a given number of households within each wealth quintile, nationally and within urban and rural settings.

The analysis was conducted using a simulation model that was implemented for each country as a whole and then for the rural and urban populations separately within each country.

For each setting the baseline estimates were determined by estimating the sanitation burden for 1,000 households for each wealth quintile. This required the burden estimates per child (described above) and an estimate of the number of children under five per household. The number of children under five was estimated using DHS data for each country.

For each setting we then simulated the effect of providing sanitation to all households within each wealth quintile separately. To do this, survey data were recoded to ‘give’ improved private sanitation to all households within that quintile. The revised data was then used to recalculate exposure and risk variables, which included updating the cluster level coverage and density of population without sanitation.

It is important to point out that improvements in sanitation for one quintile can ‘spill over’ into other quintiles through changes in cluster level coverage. For example, improving coverage for the poorest (first) quintile in this model increases cluster level coverage for second quintile households that live in the same community or cluster as the first quintile households. This spill over effect is determined by the degree of mixing among quintiles within the actual survey.

Spatial analysis

Sanitation equity across Kenya and Malawi was analyzed using kriging in ArcGIS to create interpolation maps. Data and the corresponding GPS locations used in the creation of the maps were obtained from the DHS website (www.measuredhs.com). Data were collected by DHS in 2008 (Kenya) and 2010 (Malawi) from randomly selected households in clusters (each cluster represented by one GPS point) across the respective country. For privacy purposes DHS offsets GPS points from their actual location. However, points were considered within a reasonable distance for interpolation purposes. The data from each household were then collapsed using STATA to determine statistics for each cluster.

Maps were created for both the composite variables (susceptibility index, exposure index and Sanitation Risk Index), as well as for underlying and intermediate outcomes (fraction with improved sanitation, fraction of children less than -2 SD weight for age, and population density without sanitation). For some outcomes, households were divided into wealth quintiles and maps were created for each quintile as well as at the national level. Maps were also created at a national level for clusters divided into urban and rural groups. In order to improve the accuracy of interpolation, only clusters with three or more households were used for the quintile maps and clusters with greater than 10 households were used for the national level interpolation maps. In addition, points falling outside of the study area (such as points with 0,0 latitude and longitude) were eliminated.

Semivariograms were created to determine the spatial correlation for each variable. All variables were then interpolated using ordinary kriging and no external trends were incorporated into the model. In order to decrease standard error, minimum nearest neighbors was increased to 10, maximum was increased to 20 with a division into eight sectors. This allows for an increased number of points to be taken into consideration for the creation of the interpolation map. Number of lags for all maps was 12. The color scale for each map is equal interval and is scaled to best represent the range in values of the interpolation. Prediction standard error maps were created for each map to describe spatial correlation, error in prediction of the interpolation, and the resulting reliability of each map.

3.Results

Results for selected outcomes are presented in the series of figures below. The same six countries are used to display outcomes of the analyses.

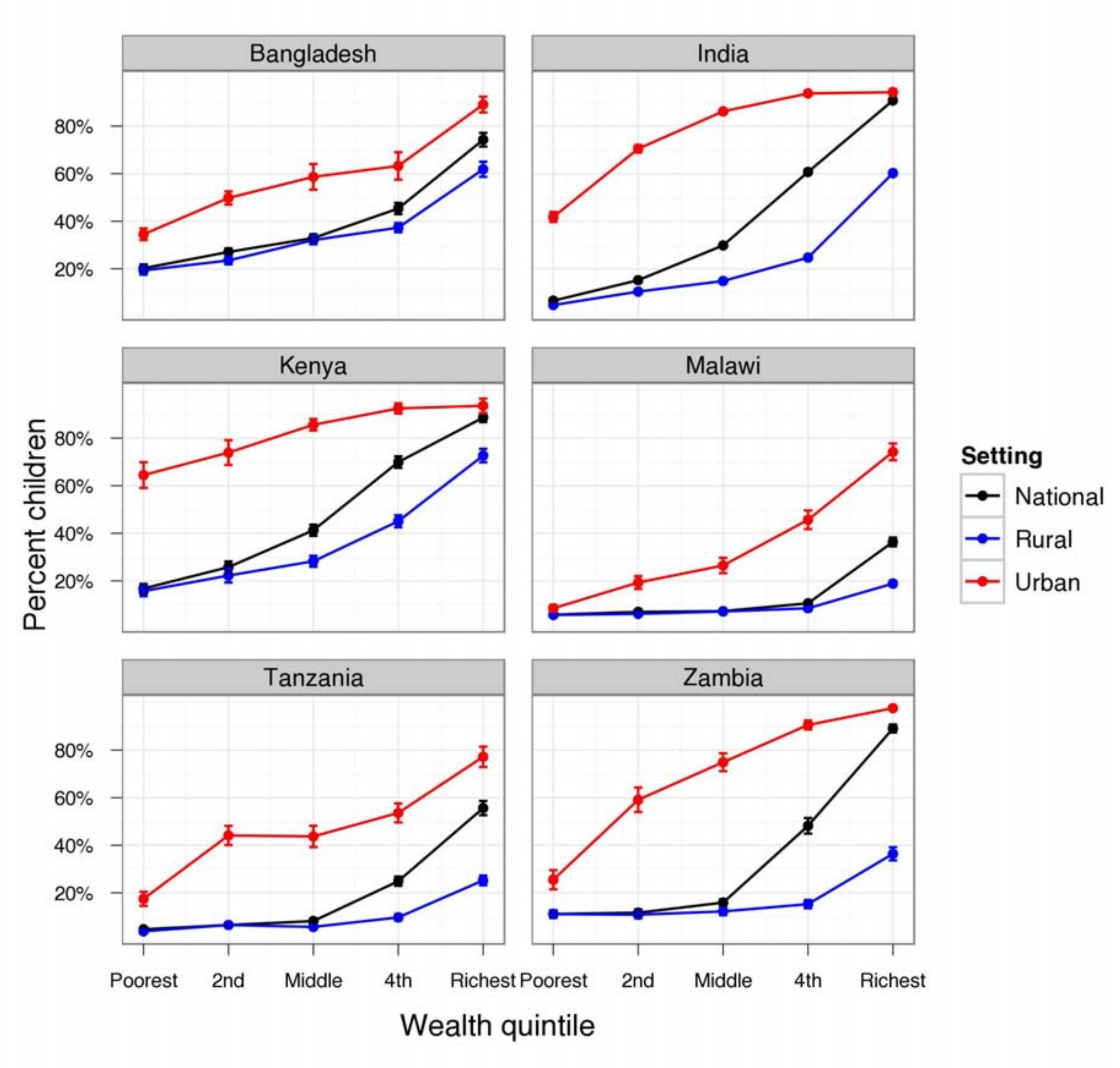
3.1 Exposure

As described above, for this study we developed an exposure index based on three components: whether a child's family had access to an improved toilet, whether the toilet was shared or private, and the density of people without sanitation in the community. Data for each variable were calculated by wealth quintile for the country as a whole and for urban and rural settings.

Access to sanitation (whether shared or private) is presented for selected countries in the graphs below. As expected, in all countries coverage is greatest in urban areas and increases from the poorest to the richest quintiles (Figure 3). Similar patterns exist for unshared improved sanitation access.

The exposure index only considered whether a facility was shared or unshared, however there are likely also disparities in the number of people sharing facilities by wealth quintile and setting. While this data is not available for all countries, preliminary assessment in countries where it is available suggests that the number of people sharing a given facility is greater in urban areas and greater for poorer households.

Figure 3: Percentage of children with improved sanitation (shared facilities included) by wealth quintile and setting



Patterns of density of population without sanitation are presented for the raw (Figure 4) and adjusted analysis (Figure 5), where the adjusted analysis accounts for each household's vulnerability to human waste in the environment, based on housing structure and infrastructure. For both measures the patterns differ between countries. While population densities are higher in urban areas in most countries, the fraction of the population without sanitation is typically lower. In both urban and rural areas in most countries, there is a trend toward increased population density as wealth increases. For the unadjusted analysis this results in increased population density without sanitation in middle and upper quintiles (Figure 4). This is noticeable in the urban context for Bangladesh and the rural context in Kenya. However this does not account for the fact that households with poor housing conditions or more vulnerable water supplies may be more affected by the population density without sanitation. In the adjusted analyses, there is a stronger trend for increasing exposure among poorer households in both urban and rural settings (Figure 5).

In three of the countries (Zambia, Malawi and Tanzania) population density without sanitation is much greater in urban areas, especially among the poorest. This is due to a combination of low rural population densities and low urban sanitation coverage. In the other countries, higher population densities and lower rural coverage result in less of an urban-rural divide.

Figure 4: Population density without sanitation by wealth quintile and setting (unadjusted)

