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Hygienic Latrine Use and Child Wasting in Urban Bangladesh

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ABSTRACT

Inadequate sanitation is a persistent threat to child health, particularly in urban slums in developing countries. In this study I evaluate a sanitation improvement initiative in fourteen slum communities in Dinajpur, Bangladesh. I estimate the effects of changing from unhygienic to hygienic latrines on child weight-for-height, an important measure of short-term nutritional status. I also test whether these effects are moderated by care behaviors including adult handwashing and breastfeeding, and by household food security. Fixed-effects methods are used to address selection bias in the placement and adoption of improved latrines. Results suggest that the prevalence of improved latrines at the community level is a stronger predictor of child weight-for-height than household-specific latrine use, net of changes in household food security and hygiene behaviors. These results can inform the targeting and implementation strategies of slum upgradation projects in similar settings.

Inadequate sanitation remains a leading cause of diarrheal disease and mortality among children in developing countries, particularly in urban slums. As the urban slum population grows rapidly in the coming decades, the sanitation crisis will continue to threaten the health and wellbeing of vulnerable children. Well-designed and effective sanitation improvement projects are urgently needed. In this paper I examine the effect of latrine improvements on child health in an urban slum in Dinajpur, Bangladesh, using data from a panel survey of households conducted as part of a community development initiative. The main components of the program were infrastructure improvements, including drains and water sources; health, hygiene and nutrition education; income-generating activities; and community mobilization. Households sampled for the survey were interviewed prior to program interventions in 2002, and re-interviewed in 2003. In the interval, many households switched from using unhygienic latrines to using improved latrines, including newly-installed community toilets.

The analysis is guided by the framework for the determinants of child nutritional status developed by UNICEF and adapted by Smith and Haddad (2000). This framework identifies dietary intake and disease status as the two most immediate determinants of child nutritional status, with household food security, care-related behaviors, and health services and a healthy environment as underlying determinants. In this paper I focus on a specific aspect of children's environment, access to good sanitation, and its role in reducing diarrheal disease and thereby improving nutritional status. I assess children's weight-for-height as the key dependent variable. Weight-for-height captures short-term changes in nutritional status and could be immediately affected by an improvement in disease status brought about by a change in latrine use.

The paper is motivated by several gaps in the literature on sanitation and child health. Most evaluation studies of sanitation projects focus either on behavior changes, for example encouraging handwashing or proper disposal of child feces, or on a household's access to sanitation either within the home or in a nearby facility. These studies assume that improvements in child health result from reducing fecal-oral transmission of diarrhea-causing pathogens due to the child's own toileting or that of adults in the child's household. In contrast, few studies examine the effect of aggregate changes in sanitation infrastructure at the community level on child health. Community-wide improvements in sanitation can reduce children's exposure to fecal pathogens in the surrounding neighborhood, for example in alleys or drainage ditches. In this paper I compare the effects of improved latrine usage within the household to increases in the level of improved latrine usage in households in the surrounding neighborhood.

To date, most evaluation studies of sanitation projects focus on rural populations, even though urban slum populations are at comparable risk of disease from inadequate sanitation. Methodological problems are also common in evaluation studies that either use cross-sectional data or clinic-based case-control designs that can introduce selection bias. Lack of an appropriate comparison group is a persistent problem, as is the difficulty in distinguishing the effects of hygiene education from the effects of sanitation infrastructure improvements (Curtis & Cairncross, 2003; Curtis, Cairncross, & Yonli, 2000; Zwane & Kremer, 2007) .

SANITATION, DIARRHEA, AND CHILDREN'S HEALTH

This study is primarily concerned with the effect of improved sanitation on child nutritional status. The nutritional status of children is a key measure of human capital development, and the consequences of poor nutritional status for young children are dire.

Nutrition in early life largely determines the proportion of genetic growth potential that will be achieved by age three (Martorell, 1995, 1999; Martorell & Ho, 1984). Stature achieved by age three is in turn associated with important human capital outcomes, including physical and mental development, school performance, and labor productivity (Alderman, Hoddinott, & Kinsey, 2006; Behrman, 1996; Grantham-McGregor, Fernald, & Sethurman, 1999; Grantham-McGregor, Walker, Chang, & Powell, 1997).

The anthropometric measure studied here is weight-for-height, standardized for age and sex based on a well-nourished reference population (Kuczmarski, Ogden, & Guo, 2002) . Weight-for-height can be expressed as a z-score, indicating the number of standard deviations away from the median of the reference population. A child with a weight-for-height z-score of less than -2.0 is defined as wasted. Unlike height-for-age, which captures long-term and accumulated effects of dietary intake and disease status, weight-for-height instead captures more recent, short-term nutritional or disease insults. Wasting can be caused by a severe bout of illness, (particularly diarrheal disease), a short-term reduction in food intake, or a combination of both (e.g., when a caregiver restricts a child's food intake during illness).

The nutritional status of children is determined by a complex set of immediate and underlying factors. Figure 1 shows a simplified schematic based on work by Smith and Haddad (2000) adapted in turn from a UNICEF model of child survival (UNICEF, 1990). Most immediately, child nutritional status is determined by dietary intake and by disease status. There is a well-documented interaction between dietary intake and disease, in which infection, particularly chronic and acute gastrointestinal and respiratory infections, can precipitate malnutrition; poor nutritional status can simultaneously leave individuals more susceptible to infection and complications of other diseases. This interaction, known as the malnutrition-infection complex, is considered the leading underlying cause of mortality, morbidity and impaired development for children in the developing world (Chen & Scrimshaw, 1983; Rice, Sacco, Hyder, & Black, 2000; Scrimshaw, Taylor, & Gordon, 1968).

At the level of the household, there are three main underlying determinants of nutritional status that operate through dietary intake and disease. As shown in Figure 4.1, the household's level of food security will determine the amount, type, and regularity of food available to individuals. A wide range of care behaviors influences both disease status and dietary intake for children, including food preparation and feeding practices (including breastfeeding), hygiene, health-seeking behaviors, and intra-household allocation of food and other resources. A healthy environment, including the absence or presence of clean water, sanitation facilities, indoor and outdoor air pollution, and safety hazards will affect disease exposure. The presence and quality of health services is also considered part of the health environment.

In this study I focus specifically on how improved sanitation affects child nutritional status, operating presumably through diarrheal and other infectious disease exposure. Diarrhea is a common and pernicious health problem for children in developing countries. Acute diarrheal causes life-threatening dehydration, while chronic diarrhea can compromise growth and development by preventing the absorption of nutrients and can also increase susceptibility to future illness. The Global Burden of Disease Study indicates that 13 percent of the disease burden (as measured by DALYs) and 15 percent of all deaths in children under five in low- and middle-income countries is directly attributable to diarrheal diseases (Lopez, Mathers, Ezzati, Jamison, & Murray, 2006). Diarrhea is caused primarily by infectious pathogens (including viruses, bacteria, protozoa, and parasites) that are excreted in the feces of infected humans. This infected fecal matter can then be transported to the digestive tract of other uninfected humans via the hands, water, food, or insects (Curtis et al., 2000). The Global Burden of Disease Study attributes 88 percent of the diarrheal disease mortality and disease burden in children under 5 to unsafe sanitation, water and hygiene (Lopez et al., 2006). Unsafe water, hygiene and sanitation also account for around 13 percent of the overall mortality and all DALYs for this age group. In lower and middle income countries in 2001, approximately 1.4 million deaths in children under five were attributable to this risk factor; 554,000 of these were in South Asia.

The framework for determinants of child health suggests at least two important routes for transmission of diarrhea-related pathogens to young children: the behaviors of the child and caregivers, and the health environment. Child care practices and hygiene behaviors can either facilitate or interrupt fecal-oral transmission routes. Several specific hygiene behaviors are hypothesized to be relevant for diarrheal disease risk. There is some evidence that cleaning the anus with water is less hygienic than using toilet paper (Aung Myo, Khin Nwe, Tin, & Thein, 1986). Washing hands after defecation with soap, dirt, or ash produces less contamination than washing with water only, although rinsing with contaminated water can recontaminate hands (Hoque, 2003). A comprehensive review of handwashing interventions suggests a reduction in diarrhea risk of 42-47 percent associated with washing hands with soap, although the reviewers express concerns that poor methodology and publication bias may skew this estimate upwards (Curtis & Cairncross, 2003).

While hygiene behaviors are important for diarrheal pathogen transmission, the availability of sanitation infrastructure is also critical. Adequate sanitation prevents fecal matter from contaminating water supplies and the surroundings in which people live, work, play, and travel each day. Several studies demonstrate a strong association between improved latrines and reductions in diarrheal disease (Meddings, Ronald, Marion, Pinera, & Oppliger, 2004; Moraes, Cancio, Cairncross, & Huttly, 2003; von Schirnding, Yach, Blignault, & Mathews, 1991; Young & Briscoe, 1988). In their extensive review of diarrheal disease intervention, Zwane and Kremer (2007) note several problems with this literature, however. First, these studies rarely disentangle the effects of sanitation improvements from water supply improvements. Second, the studies suffer from persistent methodological problems stemming from cross-sectional analysis and the lack of proper comparison group. Sanitation improvements are often assessed in case-control studies comparing children who present at hospitals or clinics, introducing several potential sources of bias (Daniels, Cousens, Makoae, & Feachem, 1990; Ekanem, Akitoye, & Adedeji, 1991).

Another set of evaluation studies attempts to prioritize behavioral or infrastructure interventions over the other, or looks for substitutive or complementary effects (Ekanem et al., 1991; Gilman et al., 1993; Mertens, Jaffar, Fernando, Cousens, & Feachem, 1992; Ram et al., 2006; Tumwine et al., 2002). Results from these studies are very mixed, suggesting the importance of distinguishing between primary and secondary prevention. Primary prevention strategies for fecal-oral transmission of diarrheal pathogens focus on limiting the fecal contamination of hands, water supply, and agricultural land, e.g. through proper disposal of excreta and handwashing after defecation. Secondary prevention efforts focus on limiting the spread of pathogens already in the environment through handwashing before meal preparation and proper water treatment and food storage (Curtis et al., 2000). Interventions designed to prevent one route of transmission may fail if contamination is still occurring through the other route.

THE URBAN SLUM SETTING

The growth of urban slums has been one of the defining characteristics of the past decades in the developing world. Approximately one billion people live in urban slums, and the slum population is growing by 2.2 percent per year (UN-HABITAT, 2006). Urban slums are characterized by crowding, high density, extreme poverty, lack of land or property tenure, lack of services and infrastructure, and a predominantly informal economy. Because many slum dwellers are recent migrants from rural areas, many of them live without the social networks and kinship ties that can provide emotional, physical and financial support in times of crisis. Sanitation in urban slums is a particular problem. More than one-quarter of the urban population worldwide has inadequate sanitation; the number is much higher for slum dwellers. Inadequate sanitation compels slum residents to use hanging latrines, unhygienic pit latrines, or nearby open spaces, creating significant disease hazards.

The nutritional status of children in urban slums is often worse that that of rural poor children or better-off urban children. While poor children in rural areas, particularly in South Asia, show very high rates of stunting, wasting is usually less severe. However, wasting rates in urban slums are very high, even in the presence of high rates of stunting (BNSP, 2002). While stunting and wasting rates have declined in rural Bangladesh, the prevalence of wasting among urban poor children in three Bangladesh cities has not declined as much as the prevalence of stunting. Seasonal fluctuations in wasting are strong, with the prevalence of wasting highest from the onset of dry season in March up to the beginning of the main harvest in October (Bloem, Moench-Pfanner, Graciano, Stalkamp, & de Pee, 2004).

Diarrheal disease is very common among slum-dwelling children in South Asia, with two-week prevalence estimates ranging from 14 percent for children under five in Karachi, Pakistan (D'Souza, 1997) to 28 percent for infants under one year in Dhaka (M. M. Rahman & Shahidullah, 2001). Because of the established link from sanitation to diarrhea to health, there have been many slum upgradation and sanitation initiatives. A qualitative study of a microfinance program for slum upgradation in India showed a 90 percent reduction in serious disease, an increase in bodyweight for women, and increase in income due to more available time for income generation. (UNDP-World Bank South Asia Water and Sanitation Program 1999a). A similar initiative demonstrated that individual slum residents were willing to build their own toilets once sewer lines were built under streets (UNDP-World Bank South Asia Water and Sanitation Program 1999b).

Slum Development in Dinajpur

Dinajpur is a city of 250,000 residents located in the northwest of Bangladesh, about 400 kilometers from the capital of Dhaka and near the border of West Bengal, India. In 2002 the city's annual growth rate was estimated at six percent. In 2002, CARE –Bangladesh partnered with the International Food Policy Research Institute to implement the SHAHAR community development program. This program was designed to strengthen the food and livelihood security of high-risk urban slum populations in Bangladesh. The main components of the program were sanitation infrastructure; health, hygiene and nutrition education; income-generating activities; and community mobilization. The program was implemented in Dinajpur after successful implementation in Jessore and Tongi, two other cities in northwestern Bangladesh (Das Gupta, 2003). Specific activities since 2002 have included filling ditches, installing hygienic latrines, and developing local Community Resources Management Committees ("Planned habitat changes lifestyle of slum dwellers," 2004).

The goals of the SHAHAR projects and the hypothesized effects of sanitation improvement on child health prompt several specific research questions. First, do improved latrines affect child nutritional status as measured by wasting? I explore this question by testing both changes in hygiene behaviors related to latrine usage as well as overall infrastructure improvements in the surrounding community. The second research question investigates diarrheal disease reduction as the mechanism through which improved latrines influence nutritional status. Finally, I ask whether hygiene behaviors and sanitation infrastructure are substitutes or complements. In other words, do improved latrines only make a difference if hygiene behaviors change?