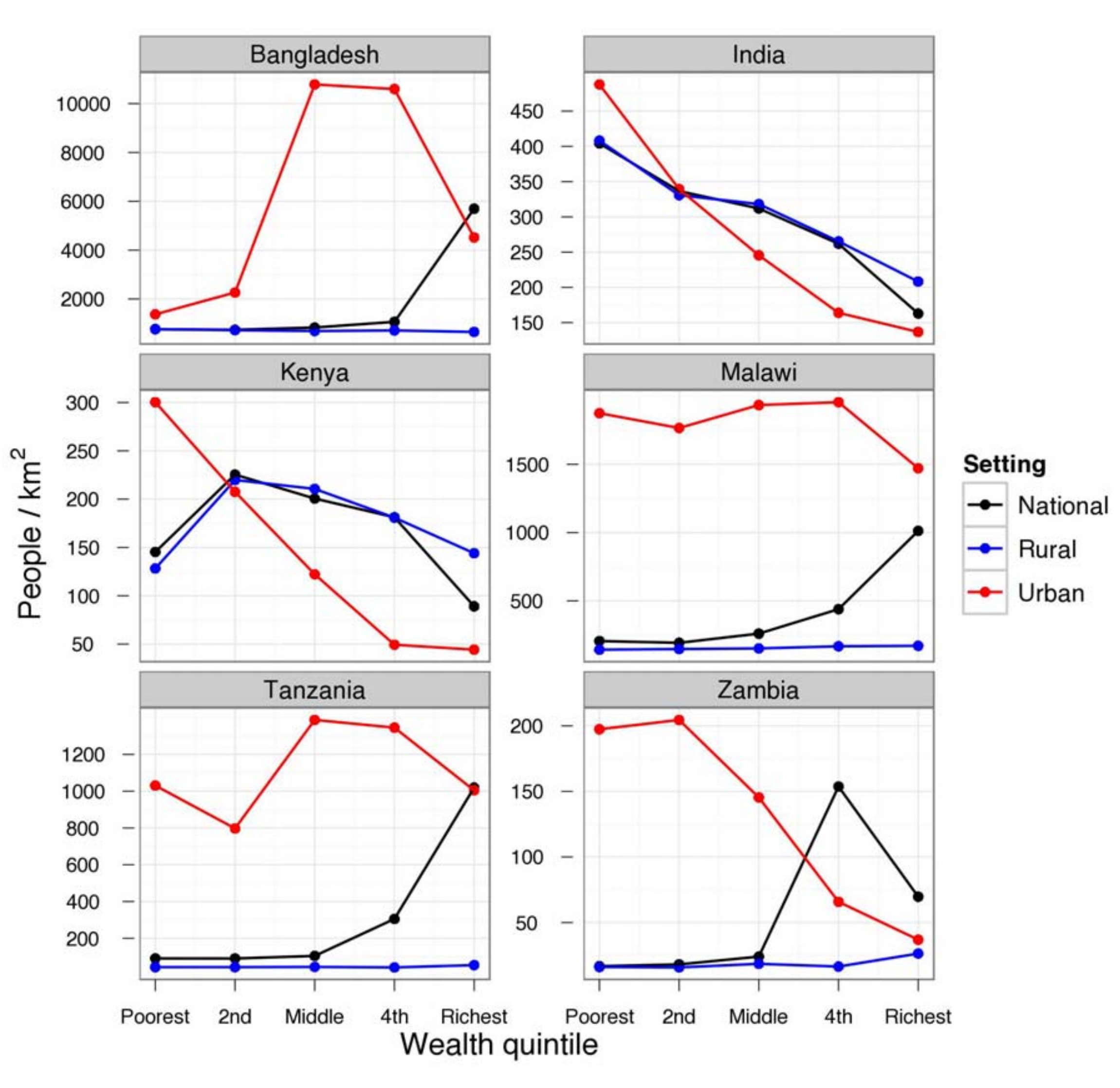
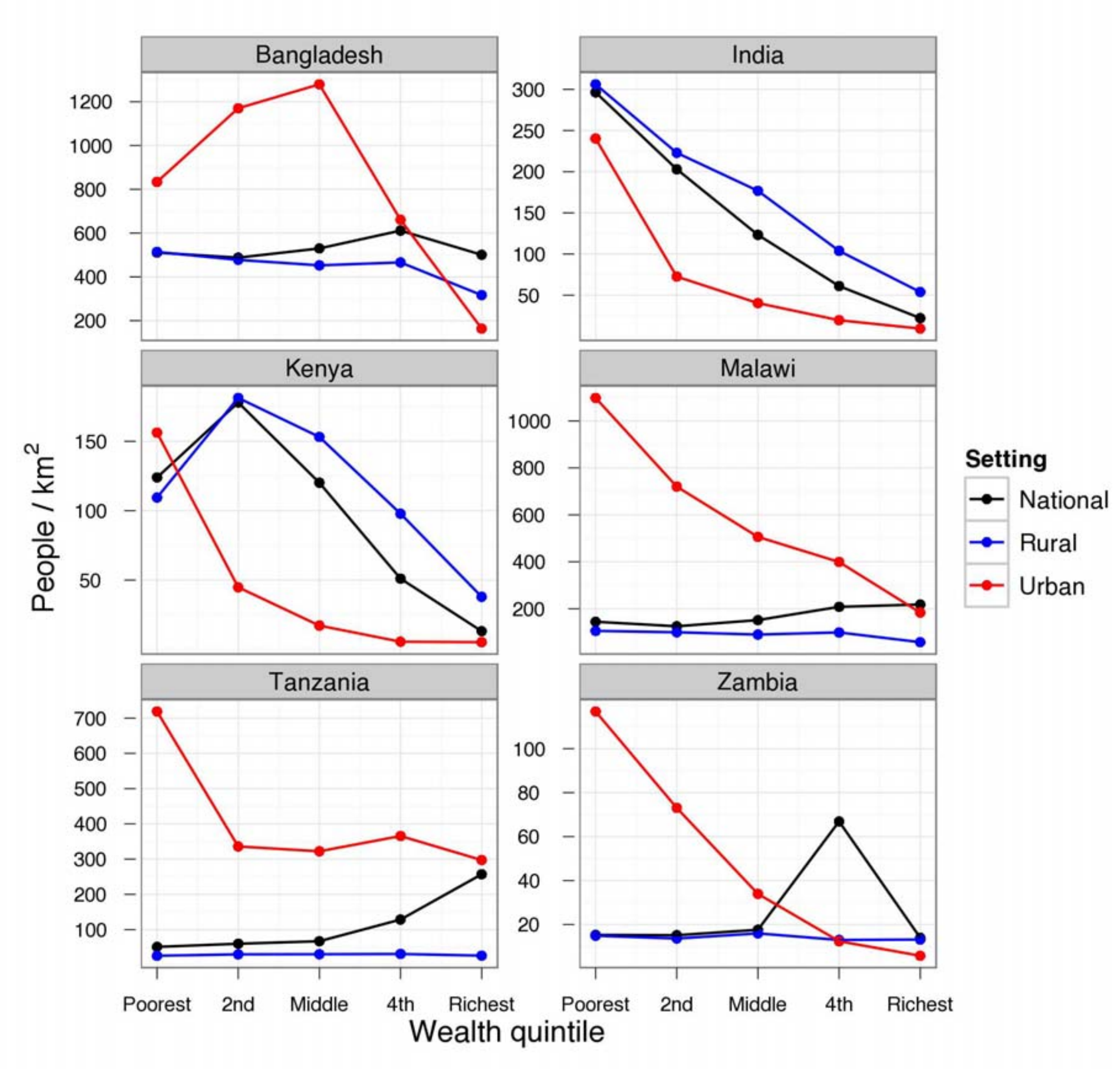


Figure 5: Population density without sanitation by wealth quintile and setting, adjusted for environmental vulnerability



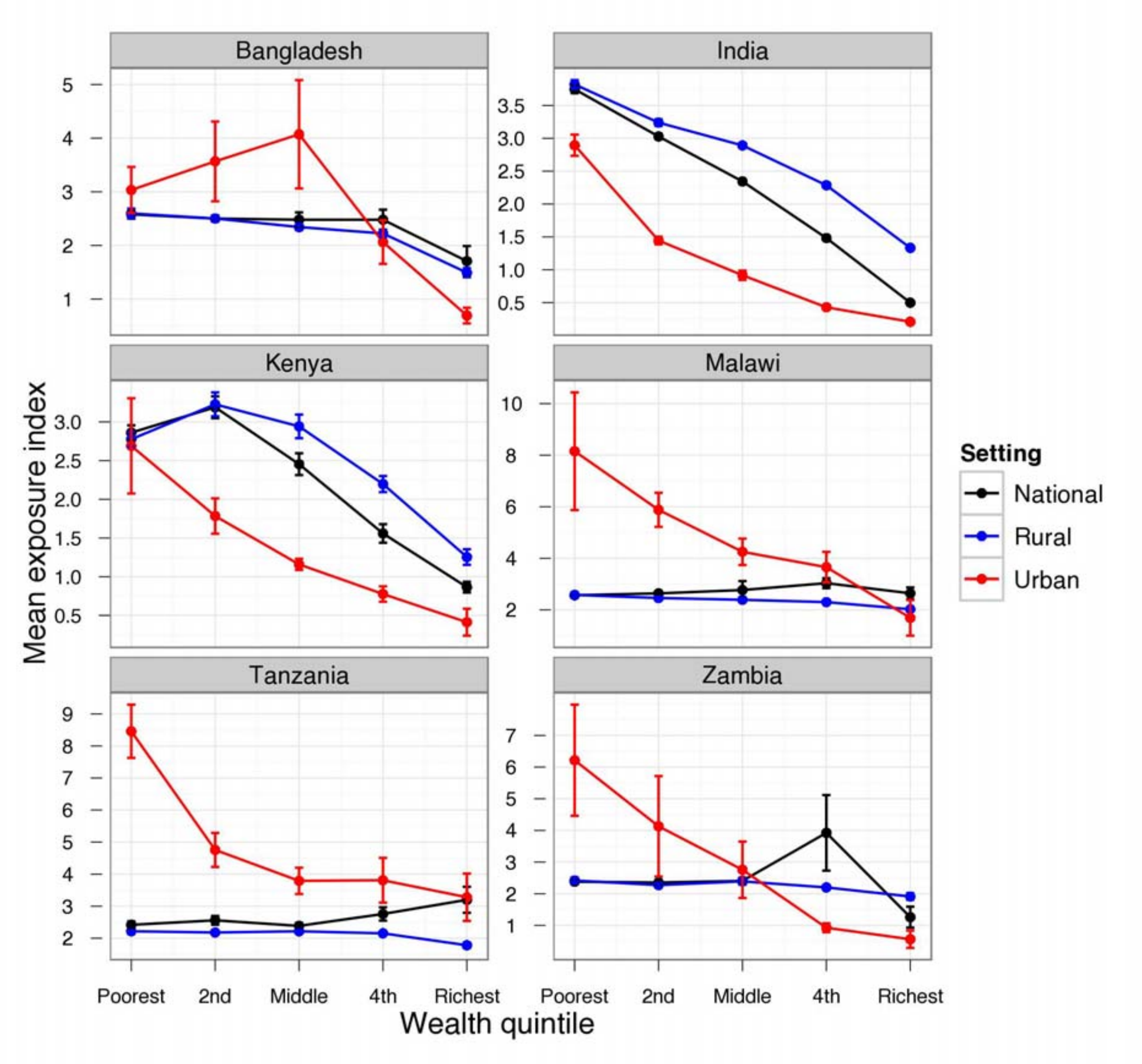
For the analyses of exposure and burden that follow, we rely on the adjusted indicators for population density without sanitation.

Overall exposure disparities were evaluated based on the sanitation exposure index. The estimated index is by wealth quintile and setting in the figure below (Figure 6). In almost all countries and settings, exposure levels are three to five times greater for children in poor households compared to those in the richest quintile. In all countries disparities in exposures are significantly greater in urban settings than in rural settings. In some cases increased population density associated with increased wealth reduced this trend.

In three of the countries (Tanzania, Malawi and Zambia) the estimated exposure index was substantially higher for the urban poor, compared to the rural poor. In the others, the levels were comparable.

Again it is important to point out that the index gives equal weight to the three components (any toilet, private toilet, and population density without sanitation), however additional information is needed to accurately estimate the relative contribution of inadequate household sanitation and community exposures associated with increased densities of people living without sanitation.