METHODS

Data

The data for this study come from the SHAHAR Dinajpur Survey fielded by CARE-Bangladesh in collaboration with the International Food Policy Research Institute. The survey was part of CARE-Bangladesh's SHAHAR (Supporting Household Activities for Health, Assets and Revenue) project. The survey was a monitoring and evaluation tool designed to provide baseline data on project communities and participants. Dinajpur was one of four cities included in the SHAHAR intervention, and was the only site with a panel component to the survey.

The sampling frame included all 59 *bastis*[1] in Dinajpur, as identified by CARE-Bangladesh staff in 2001 prior to the program intervention. *Bastis* were assigned a vulnerability score based on observed levels of poverty, social cohesion, community size, and environmental hazards. Fourteen *bastis*, representing 60 percent of the slum population in Dinajpur, were

[1] Basti (sometime spelled "bustee") is the Bangla term for a slum area or squatter settlement within a larger city.

chosen for program intervention based on high vulnerability scores. From a complete census of these fourteen *bastis*, a random sample of 614 households was selected for interviewing. The sample size was chosen to permit statistically significant analysis of child stunting. Because *basti*s were selected for high vulnerability scores, the sample is representative of the poorest slum communities in the city.

From the selected sample of 614 households, enumerators successfully contacted and interviewed 583 households (95 percent) for the baseline survey in August 2002. In twenty-eight of the sampled households, no respondent was found or the household was reported to have migrated (either seasonally or permanently) since the census. Three households had incomplete interviews due to refusal of male or female respondents. A second round was fielded in March 2003, and 567 households were successfully interviewed (92 percent of the original sample, 97 percent of the 2002 interviews). The final survey round took place in August 2003, with 554 households (90 percent of the original sample, 95 percent of the 2002 interviews) successfully interviewed.

The household questionnaire includes income, expenditures, assets, positive and negative shocks, coping strategies, social networks and other social capital measures, and anthropometry for women and children under five. The community questionnaire (completed for each individual *basti*) includes prices, infrastructure, services, violence, community participation, and common positive and negative shocks.

The analysis focuses on the nutritional status of young children ages 6-36 months old at the time of the first survey in August 2003. I exclude children ages 0-5 months who are primarily breastfed and less mobile, and therefore less likely to contract diarrhea from fecal-oral transmission. The sample includes 178 individual children, 144 of whom have complete data for both survey rounds. An additional 29 children contribute data for one round only, and five children without complete anthropometry, disease prevalence, or maternal or household data are omitted from the analysis. The analytic sample therefore includes 317 observations, with 170 in 2002 and 167 in 2003.

Attrition analysis suggests that dropping out of the sample by the second survey round may be associated with the health status of the child in 2002. Child's height-for-age z-score in 2002 significantly increases the probability of being included in the 2003 sample at the 10 percent significance level. Inclusion in the sample in the second survey round (2003) is not significantly associated with 2002 weight-for-height, use of an improved latrine, gender, breastfeeding status, or mother's BMI. There are no significant differences by *basti* community in the probability of attrition from the sample by 2003, with the fourteen *basti*s reporting attrition rates of 0-25 percent.

Measures of Child Nutritional Status and Latrine Usage

This analysis focuses on two child health outcomes hypothesized to be sensitive to changes in hygienic toilet use: weight-for-height z-score and diarrheal disease prevalence. I focus on weight-for-height as the focal dependent variable because it captures short-term changes in nutritional status and can be immediately affected by an improvement in disease status brought about by a change in latrine use. Children in urban slums in Bangladesh have very high rates of wasting, often higher than rates for rural children (BNSP, 2002). The weight-for-height variable in the analysis is calculated using the weight and height (or length, for children under 24 months old) measured by enumerators during the survey. The weight-for-height measures are then translated into z-scores using the "zanthro" command in Stata (Version 8.2). I use the CDC 2000

Growth Charts as my reference population[2]. Diarrheal prevalence is a dichotomous variable indicating whether the female head of household reported that the child suffered from diarrhea in the past 15 days.

The analysis focuses on an evaluation of the installation of improved latrines in the *basti* communities as part of the SHAHAR project. My focal independent variable therefore is the use of improved latrines. In the 2002 survey round, the female head of household was given four possible choices to report the household's latrine usage: open space or field, a hanging or "katcha" latrine, a pit latrine (unsealed), or a water-sealed latrine. By 2003, two additional choices were available based on the construction of new latrines by the SHAHAR project: community toilets, and unsealed but hygienic latrines.[3] Based on discussions with the IFPRI staff and other sources on latrine improvements in South Asia (Ahmed, 2005; WHO/UNICEF, 2004), I categorize each latrine type into "improved" (water-sealed, unsealed but hygienic, and community) or "unimproved" (unsealed/unhygienic, hanging or katcha latrine, and open space or field.).

Appendix Tables A1-A8 show the distribution of latrine usage by *basti* community for all households included in the SHAHAR survey. Tables A1 and A2 show the 2002 distribution; Tables A3 and A4 show the 2003 distribution; and Tables A5 and A6 show the changes from 2002 to 2003. Figure A1 summarizes the overall change in proportion of households using improved latrines in 2002 and 2003. Use of improved latrines increased substantially, from 35

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[2] As of 2006, the new WHO reference population for breastfed children is available. To facilitate comparisons with other analyses of this dataset and of child health measures more broadly, I use the CDC 2000 reference population here.

[3] A hanging or "katcha" latrine is usually two boards placed over a sewer, a drainage ditch, or open water. Privacy is provided by flimsy bamboo screens. An unsealed pit latrine consists of a slab placed over a pit. Water-sealed latrines, also called "pour-flush" are flushed with a bucket of water after each use, and have a u-shaped drain pipe that creates a water seal to prevent odors and flies from coming up from the pit. Community toilets consist of several water-sealed latrines built in "blocks," often with separate facilities for men and women.

percent in 2002 to 60 percent in 2003. There is considerable heterogeneity by neighborhood, however, with percentage point increases ranging from 13 to 57. For the most part, large increases in improved latrine use can be attributed to the installation of community toilets. This effect is most notable in the Sweeper Colony and Dhibi Para. In Dhibi Para, the new toilets replaced the use of open space for defecation. In the Sweeper Colony, households shifted away from both unsealed latrines and the use of open space.

In order to pinpoint the causal link from latrine use to child health, I construct several measures of improved latrine use. The first measure is the female head of household's report of the type of latrine used by the household. I next calculate a community-level measure of the proportion of households using improved latrines. This community mean is assigned to all sampled households in the *basti*. To address my research question related to the particular importance of hygienic latrine use by children, I then calculate two separate measures of latrine use at the community level: for households with one or more children under five years old, and for households with no children under five, I calculate the proportion using an improved latrine. For example, in 2002, Uttar Gosaipur had 49 households in the sample, including 29 households with at least one child under five, and 20 households with no children under five. Nine of the 49 households, or 18 percent, reported using an improved latrine in 2002. Of the 27 households with children under five, only two used an improved latrine, or seven percent. Among the households without young children, seven of the 20 (32 percent) used an improved latrine. These three measures are calculated and assigned to households by *basti* for both 2002 and 2003. Values for the three community measures of latrine use by *basti* and by year are reported in Table A7 and A8.

The analysis also controls for three other variables identified in the Smith and Haddad framework as determining children's short-term nutritional status: the food security status of the household, the mother's handwashing behavior, and whether the child is breastfed. Several questions about household food security were asked of female heads of household, including quality and quantity of meals and specific foods consumed. Separate questions were posed about the need for adult men, adult women, and children to skip meals in the past seven days "due to hardship at home." While skipping meals is very rare for adult men and children, approximately 26 percent of female respondents in the 2002 survey reported that adult females skipped meals in the past seven days; this number declined to 12 percent by 2003. I therefore use a negative response to the meal skipping question for adult women as an indicator of household food security. Regression analysis (not shown) confirms that that the level of household per capita expenditures on food items is a significant predictor of this food security measure. Food security is also associated with a significant increase in mother's BMI.

I also include two dichotomous child-care variables that may affect child weight-for-height based on the determinants of child nutritional status described above: the handwashing behavior of the female head of household, and whether the child is breastfed. The handwashing variable is dichotomized from a list of handwashing behaviors including the use of soap, ash, dirt, water only, and other. Following other studies of child care practices using this dataset, I code use of soap or ash 1 and all other choices 0 (Ahmed, 2005; Garrett & Naher, 2004).

The breastfeeding variable is taken from the anthropometry module and is reported for each child. Inclusion of breastfeeding as a child care behavior (rather than as dietary intake) warrants explanation. While breastfeeding does provide nutrients and protect against illness, these effects are greatest for children under six months (who are not included in this analysis).

Therefore, I include breastfeeding as a child care choice made by a mother. This choice will of course be influenced by the mother's preferences, constraints, and observed and unobserved characteristics of the child including the child's health status or gender. I discuss the analytic approach to this problem below.

One variable that I do not use in the analysis is the household's usual source of water for drinking, cooking, and washing. One hundred percent of the households in the SHAHAR sample reported using tubewell water, a safe source in this setting. This universal access to safe water allows the analysis to focus specifically on sanitation as a determinant of child health in the *basti* setting.

Analytic Approach

The goal of this study is to evaluate the effects of a change from unimproved to improved latrines on child weight-for-height. This raises several methodological challenges. First, both community and household-level selection biases are likely to be present. While all the communities in the SHAHAR survey were targeted for interventions, detailed data about the decision rules for placement of new community latrines and household latrines are not available. If communities that received new latrines were worse off than communities that did not receive latrines, then the children in those communities may already have had worse nutritional status than children in better-off communities. This placement rule would underestimate the effect of latrines on nutritional status. Conversely, if communities received new latrines as result of bargaining power, social capital, or community efficacy, these communities might also be able to command resources in support of child health, biasing effects of the new latrines upward. At the level of the household, families that chose to use new latrines when available might also be the same households that were motivated to protect children's health; or, households most concerned about child health because of limited resources (e.g., food, a healthy environment) might be the most motivated to use new latrines.

To control for both nonrandom program placement of latrines in communities and selection bias in the use of available latrines, I employ an individual fixed-effects (or first-differenced) model to test the effects of new latrines on child nutritional status. This technique compares a child's weight-for-height and latrine use at two points in time. Formally, the equation for this model is:

$$WHZ_{it} = \alpha + \beta 1 LAT_{it} + \beta 2 X_{it} + \gamma Z_i + \delta TIME_t + \varepsilon_i + \mu_{it}, TIME = 0,1$$

The outcome of interest is child weight-for-height, standardized to a z-score (WHZ), measured for child *i* in time *t*. LAT captures the household's experience of latrine usage in one of the four measures described above. X is a vector of time-varying observed characteristics of the households that I expect to affect weight-for-height, including food security, handwashing, and breastfeeding. Z is a vector of time-invariant observed characteristics of the child and household (note no time subscript) including gender, household occupation, and parental education. Parameters to be estimated include α, $\beta 1$ $\beta 2$, γ, and δ. TIME is a dummy variable that equals zero when t=0 and one when t=1. Therefore, δ estimates the secular change in WHZ from period 0 to period 1. The error terms ε_i and μ_{it} capture time-invariant and time-varying error (including unobserved heterogeneity), respectively. To estimate the equation with the panel data, I subtract the equation for time t=1 from the equation for time t= 0 and rearrange terms, leaving:

$$\Delta WHZ_{it} = \Delta \beta 1 LAT_i + \Delta \beta 2 X_i + \delta TIME + \mu_i$$

Fixed-effects formulations are useful in program evaluations because they can control not only for selection bias into programs but also for nonrandom program placement at the community level (Frankenberg & Thomas, 2001; Gertler & Molyneaux, 1994). The fixed effects approach is computationally equivalent to adding a dummy variable for each child in the analysis, and guarantees that any observed or unobserved characteristics of children, households or communities that may have determined the placement and use of latrines and that did not change from 2002 to 2003 will not bias the estimates of the coefficients of the covariates (Wooldridge, 2003).

Using this fixed-effects approach, I estimate a series of models of the change in child weight-for-height from 2002-2003. I first test the four measures of latrine usage described above: the household's use of an improved latrine, the proportion of households in the community using improved latrines, and the proportion of households using improved latrines among households with and without children under five. To address other determinants of child weight-for-height that may have also changed as a result of the SHAHAR program, I include the household food security variable (whether adult women reduce the size and number of meals), and the two care variables (mother's handwashing practice and breastfeeding).

In addition to estimating the effect of latrine usage on weight-for-height, I am also interested in whether this effect operates through diarrheal disease prevalence. To evaluate this, I first add diarrheal prevalence for the child (any diarrheal episode in the past 15 days) to the model predicting change in weight-for-height. I also estimate a separate logistic regression model for diarrheal episode in the past 15 days as a function of latrine usage, controlling for food security, child care, and survey round.

The second research question in this study concerns the interaction of behavioral and environmental variables in determining child nutritional status. As discussed above, I hypothesize that the effect of latrine usage on child health may depend on household and individual characteristics. I test three interactions here: the interaction of handwashing and latrine usage, breastfeeding and latrine usage, and food security and latrine usage Finally, previous research suggests that effects of latrine usage may differ by gender of the child. I test this hypothesis with interactions of gender and latrine usage.

RESULTS

Descriptive statistics by year of survey for the full sample of 317 observations are presented in Table 1. Note that the sample ages twelve months from 2002 to 2003. Several variables reflect this aging process in predictable ways: mean weight-for-height declines slightly from -1.44 to -1.57, and height-for-age deteriorates as well. As would be expected for this age group, breastfeeding and diarrheal disease prevalence also decline. The most notable change at the household level across survey rounds is the steep increase in the use of improved latrines (from 32 to 59 percent). Hygienic handwashing and household food security also increase.

Effects of improved latrines on child health

I first test for an effect of changes in latrine usage on child weight-for-height. Results from fixed-effects models are shown in Table 2. The first column shows coefficients for a model testing the change from unimproved to improved latrine use at the household level. This measure of latrine usage has no significant effect on the change in child weight-for-height. A change in food security status (from insecure to secure) increases weight-for-height by .341 standard deviations. A change in handwashing practices also increases weight-for-height by .250 standard deviations, but this is not a significant result. Breastfeeding, although not significant, is associated with a reduction in weight-for-height[4] . The large, negative and significant coefficient on the survey round term shows the expected decline in weight-for-height over time in this young population.