Figure 6: Mean exposure indices by wealth quintile and setting

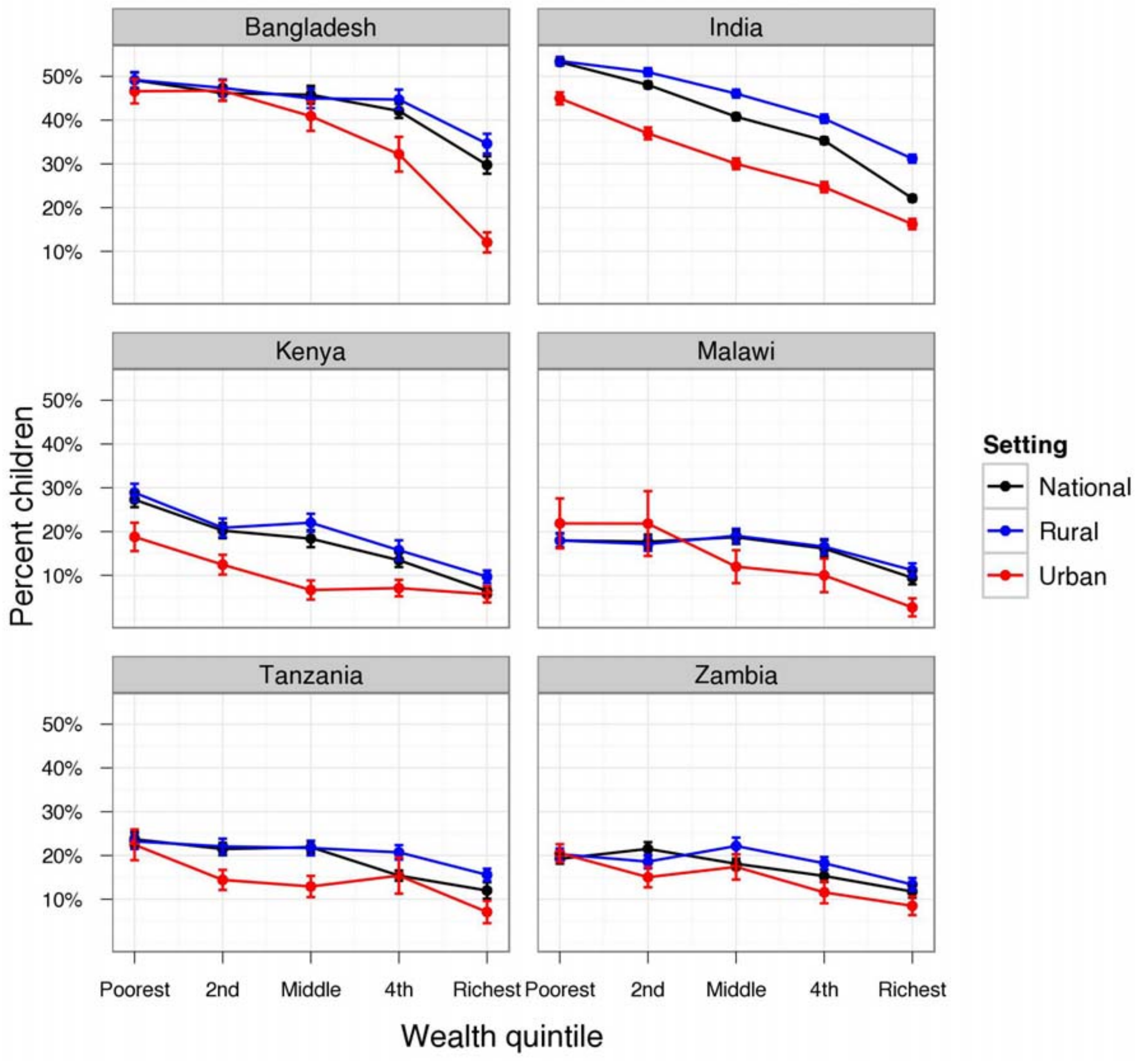


3.2 Susceptibility

As discussed above, we developed a measure of individual susceptibility based on three measures; (1) nutritional vulnerability, specifically low weight-for-age (WFA), (2) Vitamin A supplementation, and (3) probability of receiving oral rehydration solution (ORS) for diarrhoea. While all measures contribute to this estimate of a child's vulnerability to poor sanitation, a child's weight-for-age measure is the main driver of disparities in susceptibility.

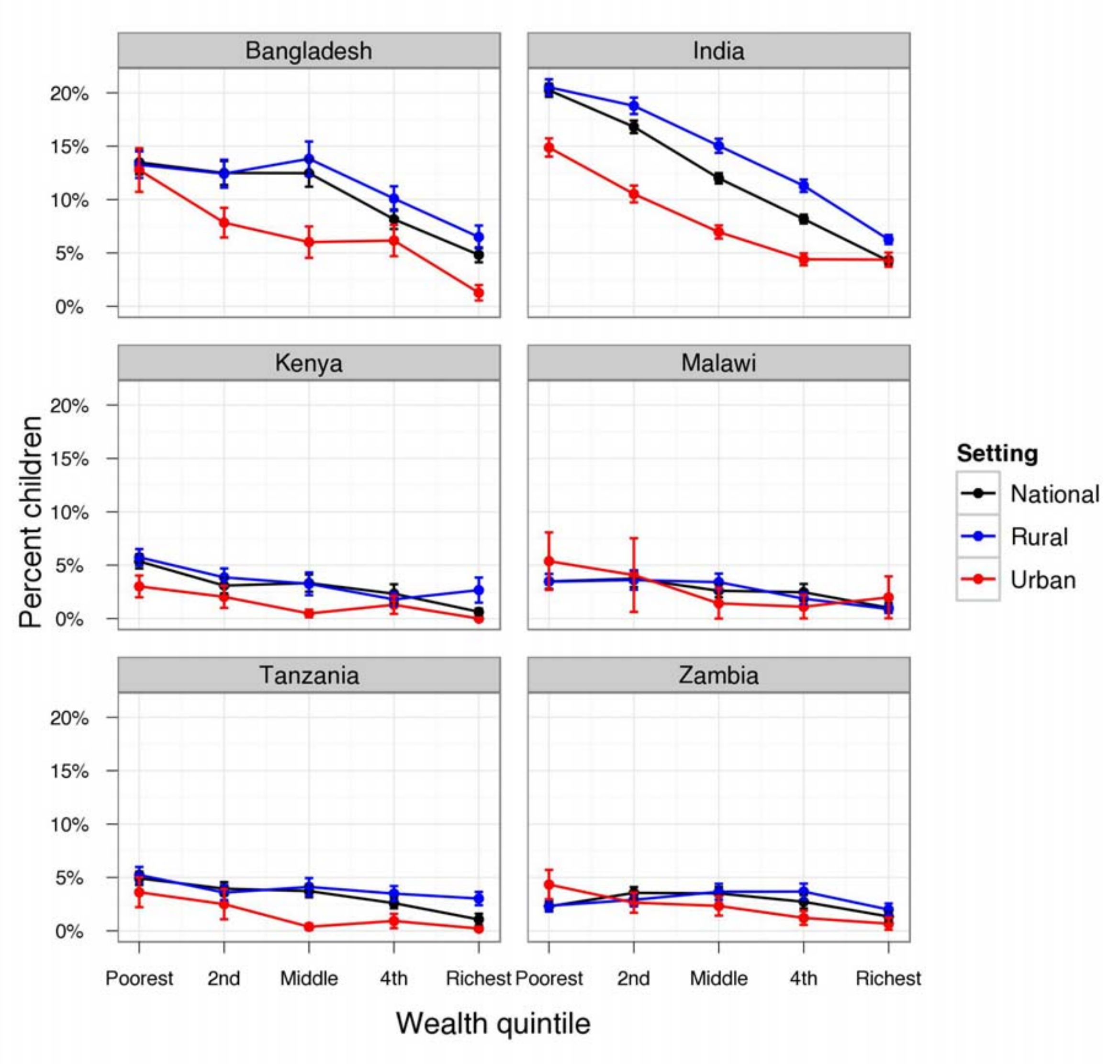
In all countries, the percent of children more than -2 and -3 standard deviations below normal weight was greater among children in the lowest wealth quintile. This was true at the national level as well as within urban and rural settings. In general, the percent of children with low weight-for-age was greater in rural settings than in urban settings. However, percentages of children less than -2 standard deviations below normal weight in the poorest urban wealth quintile often had similar levels to the poorest in rural areas (Figure 7).

Figure 7: Percentage of underweight children (< -2 standard deviations weight-for-age by wealth quintile and setting)



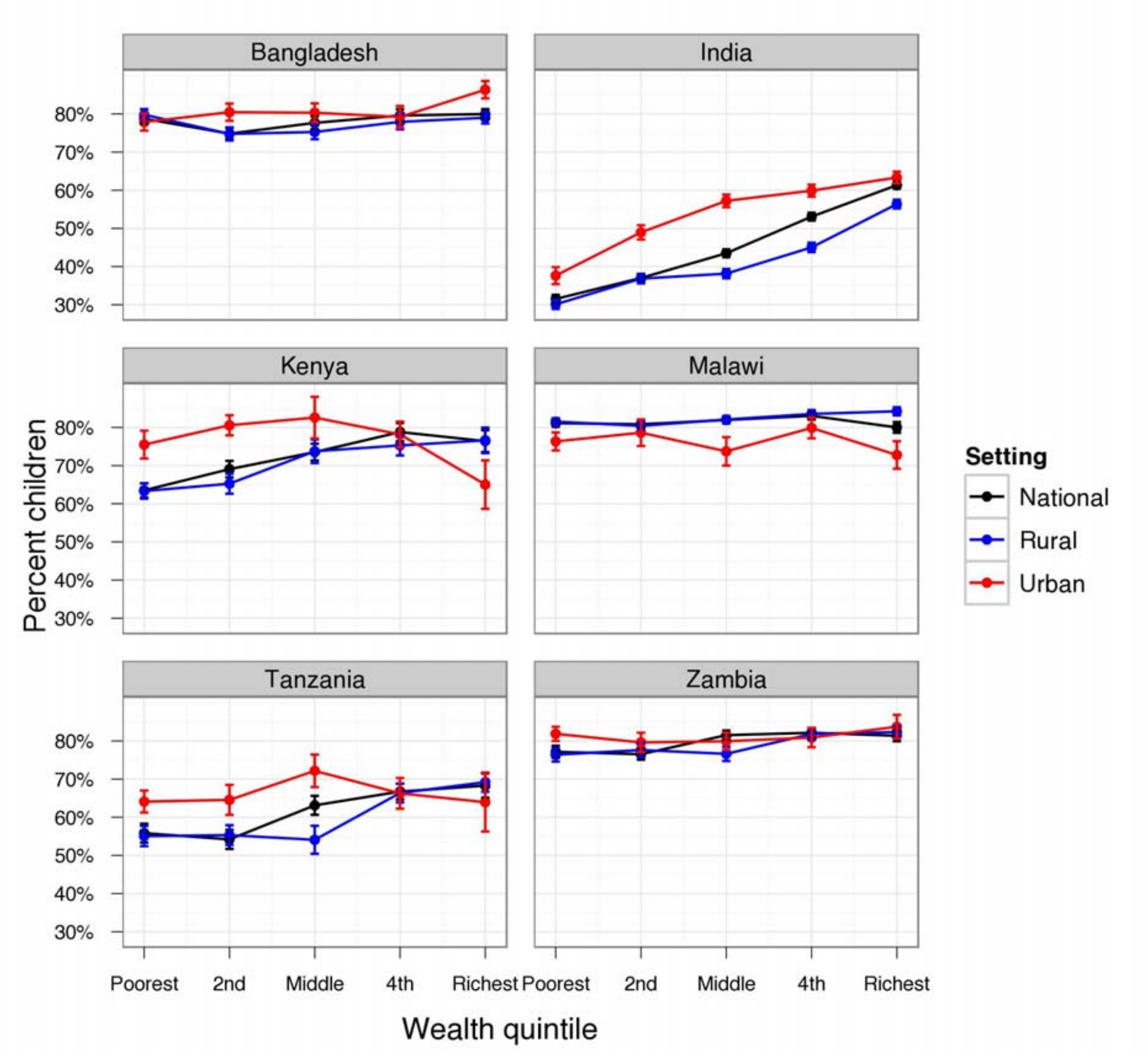
The patterns of children that are < -3 standard deviations WFA (Figure 8) are similar to the patterns in the < -2 standard deviations WFA (Figure 7). The greatest disparities exist in Bangladesh and India. These two countries also have the highest overall percentages of children < -3 standard deviations under normal weight. In contrast, the remaining countries have about 5% or less of children underweight (< -3 standard deviations WFA), in both urban and rural populations. The poorest urban households have lower percentages of underweight children, but have similar percentages of underweight children as the poorest rural households.