In the second column, the measure of latrine usage is the proportion of all sampled households in the child's community (*basti*) that use improved latrines. Here a change from no households using improved latrines to all households using improved latrines increases weight-for-height by 2.105 standard deviations, a large and highly significant effect. A twenty-five percent increase, typical for communities in this survey, would increase weight-for-height by .526 standard deviations, still considerably larger than the weight-for-height increase associated with the household becoming food secure or a change in mother's handwashing behavior. This model also shows a much steeper secular decline of .762 standard deviations in weight-for-height.

In the third column I focus specifically on the effect of improved latrine usage in households in the community with children under five on individual children's weight-for-height. Just over half of all surveyed households in both years have at least one child under five years old. The effect remains strong and significant, and of comparable magnitude to the coefficient on the overall proportion of household: a change from no latrine usage among households with small children to latrines with 100 percent usage in that group is associated with a 1.749 standard deviation increase in weight-for-height. Again, using the 25 percent increase typical of communities in the sample, the associated weight-for-height increase would be .437 standard deviations, larger than the increase associated with food security or with changes in handwashing. The secular decline in this model is similar to the previous model.

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[4] Very few children in this sample change from not breastfeeding to breastfeeding, so this variable may be better interpreted as an increase in weight-for-age z-score that associated with the cessation of breastfeeding.

Is there a similarly identifiable effect of changes in latrine use among households with no young children? In the fourth column I replace the variable capturing latrine usage among households with young children with the variable representing latrine usage among the households with no young children. There is no significant relationship. Although the correlation between these two variables is large enough (.687) to warrant collinearity concerns, in column 5 I put both variables in the analysis and test the equivalence in the coefficients, which is rejected. Clearly the effect of latrine usage in households with young children dominates any effects of latrine usage in households with no young children.

The mediating role of diarrheal disease

These models suggest that the overall usage of improved latrines in the surrounding neighborhood has a strong effect on child health, particularly when households with small children make the change to improved latrines. However, the mechanism through which the community's level of latrine usage affects child weight-for-height is not obvious. In theory, the expected mechanism is through a reduction in diarrheal disease prevalence in the children, through reduced exposure to pathogens in fecal matter. To test this empirically, I add the measure of diarrheal disease (child had episode in last 15 days) to the Model 3 from Table 2. Results from this test are shown in Table 3. The measure is not significant and does not attenuate the effect of latrine usage on child weight-for-height.

For a more direct test of the association between latrine usage on diarrhea, I also model the odds of having a diarrheal disease episode in the past fifteen days as a function of latrine usage among households in the community with children under five. A fixed-effects specification is difficult here because the model would be estimated on only 48 observations for

24 children: 18 children who report diarrhea in 2002 but not in 2003, and six who report the opposite. Instead, I use logistic regression on the pooled sample of 317 observations, controlling for breastfeeding, handwashing, household food security, age, gender, survey round and the interaction between survey round and latrine usage. I also adjust standard errors for clustering at the community level. Results (shown in Table 4) suggest that increasing improved latrine usage from 0 to 100 percent of households with young children is associated with a reduction in the odds of diarrhea of 97.5 percent, a highly significant finding at least in this pooled cross-sectional analysis. This provides at least weak evidence for the hypothesis that changes in latrine usage improve children's nutritional status by reducing diarrheal disease incidence. The interaction of latrine use and survey round is not significant, suggesting that the association of latrine usage with child health is not due to some other aspect of the SHAHAR program intervention.

Behavior-environment synergies

Studies of improved sanitation find that behavioral change and sanitation improvements may have either substitutive or synergistic effects. I test for these effects with interactions between household or child characteristics and latrine usage at the community level. First, I test whether the large effects of community-level latrine usage on child weight-for-height depend on the latrine usage and toileting behaviors of the child's own household. It may be that changes in neighborhood levels of latrine usage are most beneficial for a child whose own household does not use an improved latrine or whose mother does not wash hands with soap (substitutive effects). Conversely, the gains in health associated with changes in community latrine usage may be greatest for children in households where adults use improved latrines or wash hands with soap (synergistic effects). If the effects of own household latrine usage and adult handwashing are independent of the neighborhood effects, then this suggests two different modes of fecal-oral transmission. The latrine usage and handwashing in the child's household will affect fecal-oral transmission during the toileting of the child or the child's household members. Community levels of latrine usage will affect the amount of fecal material to which the child is exposed in ditches or alleys running near latrines, or in the water supply.

The first column of Table 5 presents results from a fixed-effect specification testing this hypothesis. I include the household's own latrine usage as well as the community level measure, and the interaction between the two. I also include an interaction between community latrine usage and mother's handwashing behavior. Neither the zero-order term for household's own latrine use nor the interaction terms are significant, indicating that the effects of community-level latrine usage are independent of the household's behaviors. This suggests that children are more likely to be exposed to fecal contaminants in the general neighborhood environment rather than during toileting.

Other individual and household characteristics that are hypothesized to directly affect child nutritional status may also moderate the effect of community-level latrine usage on nutritional status. Improvements in community levels of latrine usage may be more important in households that are food insecure or for children who are not breastfeeding. Gender differences in susceptibility to infection and in treatment by caregivers may also generate differential effects of improved sanitation on weight-for-height. The final model, shown in the second column of Table 5, tests these three interactions[5]. There is a moderating effect (significant at the ten percent level) of food security status which attenuates the effect of community-level latrine

[5] There is no zero-order term for gender in the fixed effects model because gender is constant within child over time and so drops out of the model.

usage in households with young children. This suggests that the health effects of improved latrines are greater for children in food insecure households relative to those in food secure households. A similar attenuation is observed for breastfeeding children: the effect of community-level improvements in latrines usage among households with small children on child weight-for-height in reduced by one-third if the child is breastfed. There is no significant moderating effect of gender.

DISCUSSION

The Millennium Project Task Force on Water and Sanitation has called the lack of sanitation and water in Africa and Asia, particularly among the poor, a "silent humanitarian crisis" killing almost 4,000 children every day (Ali, Emch, Donnay, Yunus, & Sack, 2002; Bartram, Lewis, Lenton, & Wright, 2005). Cost-benefit analyses indicate that meeting Millennium Development Goal 10 of halving the number of people without access to safe water and basic sanitation would yield annual health-related savings of over $7 billion, and an additional annual dividend of $750 million in earnings from avoided sick days. This theoretical return of $3-4 per dollar invested is impressive, but achieving this return requires that sanitation investments be made wisely and efficiently.