Figure 8: Percentage of underweight children (< -3 standard deviations weight-for-age by wealth quintile and setting)



Vitamin A supplement coverage is generally equitable in most countries, with the exception of India (Figure 9). India has the largest disparities in coverage across wealth quintiles, while the remaining countries show more equitable Vitamin A supplement coverage. India also has the lowest coverage, less than 60% for all quintiles, while most other countries showed supplement coverage that is around or above 60% in most quintiles. Vitamin A coverage is generally higher in urban than rural households across countries, except for Malawi.

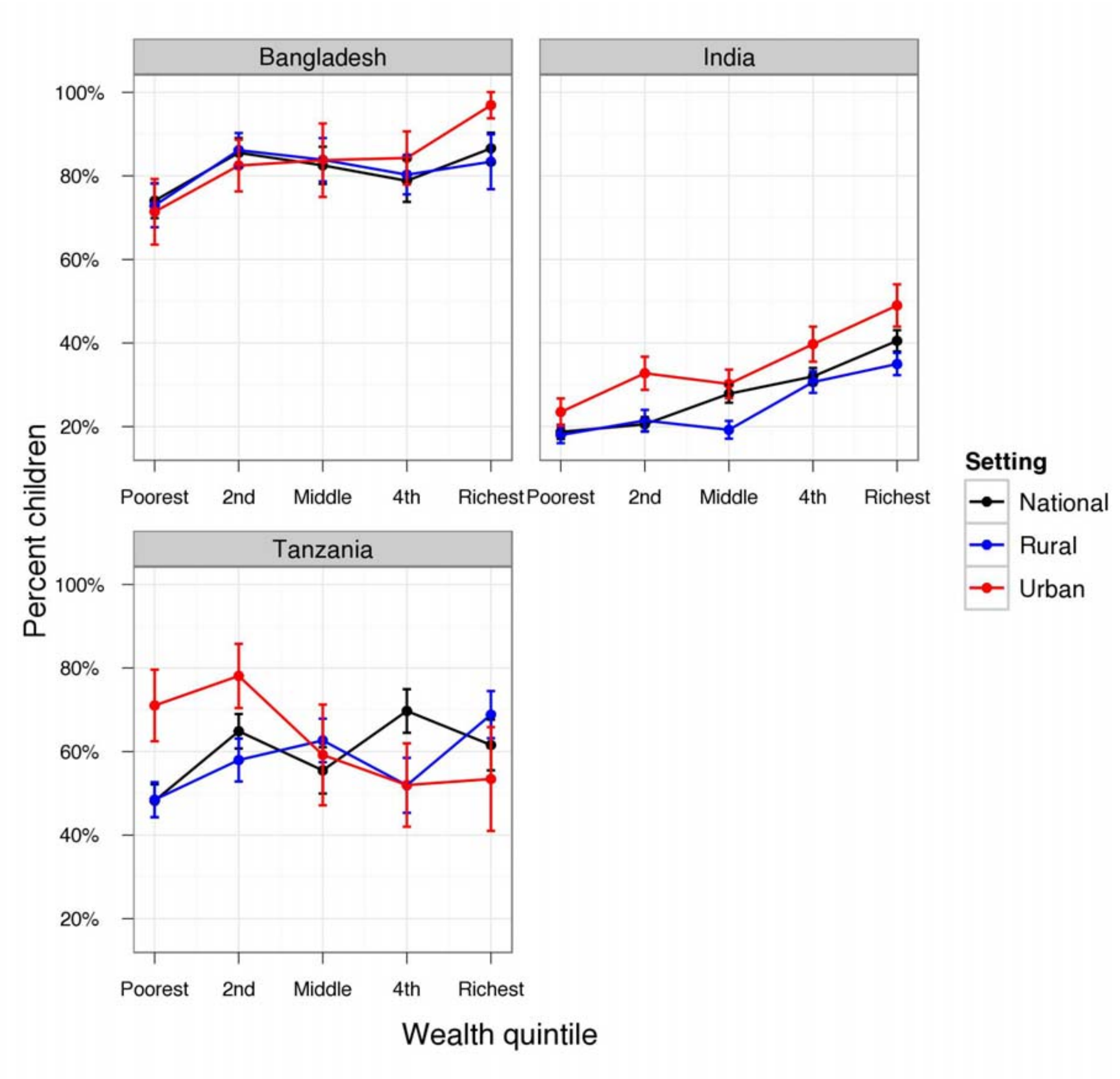
Figure 9: Percentage of children receiving Vitamin A doses by wealth quintile and setting



With the exception of urban households in Tanzania, proportions of children that received ORS treatment were lowest in the poorest national quintiles (Figure 10). Bangladesh has the lowest disparities between proportions of children that were given ORS treatments. In Tanzania, the richest national quintile had proportions that were lower than the second and fourth national quintiles and were more comparable, but higher, than households in the middle quintile.

Disaggregation of the data into rural and urban households shows heterogeneous patterns across each country (Figure 10). The disparities in Bangladesh are similar across settings, while households in urban settings in India have higher probabilities of ORS treatment. There is a pro-poor pattern among urban households in Tanzania, with the poorest and 2nd quintiles having higher probabilities of ORS treatments than households in higher quintiles. A pattern more similar to Bangladesh and India is present for rural Tanzanian households.

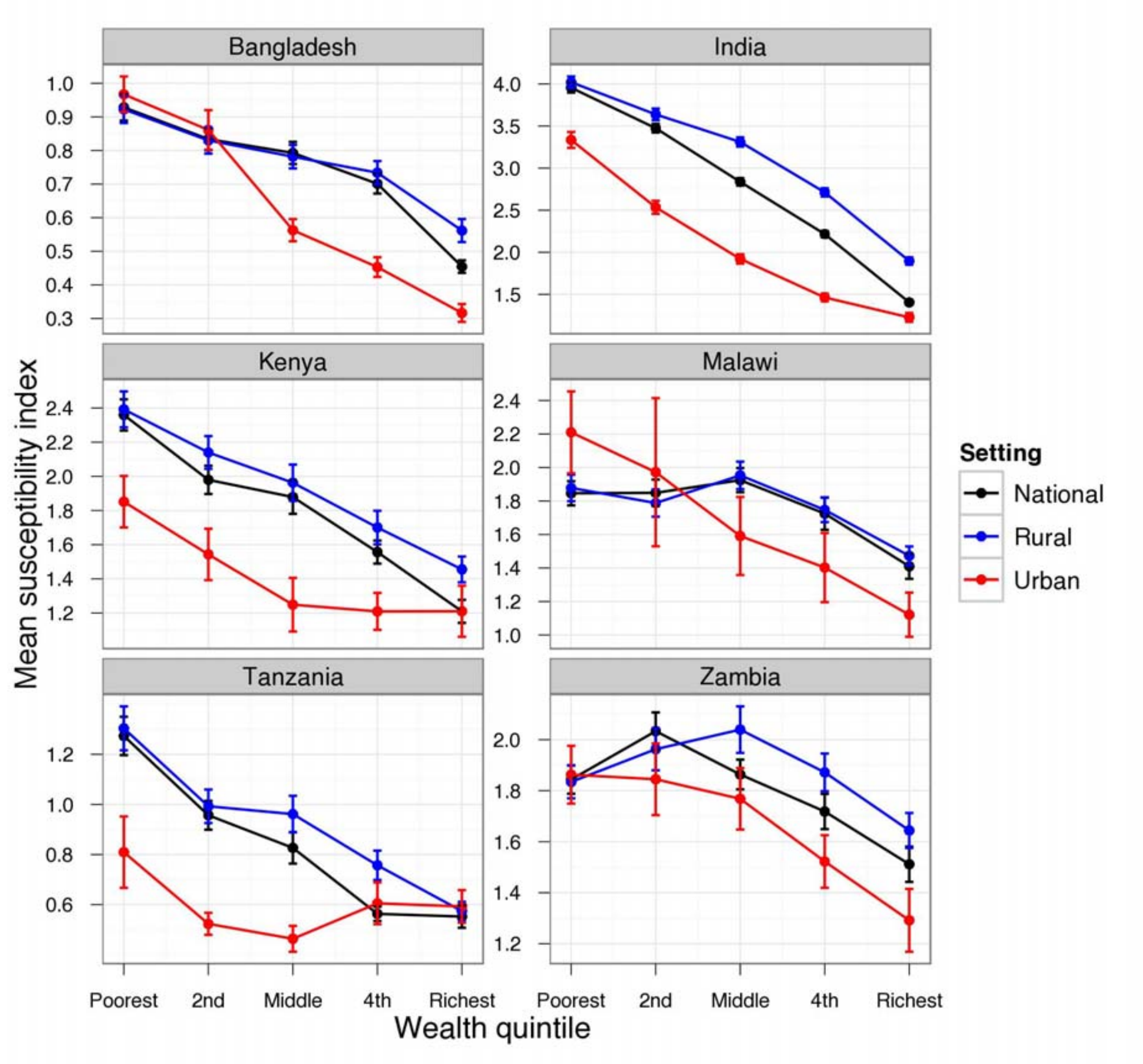
Figure 10: Percentage of children given oral rehydration solution (ORS) to treat diarrhoea by wealth quintile and setting



The susceptibility index captures the disparities in nutritional vulnerability, Vitamin A supplementation and diarrhoeal treatment with ORS. With the exceptions of Zambia and Malawi, national susceptibility values are highest in the poorest quintiles (Figure 11). In Zambia, the second quintile has the highest susceptibility, likely reflecting a peak in the rural households in the middle quintile. Malawi's trend in national susceptibility mirrors the patterns found in rural households. India displays the highest susceptibility values and a two-fold difference between the poorest and richest wealth quintiles, echoing the trends in all of the vulnerability measures.

Disaggregating the index by rural and urban households displays lower vulnerability in urban settings, but disparities that are consistent with, or much greater than, rural settings (Figure 11). Disparities between wealth quintiles in Bangladesh, India, Malawi and Zambia are much higher in urban households than in rural households. Susceptibility estimates in Tanzania show a unique trend in susceptibility in urban settings with the middle quintile households having the lowest values. However, index values in the middle quintile are comparable to households in the second,fourth and richest quintiles, and much lower than households in the poorest quintile. In Zambia, susceptibility values were highest in the second and middle quintiles in both urban and rural settings.