This study reveals significant and strong effects of sanitation improvements on the health of young children in an urban slum setting in Bangladesh. Specifically, I find that increases in the proportion of households in the surrounding *basti* that use an improved latrine (versus an unimproved or unhygienic latrine) is associated with improvements in child weight-for-height, an important measure of short-term nutritional status. Notably, the effect remains strong and significant when the community-level measure includes only households with children under five, but is not observed when the community-level measure includes only households with no young children. In addition, the latrine usage of the child's own household does not appear to influence child weight-for-height. The effect is net of all time-invariant observed and unobserved characteristics of the children, their households, and *bastis* over a one-year period of time during which latrine improvements and other initiatives related to the SHAHAR community development project took place, and is also net of observed time-varying characteristics of the child and household that might be associated weight-for-height including breastfeeding status, food security, and mother's handwashing behaviors. The analysis controls for the age pattern of wasting in this population.

The fixed-effects specification does not control for any time-varying characteristics of the child, household, or *basti* that may have changed from one survey round to the next, and that might have influenced weight-for-height independently of latrine usage. Because the latrine intervention was part of a larger community development initiative, it could be the case that other features of the SHAHAR program led to health and nutrition improvements in the sampled children. I examine this possibility in two ways. First, the analysis shown includes two household measures that should capture some of the other improvements related to SHAHAR: the household food security status and the mother's handwashing behavior. To the extent that these variables significantly influence child weight-for-height, these results might be considered additional measures of success of the SHAHAR project. (There is stronger evidence of this for the food security measure than for mother's handwashing.) However, the addition of these measures does not attenuate the community-level improved latrine measure. In an alternative specification (not shown) I employed a more general community-level measure: whether the community respondent reported that the community had come together to build something or start a new program in the past year. A change in this variable from 2002 to 2003 might indicate an overall increase in activity, resources, or social efficacy that could improve child health independently of the latrine effect. This variable is not significant in any specification.

It is a concern in this analysis that the sampled children are both short and skinny, with low and declining height-for-age and weight-for-age z-scores over the course of the survey period. This makes the interpretation of a change in weight-for-height somewhat challenging. Consider two children of the same weight, height, and age at Time 1. If they gain weight at the same rate from Time 1 to Time 2, but one of the children has compromised linear growth, then this child will appear to have a healthier weight-for-height at Time 2. To control for this dynamic, I include height-for-age z-score as a control in a separate set of analyses of weight-for-height. Results (not shown) reveal a significant and negative coefficient on the height-for-age term, suggesting that taller children do indeed gain weight (for height) more slowly than shorter children. The addition of height-for-age increases the size of the coefficient on the community latrine usage term slightly.

The study also explored the role of diarrheal disease as the mechanism through which latrine improvements lead to healthier children. Adding recent diarrheal disease prevalence to the model predicting weight-for-height from community-level latrine usage did not attenuate the effect of improved latrines, but the diarrhea reporting period is only last 15 days, so the story could still be consistent with reductions in diarrhea that are not picked up in a 2-week recall. Cross-sectional analysis of the odds of reporting a diarrheal disease episode suggests that community latrine improvements drastically reduce the odds of diarrhea, an effect that does vary by survey round.

The third research goal of the paper was to examine the complementary or substitutive effects of sanitation infrastructure and hygiene behaviors. I find that the effect of community latrine usage on child weight-for-height does not depend on the household's own latrine usage, nor on the mother's handwashing behavior. This suggests that children are more likely to encounter diarrheal pathogens in the surrounding neighborhood during play, rather than becoming infected directly due to the hygiene behaviors of caregivers during their own toileting or when caring for children. On the other hand, the effect of improved latrines at the community level on child health does vary by the food security status of the household, with positive effects diminished for food secure compared to food insecure households. Effects are also smaller for breastfed children, consist with the hypothesis that breastmilk provides immunologic protection from pathogens. I do not find any differential effect of community latrine usage by gender of child.

These results build on previous findings on sanitation in child health in important ways. No other study of which I am aware specifically compares the effects of latrine use at the household level to community-level measures of latrine use. A randomized intervention in rural Kenya does find that community-level efforts to protect spring water leads to cleaner water, but not to improvements in child nutritional status or diarrhea incidence (Kremer, Leino, Miguel, & Zwane, 2006). The finding in the present study that latrine usage among households with children under five drives the community-level results is particularly novel. The use of longitudinal data allows children to act as their own controls, a stumbling point of many other evaluation studies using cross-sectional or case-control methods.

The results also suggest the importance of household food security in improving children's health. While the food security measure employed here (adult women not limiting meals) may be capturing broader changes in household income or livelihoods, it is still notable that this measure is associated so strongly with increased in weight-for-height z-score. I do not find a significant effect of changes in mother's handwashing practice, though it is difficult in these data to assess the content and intensity of hygiene education in the SHAHAR project. The literature on handwashing has established the effectiveness of handwashing in reducing contamination by and transmission of pathogens, with an associated decline in children's diarrheal disease risk among children (Curtis & Cairncross, 2003). What is less certain is how well hygiene education leads to actual behavior change, how persistent the behavior change may be over time (Hoque, 2003; Shordt & Cairncross, 2004), and whether handwashing can substitute for or complement water and sanitation improvements (Kremer et al., 2006; Luby et al., 2006; Shahid, Greenough, Samadi, Huq, & Rahman, 1996)

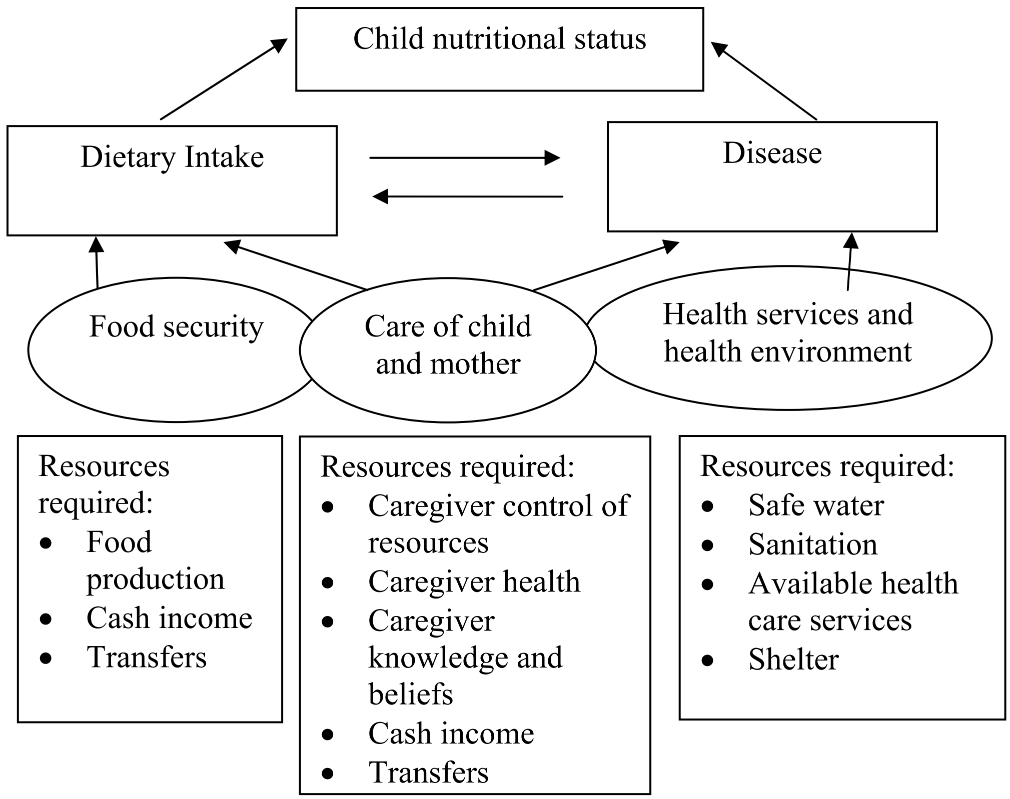
This study does have important limitations. First, there is no information on how community latrines were allocated to *bastis*, for example whether *bastis* had to compete for a limited number of installations or if latrine blocks were allocated to the most vulnerable communities first. There is also no information on how community latrines were maintained over time. The short time window of the survey allows me to identify only short-term changes in nutritional status of children. Though the gains are impressive, it is impossible to know whether these results will persist, particularly if the communal facilities are not well-maintained. The fixed-effects specification, while offering substantial benefits in terms of controlling selection bias, also has limitations, primarily in its assumption that all unobserved characteristics of children, households and *bastis* are fixed between the two survey rounds. Finally, the fact that the sampling frame included only the most vulnerable *bastis* in Dinajpur may limit the applicability of the findings to other urban slum communities.