Figure 11: Mean susceptibility indices by wealth quintile and setting

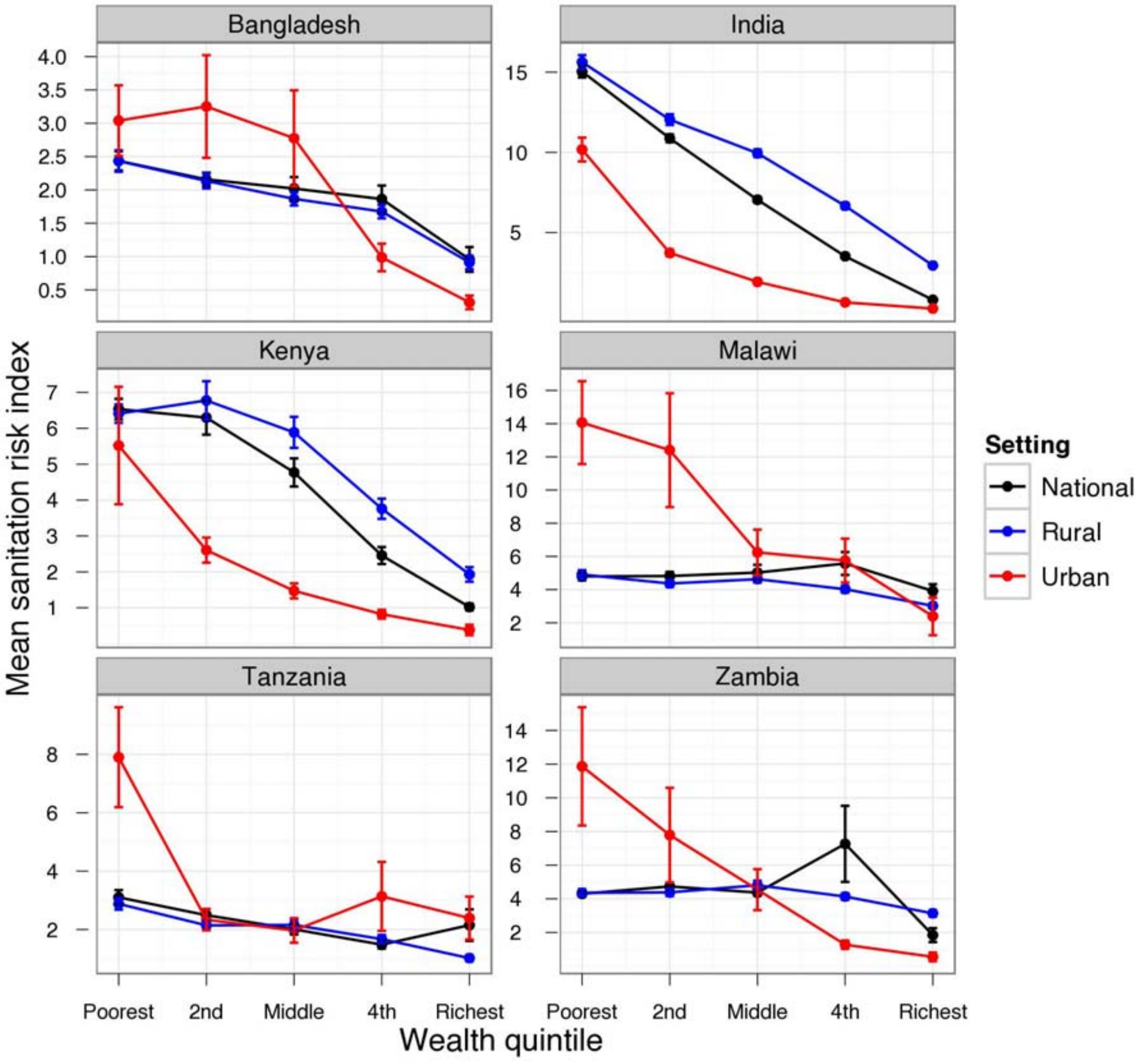


3.3 Sanitation risk

Sanitation Risk Index (SRI) results incorporate community-level exposure and individual susceptibility into a comprehensive estimate of risk due to poor sanitation for each child across wealth and setting. With the exception of Zambia, the poorest quintiles have the highest sanitation risk (Figure 12), a pattern that is displayed in both susceptibility and exposure results discussed earlier in this report. The highest index values are found in the poorest households in India and urban Malawi. India displays the greatest disparity between poorest and richest quintiles, with sanitation risk values an order of magnitude higher in the poorest quintile than the richest quintile.

Comparisons between urban and rural settings reveal differences in disparities between these two settings (Figure 12). In Tanzania and Zambia, the patterns of disparities in sanitation risk values mirror the exposure index values, especially in urban populations. This is more apparent in Tanzania particularly because of this distinct pattern of large disparities between the poorest quintile as compared to the four higher quintiles. Large disparities in sanitation risk are also present between the poorest and richest households in urban Malawi. In addition to India, these urban populations have the highest overall risk observed across all urban households in each country. In contrast to urban households, Tanzania, Malawi and Zambia display relatively more equitable sanitation risk in rural households across wealth quintiles, highlighting an overall pattern of greater disparities in sanitation across urban settings.

Figure 12: Mean sanitation risk indices by wealth quintile and setting



Burden

The figures below show the estimated burden by setting and wealth quintile for selected countries (Figure 13). For each country, there are substantial disparities among wealth quintiles in both urban and rural settings, as well as for the country as a whole. Estimates are for the preventable burden per 1,000 children under five years of age.

At the national level, the sanitation-related burden is three to 40 times greater in the poorest quintile compared to the richest. The largest gaps are in Zimbabwe (39 times greater), India (33 times greater), and Kenya (over 18 times).

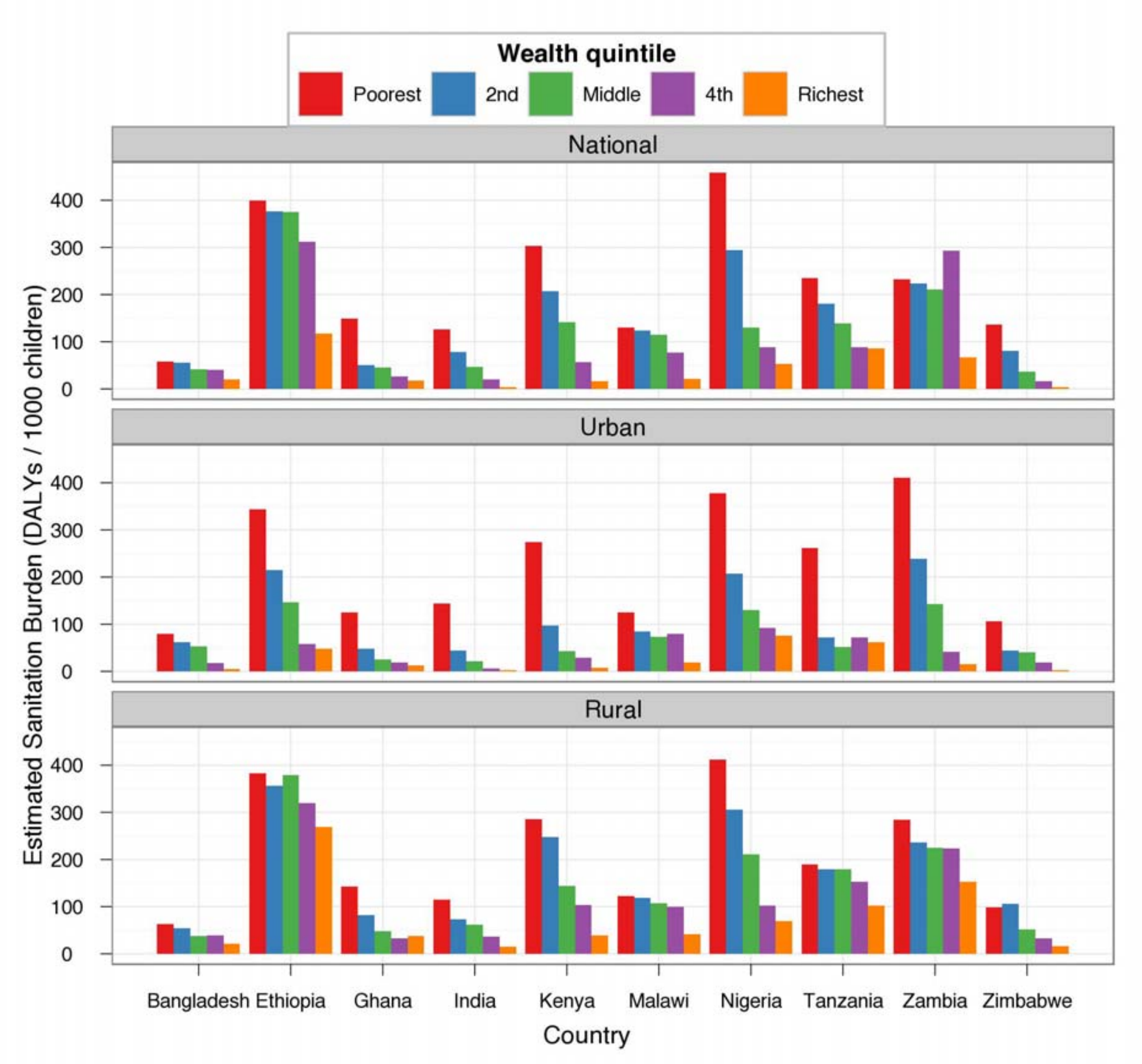
While most countries have substantial disparities at the national level, in some cases the national level analyses hide larger burden differences within urban and rural settings (Figure 13). This is particularly true in urban areas. For example, in Kenya the burden among the poorest 20% of the urban population is 34 times greater than the richest; in India it is 65 times greater; and in Zimbabwe it is 34 times greater. These differences are driven by the disparity in both susceptibility and exposure indices in these countries.

In rural areas the sanitation-related burden is somewhat less striking and is generally two to seven times greater in the poorest quintile compare to the richest. However there are some examples such as Zimbabwe and Tanzania where there is little difference.

The figures also reflect differences in sanitation burden among countries. These differences are the result of varying national diarrhoeal mortality estimates, and to a lesser degree the estimated population attributeable fraction. However, differences between countries should be viewed with caution.

While urban and rural burden estimates are presented on the same scale, caution should be used in comparing between them. Differences in the magnitude of the burden are generally a function of how different elements of the exposure index are weighted. Nevertheless, while estimated sanitation burden is generally lower in urban areas, the burden for the poorest urban quintile is often similar to or worse than the poorest rural quintile. If in fact the population density without sanitation is more of an exposure factor then assumed here, then the burden for the urban poor could be even greater.

Figure 13: Estimated sanitation burden by setting and wealth quintile



3.4 Impact

The figure below shows the estimated impact of improved sanitation services by wealth quintile and setting for selected countries (Figure 14). For each country, the bar represents an individual scenario of providing improved private sanitation to households within a given wealth quintile. The majority of the impact from these improvements is received by that quintile, however some benefits ‘spill over’ to other quintiles. Each bar reflects the total impact (including that on other quintiles) resulting from providing sanitation to households in each quintile. That is, it represents the total public and private benefit, not just that accrued to the quintile being modeled as receiving the intervention.

At a national level, all countries show substantially higher estimated returns to improvements in sanitation for poorer households (Figure 14). The differences are greatest in Zimbabwe where the impact is over 12 times greater in poor household, in Kenya (10 times greater) in Nigeria (nine times greater), and India (eight times greater). For several countries, notably Bangladesh, the national level comparisons do not show dramatic differences. This may reflect smaller differences or it may reflect the inability of our exposure and risk measures to capture the full range of disparities. It also is the result of particular differences between urban and rural settings.

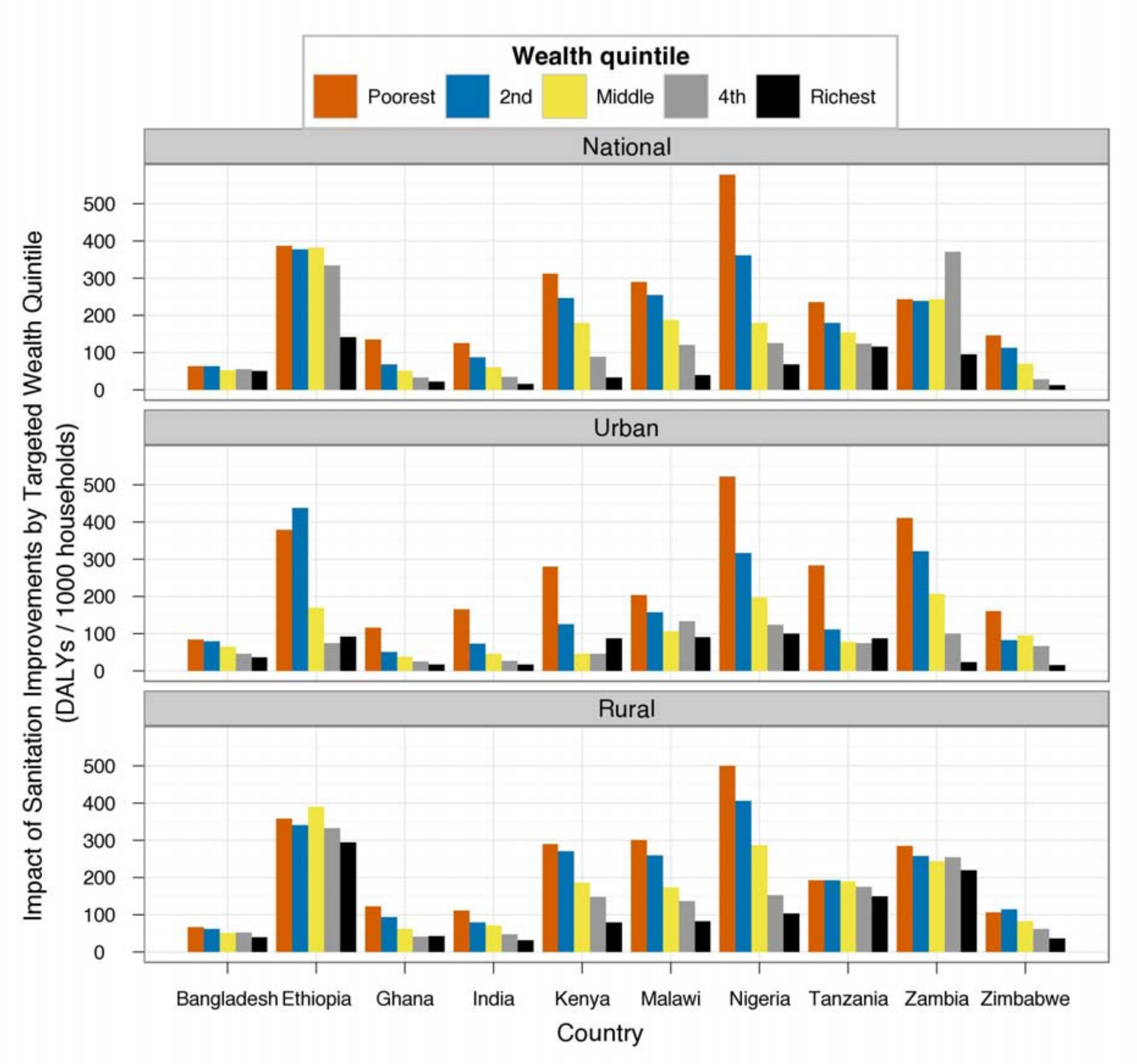
There are also differences within urban and rural populations (Figure 14). These patterns differ between countries. In urban settings the greatest differences are in Zambia (18 times greater impact in the poorest quintile), Kenya (10 times greater), in India (10 times greater), and in Nigeria (five times greater).

In rural areas the gap between rich and poor quintiles is somewhat less, with the maximum in Nigeria where the impact of sanitation in the poorest quintile is five times that of the richest rural quintile, in Kenya (four times greater), in Malawi (four times greater) and in India (three times greater)

In almost all countries and settings the impact of providing improved sanitation to the poor is substantially greater than providing it to the richest, typically more than four to 10 times as impactful. A number of factors contribute to this difference.

- In most countries, poorer households have more children, resulting in greater impacts from improved sanitation in those households
- In both rural and urban settings, children in poorer households are more susceptible to the effects of poor sanitation, primarily due to poor nutritional status
- In rural and urban settings poor households are less likely to have any sanitary facility and more likely to have to share it if they do (resulting in a ‘greater’ leap in sanitation service level)
- Poor households, especially in urban settings, are more likely to be surrounded by other poor households with low sanitation access, resulting in a ‘spillover’ effect as improved sanitation reduces exposure for a high number of other vulnerable children

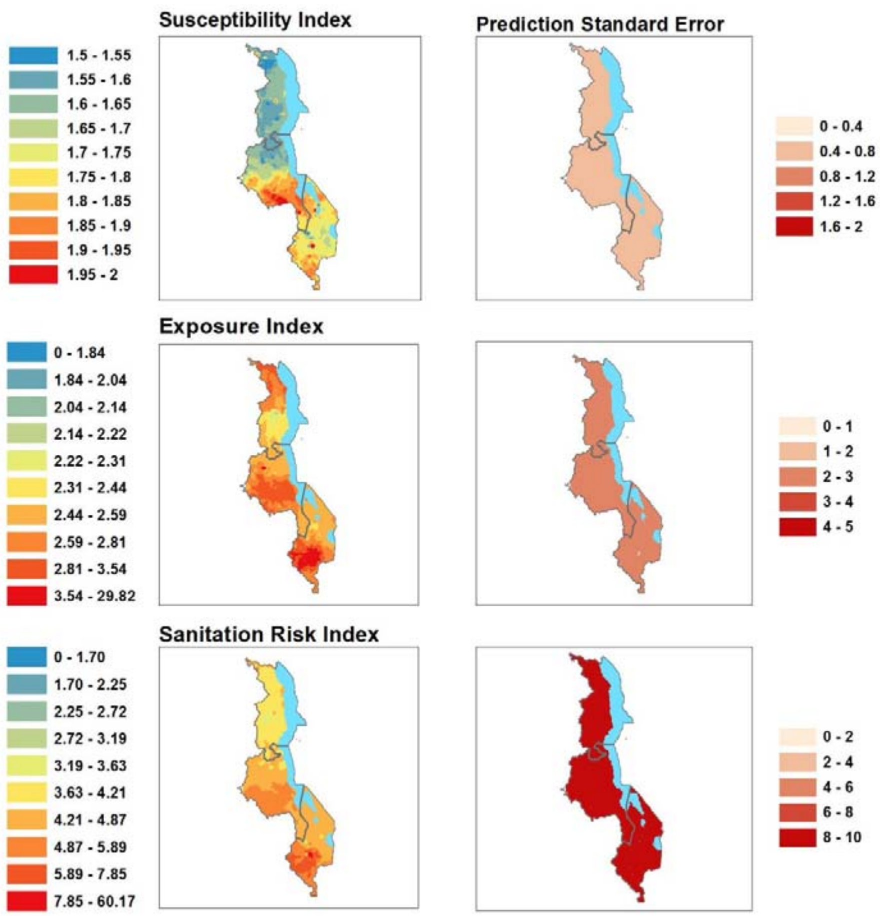
Figure 14: Estimated impact of giving sanitation to target group by setting and wealth quintile



Spatial

For Malawi (2010) and Kenya (2008) we estimated the spatial distribution of our three key outcomes: susceptibility index, exposure index, and sanitation risk index. Figure 15 shows the spatial distribution of the three indices for Malawi. The graphs on the left show the interpolated values and those on the right show the standard error of the prediction. In some cases, such as for the sanitation risk index, there is a prediction error. This is the result of low spatial correlation of the points due to heterogeneity at a local scale. This is not surprising given that clusters with poor coverage may be found next to those with good coverage, as well as the variability in population density.

Figure 15: Spatial distribution of sanitation susceptibility, exposure and risk in Malawi (2010)



Both exposure and susceptibility are highest in the southern and west central portion of the country, in the urban and surrounding rural areas of Blantyre and Lilongwe. One of the primary drivers for this pattern in exposure is the higher population density without sanitation in the urban areas. This can be seen in Figure 16, particularly for Blantyre in the south.

Figure 16: Spatial distribution of population without sanitation in Malawi (2010)

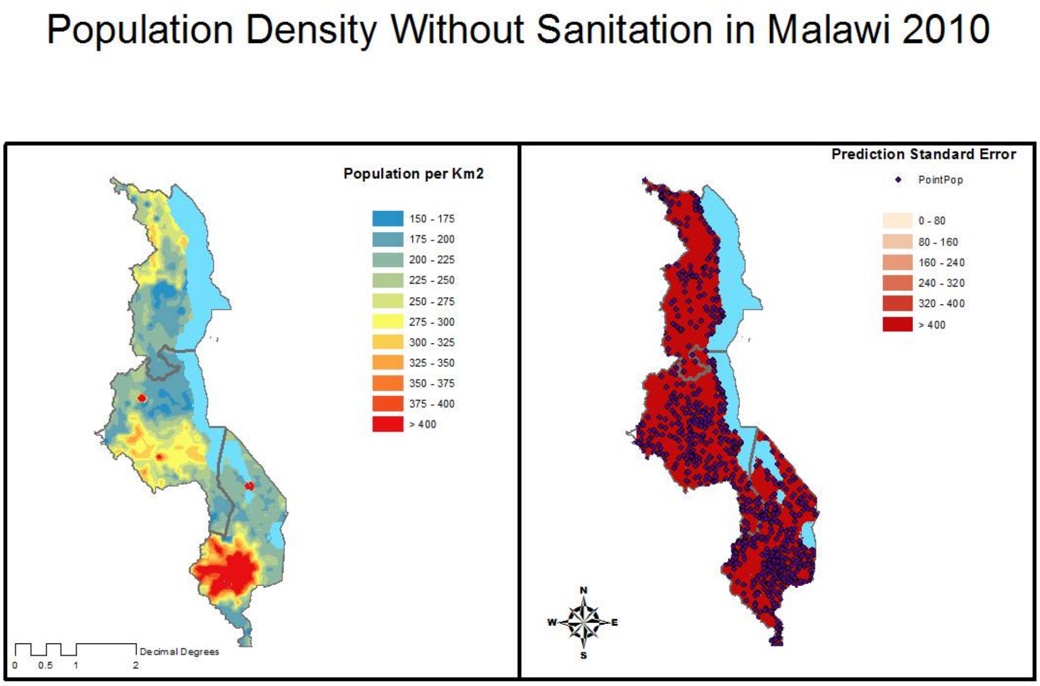


Figure 17 shows the distribution of sanitation risk by wealth quintile (based on the national quintiles). The pattern generally shows increased risk among the poorest. However the maps for the middle and upper quintiles show the increasing risk among urban populations. This is primarily due to the fact that most of the poorest urban households fall within the middle quintiles in the national context. These higher risks for the middle quintiles reflect the high risk of the urban poor.