The results on the importance of community-level sanitation measures highlight several other types of analyses that could be fruitful here. First, spatial analysis that pinpoints the location of new community toilets and shows which houses within each *basti* changed latrine usage could provide additional insight into the specific mechanisms through which sanitation improvements work. Spatial analyses of cholera and diarrheal risk in Matlab, Bangladesh suggest that this approach can effectively incorporate multiple types of data and can also improve the applicability of results to other areas with different risk profiles (Ali et al., 2002; Emch, 1999). The present analysis employed the community-level measure of latrine usage as a linear variable. It may also be the case that important threshold effects are operating, which would have critical implications for the implementation of a sanitation improvement scheme.

Findings from the present study suggest that behavior change interventions aimed at adults may not be effective if children still encounter contaminants in the surrounding neighborhood. They also indicate that sanitation upgrades are less effective in improving child health when implemented in individual households, but more effective when implemented in a clustered way. A key message from this study is that the environment vs. behavior dichotomy is a false one. In Dinajpur's *basti* setting, a child's "environment," at least in terms of diarrheal pathogen exposure, is largely shaped by the behavior of other children and adults in the surrounding households. This implies that social networks and social processes (including the social efficacy of the *basti* area) may be as important in determining the health environment as the placement of services or investment in infrastructure. Analyses that seek to pinpoint the effects of behavior change and sanitation programs on child health should incorporate this perspective.

FIGURES AND TABLES

Figure 1. Determinants of child nutritional status



From Smith, L., & Haddad, L. (2000). *Overcoming child malnutrition in developing countries: Past achievements and future choices* (Food, Agriculture and the Environment Discussion Paper 30). Washington DC: International Food Policy Research Institute.

Table 1. Descriptive statistics, children 6-36 months old in 2002 in fourteen *basti* (slum) communities, Dinajpur, Bangladesh [N=317 observations].

Survey round:	2002		2003	
	Mean or Proportion	SD	Mean or Proportion	SD
Child characteristics				
Age in months	19.91	8.83	32.62	8.89
Male = 1	0.55	-	0.55	-
Weight-for-height z-score	-1.44	1.15	-1.57	1.08
Height-for-age z-score	-1.67	1.21	-2.03	1.12
Child is breastfed	0.86	-	0.58	-
Child had diarrheal epidode, last 15 days	0.12	-	0.04	-
Household characteristics				
Household uses improved latrine	0.32		0.59	
Household is food secure	0.66	-	0.71	-
Adult female washes hands with soap after defecation	0.82	-	0.95	-
Community characteristics				
Proportion of households in *basti* using improved latrine	0.34	0.12	0.60	0.09
N	161		156	

Table 2. Coefficients for determinants of child weight-for-height z-score from individual fixed-effects models, children 6-36 months old in 2002 in fourteen *basti* (slum) communities in Dinajpur, Bangladesh, 2002-2003 [N=173].

Outcome: Child weight-for-height z-score	(1)	(2)	(3)
Health environment			
Household uses improved latrine	0.123		
	[0.95]		
Proportion of households in *basti* using improved latrine			
All households in *basti*		2.015	
		[2.74]***	
Households with children < 5			1.749
			[2.96]***
Households with no children < 5			
Household food security			
Adult women do not curtail number of meals	0.341	0.347	0.339
	[2.24]**	[2.33]**	[2.28]**
Care variables			
Mother washes hands with soap or ash	0.25	0.327	0.332
	[1.17]	[1.56]	[1.59]
Child is breastfed	-0.235	-0.248	-0.237
	[1.41]	[1.51]	[1.46]
Survey round = 2003	-0.262	-0.762	-0.710
	[2.73]***	[3.58]***	[3.86]***
Constant	-1.714	-2.417	-2.296
	[5.84]***	[6.16]***	[6.52]***
Number of observations	317	317	317
Number of children	173	173	173
R-squared	0.08	0.13	0.13

Absolute value of t statistics in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 2. (Continued from previous page.) Coefficients for determinants of child weight-for-height z-score from individual fixed-effects models, children 6-36 months old in 2002 in fourteen *basti* (slum) communities in Dinajpur, Bangladesh, 2002-2003 [N=173].

Outcome: Child weight-for-height z-score	(4)	(5)
Health environment		
Household uses improved latrine		
Proportion of households in *basti* using improved latrine		
All households in *basti*		
Households with children < 5		1.681
		[2.75]***
Households with no children < 5	0.819	0.323
	[1.14]	[0.45]
Household food security		
Adult women do not curtail number of meals	0.35	0.342
	[2.30]**	[2.29]**
Care variables		
Mother washes hands with soap or ash	0.27	0.334
	[1.27]	[1.60]
Child is breastfed	-0.249	-0.24
	[1.49]	[1.47]
Survey round = 2003	-0.451	-0.778
	[2.12]**	[3.25]***
Constant	-1.96	-2.385
	[5.12]***	[5.89]***
Number of observations	317	317
Number of children	173	173
R-squared	0.09	0.13

Absolute value of t statistics in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 3. Coefficients for determinants of child weight-for-height z-score from individual fixed-effects models, children 6-36 months in 2002 in fourteen *basti* (slum) communities in Dinajpur, Bangladesh, 2002-2003 [N=173].

Outcome: Child weight-for-height z-score	Coefficient [t-statistic]
Health environment	
Proportion of households with children < 5 in *basti* using improved latrine	1.753
	[2.94]***
Household food security	
Adult women do not curtail number of meals	0.34
	[2.38]**
Care variables	
Mother washes hands with soap or ash	0.333
	[1.59]
Child is breastfed	-0.238
	[1.45]
Survey round = 2003	-0.711
	[3.84]***
Child had diarrhea, last 2 weeks	0.013
	[0.07]
Constant	-2.3
	[6.41]***
Number of observations	317
Number of children	173
R-squared	0.13

Absolute value of t statistics in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 4. Odds ratios for determinants of child diarrheal disease prevalence, children 6-36 months old in 2002 in 14 *basti* (slum) communities in Dinajpur, Bangladesh, 2002-2003 [N=317 observations].