Figure 17: Spatial distribution of sanitation risk index by wealth quintile in Malawi (2010)

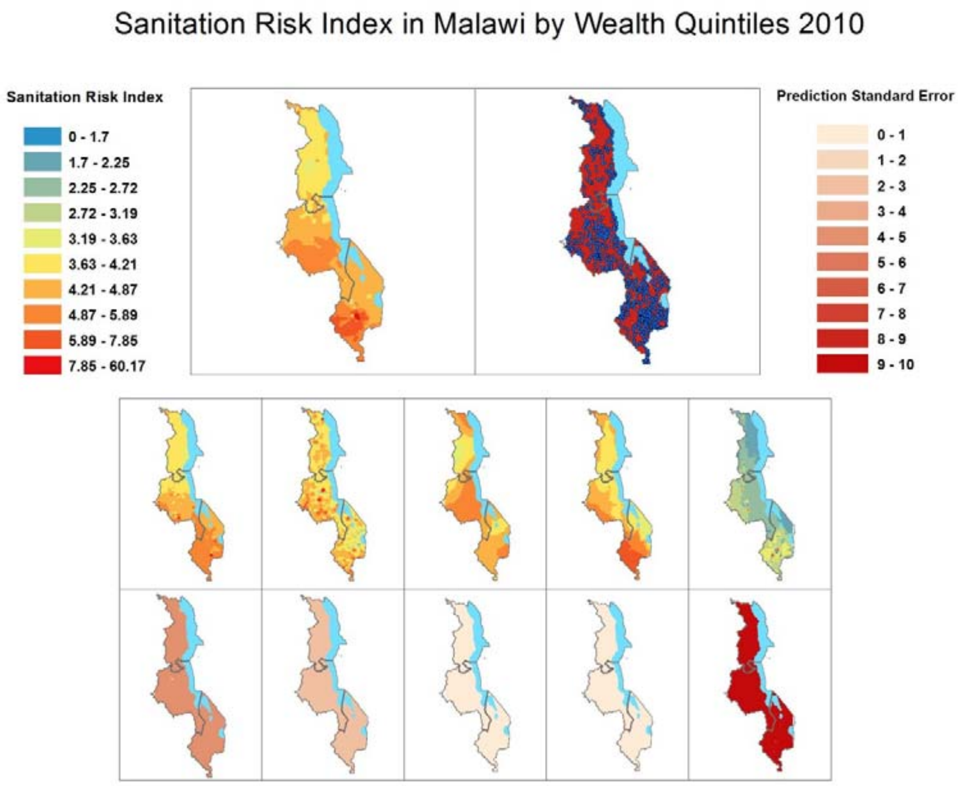


Figure 18 shows the estimated spatial distribution of the susceptibility, exposure and sanitation risk indices in Kenya. The susceptibility and exposure indices show slightly different geographic patterns, with susceptibility being highest primarily in the northern regions where food and water insecurity and poor access to health care result in greater vulnerability. In contrast, exposure is highest in the urban and peri-urban areas in western Kenya (near Kisumu) where population density is high and improved sanitation coverage is variable (Figure 19). These two factors combine to create number of high-risk clusters. As with the case of Malawi, these maps interpolated at a national level are likely to hide a good deal of heterogeneity at a meso-scale, with high and low risk communities in close proximity to each other.

Figure 18: Spatial distribution of sanitation susceptibility, exposure and risk in Kenya (2008)

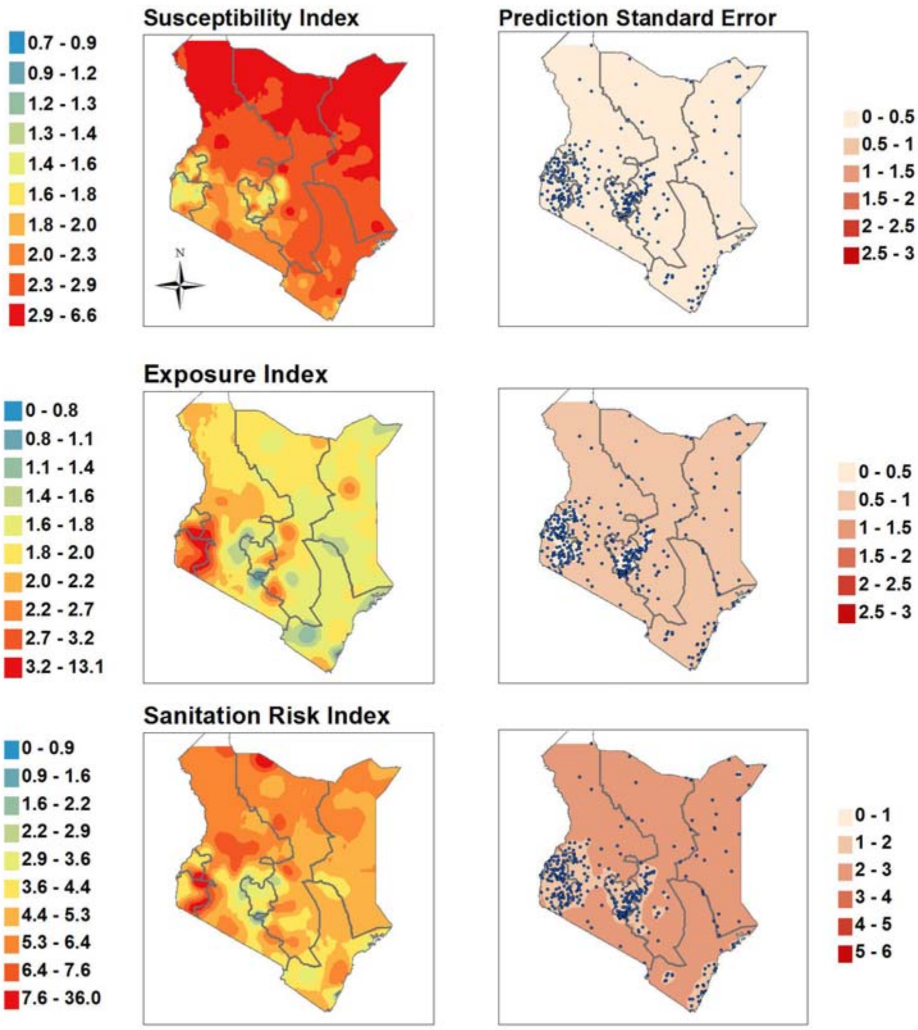


Figure 19: Spatial distribution of population without sanitation in Kenya (2008)

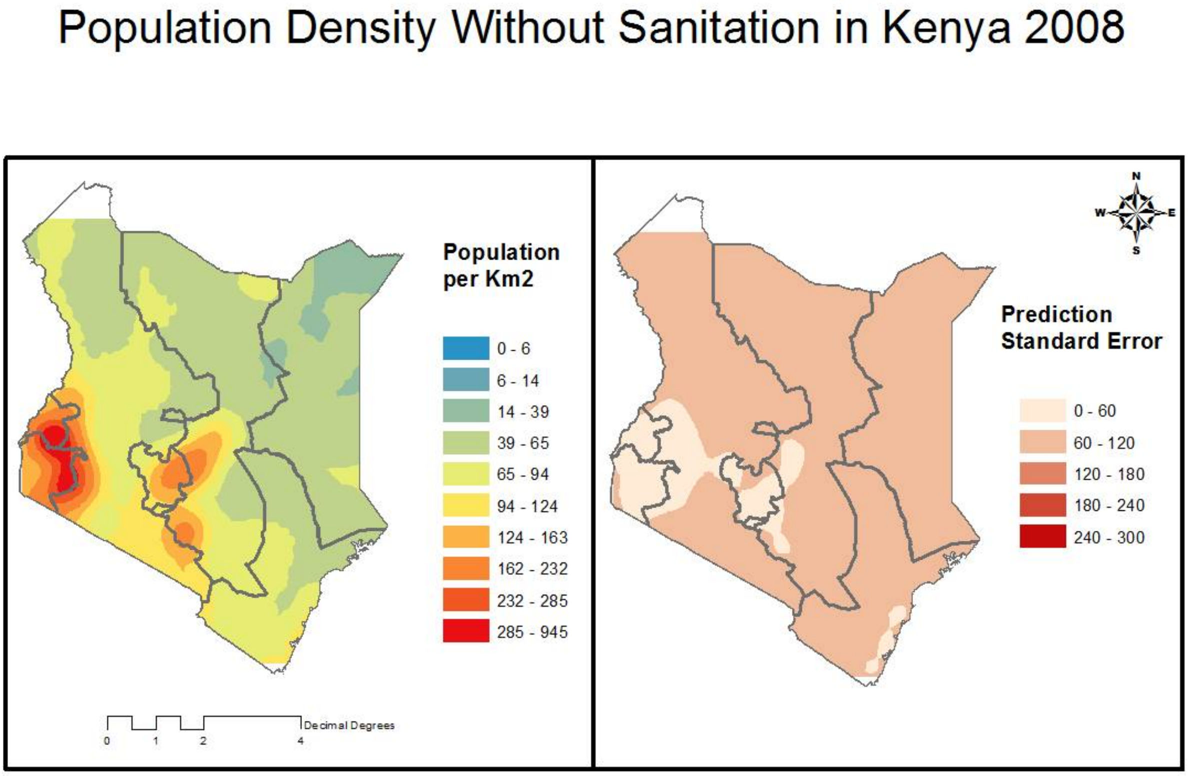
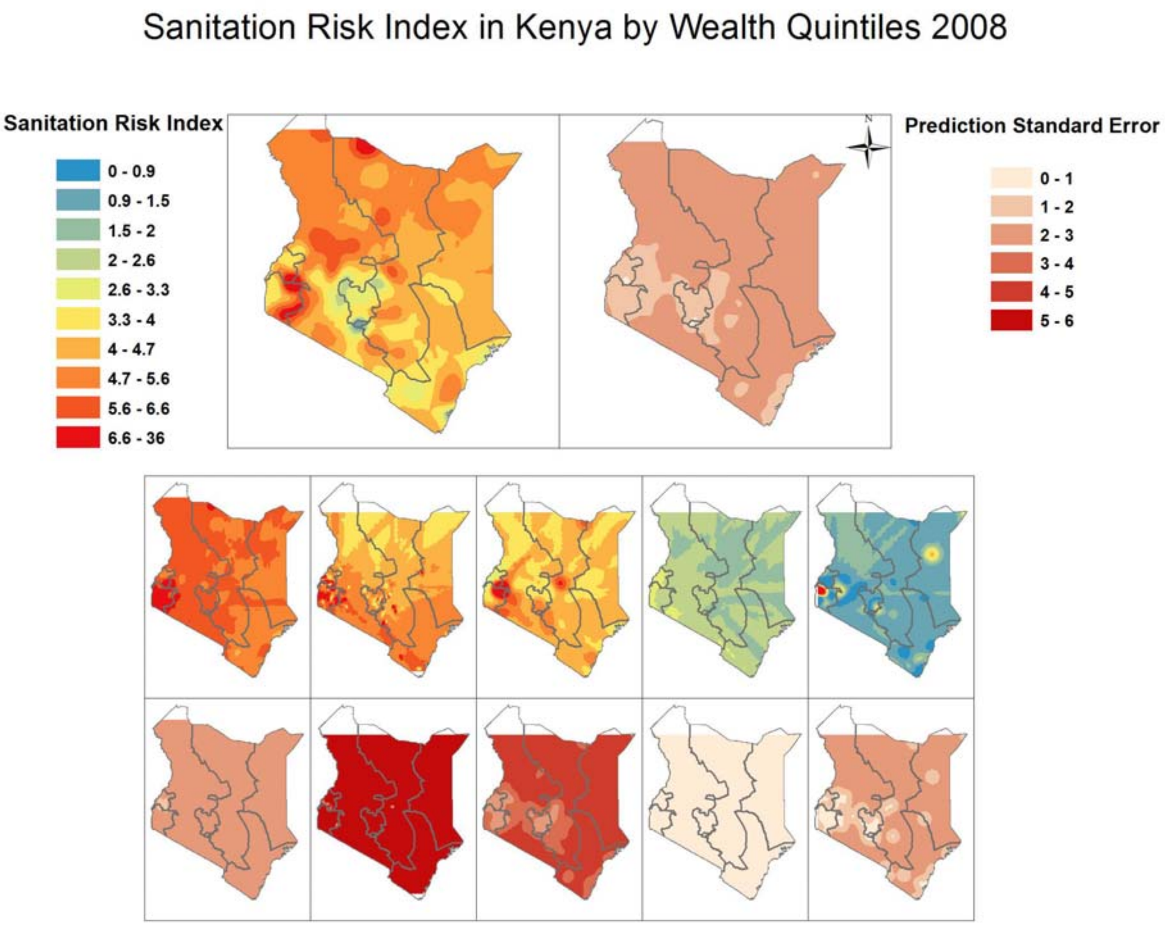


Figure 20 shows the distribution of sanitation risk by wealth quintiles in Kenya. The national map hides the heterogeneity between quintiles over space. Across the country, children in poorer households are exposed to higher sanitation risk. At the same time, areas like western and northern Kenya have higher risks across quintiles due to underlying community and landscape-level variables that affect all quintiles.

Figure 20: Spatial distribution of sanitation risk index by wealth quintile in Kenya (2008)



4. Discussion

4.1 Key findings

The limitations of this analysis are discussed below (see section 4.2) but several key points emerge that are of importance in understanding disparities in the risk and potential impacts associated with sanitation for households – and in particular children – across wealth groups.

1. The poorest children bear the greatest sanitation-associated health burden

The analysis estimated that the sanitation related burden of disease is substantially higher among poor households as compared to more wealthy households. While this finding alone should not be surprising, the model demonstrates how this disparity in burden may be exacerbated by a combination of a number of factors beyond traditional measures of household access. Across the 10 countries children in the poorest households may bear up to 20 times the sanitation-related health burden compared to children in the richest households.

2. A combination of factors place the poorest children at greatest risk of mortality

This disparity is a function of multiple factors relating to household and community exposure as well as multiple susceptibility parameters. The poorest children are more likely to be in households with no sanitation facilities, more likely to be in households that share facilities, and (in most countries) are more likely to be in communities with high densities of people without sanitation. The multiple exposures faced by poor children are compounded by increased susceptibility to fatal diarrhoea as these children are more likely to be under-nourished, and without access to ORT or vitamin A and zinc supplementation.

3. Reaching poor households maximizes the potential returns offered by sanitation

The investment scenarios estimated the impact of improving access to households by wealth quintile and suggest that for the same number of households attaining improved sanitation, the health benefit is two to 10 times greater among the poorest quintile compared to the richest. While it may be impossible to exclusively implement improvements in one wealth quintile at a time, it provides a hypothetical model for assessing the impact of targeted strategies.

The pattern of difference between rich and poor was present in both the urban and rural contexts. However, in most countries the differential was even more marked in urban contexts where children in the poorest households are exposed to poor household sanitation, local environments with high population densities without sanitation, and are often equally likely to be vulnerable to diarrhoeal mortality due to low weight-for-age, compared to their rural counterparts. This has potential implications for the geographic and economic targeting of sanitation investments. While rural populations may generally have lower sanitation coverage than urban ones, the sanitation related health burden for poor urban populations might be similar to, or greater than, their rural counterparts, suggesting that there are greater needs for reaching the urban poor. In addition, the analysis suggests that in urban contexts the impact gradient is much greater and that it is particularly important to ensure that investments reach the poorest households.

It is also important to note that these estimates, based on DHS surveys which often under-sample or do not sample poor urban populations, may substantially under-represent the poorest urban populations in informal settlements, suggesting that the true differentials may be even more pronounced.

4. In both urban and rural settings, the poorest children suffer disproportionately

Across all 10 countries, separate analysis for urban and rural populations showed that children in the poorest households suffer the greatest sanitation-related health burden. While rural populations generally have lower levels of access, the sanitation-associated risk may be greater for the urban poor due to the increased likelihood of these households being in areas with a high density of people without sanitation.

5.Population density without sanitation may be an important factor for sanitation-related disease burden and disparities

Current investments and monitoring focus on household-level access, however community-level sanitation may be a critical determinant of burden. In addition, community-level exposures account for an additional element of the disparities between rich and poor households, as poor households are more likely to be in communities with lower levels of coverage and are more likely to have poor housing and infrastructure making them more vulnerable to community-level contamination.

6. Spatial analysis provides a tool for identifying areas of greatest potential impact

Spatial analysis was only conducted for two countries (Malawi and Kenya). The preliminary estimates for these two countries suggest that, in addition to economic disparities, there are also geographic disparities in sanitation exposure and susceptibility. Exposure patterns are likely to be strongly affected by population density, in particular the increasing density in rural areas and the growth of peri-urban areas. In these settings, access alone may understate the localized exposures and risks. Improved modeling may improve targeting of particular areas and specific approaches depending on whether risk corresponds to increased vulnerability, household exposures or community exposures.

4.2 Limitations of this analysis

From the outset it has been clear that there is inadequate data and knowledge to fully and definitively answer the question posed by this study. Instead it has been our intent to use existing information to address the questions as best as possible and identify how improved information could refine these findings and resulting recommendations. As such, identifying limitations is central to our purpose. Three major categories deserve particular attention: 1) uncertainty in the exposure index, 2) uncertainty relating to susceptibility and 3) the overall burden associated with sanitation.

1. Uncertainty in the exposure and susceptibility index

The current exposure index assumes that three factors (lacking a toilet, lacking a private toilet, and density of people without sanitation) have equal impacts on exposure to sanitation-related enteric pathogens. Current definitions of improved sanitation only focus on the presence of a toilet and whether it is private. Shared facilities are considered unimproved in current JMP definitions. However there is great uncertainty as to whether shared facilities pose an increased risk and whether the level of risk depends on the number of people sharing. Without additional information on the risks associated with shared facilities it is difficult to determine whether the impact on sanitation risk and burden should be greater or less.

Similarly, there is evidence that community-level coverage is a separate exposure factor from household facilities. While it is logical that this effect of community sanitation on exposure would be a function of population density, there is insufficient evidence to define the functional form of this relationship. Better evidence of the effect of public exposures would provide a stronger foundation for estimates of benefits. The current model is also limited in that the measure of public exposure for a given child is based on population density and household coverage, however it does not account for waste treatment or other public exposures. Improved information on exposure patterns from public sources is essential to understanding and estimating the benefit of discrete changes in household level coverage.

The susceptibility index currently includes three elements: weight-for-age, Vitamin A supplementation and probability of receiving rehydration treatment for diarrhoea. While there is an evidence base for the effectiveness of these factors contributing to diarrhoeal mortality, there is incomplete information on two of the risk factors in the DHS surveys. Specifically, information about treatment is only available for some children and was imputed for others. In addition, there is limited information on the timing of vitamin A supplementation, which is likely to influence effectiveness. Both of these are elements are measures of exposure and susceptibility if they were independently and empirically validated.

2. The health impacts of sanitation extend beyond diarrhoea

While the current analysis accounts for a number of mechanisms for disparities in sanitation health burden and impact, it neglects others. In particular, it does not account for derivative effects whereby poor sanitation may reduce the effectiveness of other health interventions. For example, Humphrey *et al*. (2009) suggest that poor sanitation and hygiene may reduce the impact of nutrition interventions. Similarly, Madhi and colleagues (2010) suggest that environmental enteric exposures may reduce the effectiveness of live oral vaccines such as that for rotavirus. In addition, poor sanitation may reduce the effectiveness of preventive chemotherapy for neglected tropical diseases such as schistosomiasis, soil-transmitted helmiths and trachoma (WHO 2008).

5. Implications for national sanitation policy

Within global poverty reduction efforts, and particularly in the context of the Millennium Development Goals (MDGs), there is a growing interest in the issue of equity. It has been argued that progress against the MDGs has been inequitable and, as a result, often ineffective in tackling entrenched poverty (UNICEF 2010; Vandemoortele and Delamonica 2010; Vandemoortele 2010).

Efforts to improve access to sanitation are often characterized as inequitable at a global level (UNDP 2006). It has been shown that the regions or countries most in need are failing to attract sector aid (OECD-DAC 2008; WHO 2010) and access to sanitation is highly inequitable (WHO and UNICEF 2010) with the 2.6 billion people without sanitation largely concentrated in sub-Saharan Africa and South Asia. At the national level, recent work by UNICEF has shown that progress towards the MDG target on improved sanitation is often markedly inequitable, with negligible progress in poorer wealth quintiles in some countries (UNICEF 2010; WHO and UNICEF 2011).

This analysis considered disparities in sanitation related risk to explore how inequities in access may impact children in the poorest households. For the 10 countries assessed, the results suggested that the health burden associated with poor sanitation is distributed highly inequitably with children in the poorest quintile bearing up to 20 times the burden of those in the richest quintile. Building on the work of UNICEF and others that shows that the poorest households are not being reached, this analysis suggests that a failure to reach those households is undermining the potential effectiveness of sanitation investments.

The results of this analysis have significant implications for how sanitation investments might be better planned, targeted and monitored to address these disparities. The following five points emerge for consideration at the policy level:

1. Strategies to reach children in the poorest households are required to both protect these children and households most at risk, and to maximize the impact of sanitation investments more broadly
2. Although the study did not directly consider the relative costs of targeting the poorest households, reaching these households may yield substantially higher health benefits and greater economic returns
3. Better use of available information on the distribution of the sanitation-related health burden and potential benefits could lead to more effective planning and more efficient use of resources at the national level
4. Current monitoring indicators at the national and global levels fail to incentivize the targeting of the areas of greatest need and potential greatest impact
5. Existing limitations in monitoring efforts include a focus on household coverage rather than child coverage; the use of only household access, not community-level exposure measures; no direct targets for focusing improved access on the poorest; and, in some settings, the under counting of the most vulnerable urban population

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Research for sanitation and hygiene solutions

The world is seriously off-track in meeting the Millennium Development Goal on sanitation and 2.6 billion people are still without a toilet.

SHARE aims to address these challenges by accelerating progress on sanitation and hygiene in developing countries by generating rigorous and relevant research, and ensuring new and existing solutions are adopted at scale.

The consortium conducts research across four pillars:

- Health
- Equity
- Urban
- Markets

SHARE has four focus countries:

- Bangladesh
- India
- Malawi
- Tanzania

The DFID-funded SHARE consortium is led by the London School of Hygiene and Tropical Medicine. Its other partners are the International Centre for Diarrhoeal Disease Research, Bangladesh, International Institute for Environment and Development, Shack/Slum Dwellers International and WaterAid.

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