Outcome: Child had diarrhea, last 15 days	Odds ratio [z-statistic]
Male = 1	0.792
	[0.44]
Child age	1.006
	[0.15]
Health environment	
Proportion of households with children < 5 in *basti* using improved latrine	0.025
	[4.55]***
Household food security	
Adult women do not curtail number of meals	0.434
	[1.95]*
Care variables	
Mother washes hands with soap or ash	0.726
	[0.76]
Child is breastfed	1.65
	[0.55]
Survey round = 2003	0.663
	[0.43]
Interaction: Survey round = 2003 * Latrine use	2.005
	[0.30]
Number of observations	317

Robust z statistics in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Table 5. Coefficients for determinants of child weight-for-height z-score from individual fixed-effects models, children 6-36 months old in 2002 in 14 *basti* (slum) communities in Dinajpur, Bangladesh, 2002-2003 [N=176].

Outcome: child weight-for-height z-score	(1)	(2)
Health environment		
Household uses improved latrine	-0.083	
	[0.27]	
Proportion of households with children < 5 in *basti* using improved latrine	1.826	2.999
	[1.69]*	[3.36]***
Household food security		
Adult women do not curtail number of meals	0.357	0.726
	[2.34]**	[2.61]**
Care variables		
Mother washes hands with soap or ash	0.438	0.289
	[0.93]	[1.39]
Child is breastfed	-0.224	0.257
	[1.35]	[0.71]
Survey round = 2003	-0.721	-0.743
	[3.86]***	[4.05]***
Interactions with community mean latrine usage, households with children < 5		
Household uses improved latrine	0.323	
	[0.55]	
Mother washes hands with soap or ash	-0.259	
	[0.27]	
Adult women do not curtail number of meals		-0.997
		[1.70]*
Child is breastfed		-1.072
		[1.66]*
Male child		0.606
		[1.19]
Constant	-2.378	-2.924
	[4.36]***	[6.49]***
Number of observations	317	317
Number of children	173	173
R-squared	0.14	0.17

Absolute value of t statistics in brackets
* significant at 10%; ** significant at 5%; *** significant at 1%

Appendix: Latrine Usage by Basti

Figure A1. Proportion of households using improved latrines, 14 urban slum communities, Dinajpur, Bangladesh, 2002-2003 [N= 583].

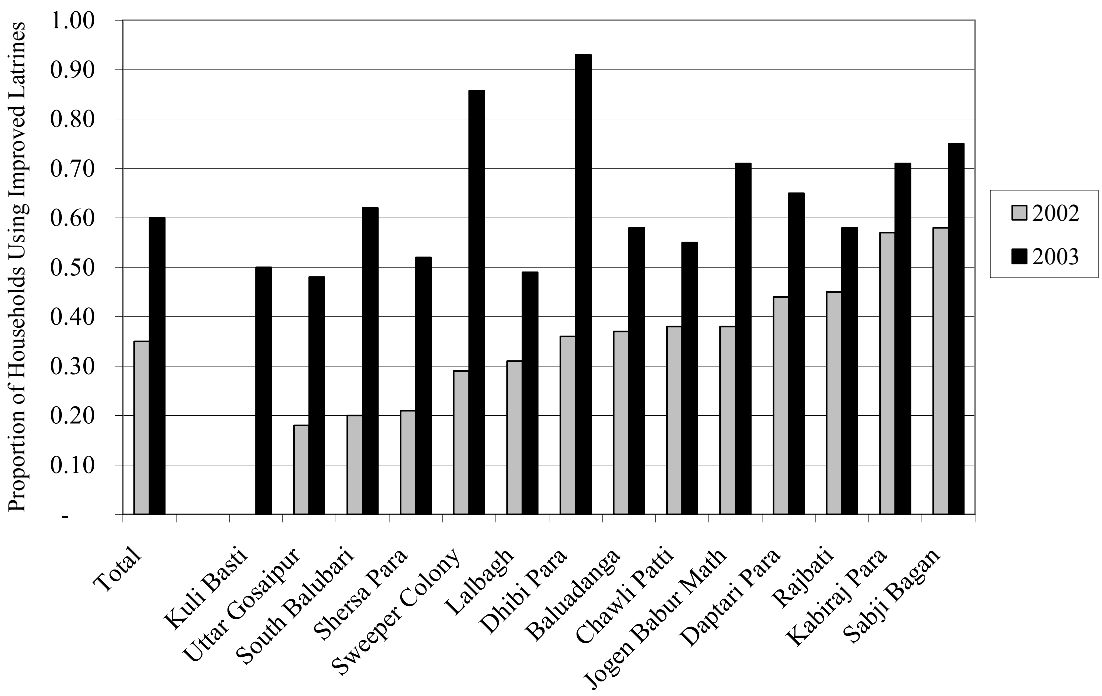


Table A1. Improved latrine use by type and community, Dinajpur, Bangladesh, 2002 [N= 583].

2002	Improved				
	Sealed	Unsealed hygienic	Community toilet	Subtotal of all households	N
Total	0.35	-	-	0.35	583
Uttar Gosaipur	0.18	-	-	0.18	49
Shersa Para	0.21	-	-	0.21	19
Jogen Babur Mat	0.38	-	-	0.38	29
Kuli *Basti*	-	-	-	-	6
Sweeper Colony	0.29	-	-	0.29	21
Dhibi Para	0.36	-	-	0.36	14
Kabiraj Para	0.57	-	-	0.57	14
South Balubari	0.20	-	-	0.20	60
Daptari Para	0.44	-	-	0.44	88
Baluadanga	0.37	-	-	0.37	124
Chawlia Patti	0.38	-	-	0.38	53
Lalbagh	0.31	-	-	0.31	49
Sabji Bagan	0.58	-	-	0.58	24
Rajbati	0.45	-	-	0.45	33

Table A2. Unimproved latrine use by type and community, Dinajpur, Bangladesh, 2002 [N= 583].

2002	Unimproved				
	Unsealed	Hanging/ Katcha	Open Space	Subtotal of all households	N
Total	0.33	0.15	0.17	0.65	583
Uttar Gosaipur	0.04	0.12	0.65	0.81	49
Shersa Para	0.47	0.05	0.26	0.78	19
Jogen Babur Mat	0.41	0.17	0.03	0.61	29
Kuli *Basti*	0.50	0.17	0.33	1.00	6
Sweeper Colony	0.48	0.14	0.10	0.72	21
Dhibi Para	0.07	0.07	0.50	0.64	14
Kabiraj Para	0.36	-	0.07	0.43	14
South Balubari	0.55	0.25	-	0.80	60
Daptari Para	0.32	0.14	0.10	0.56	88
Baluadanga	0.32	0.18	0.13	0.63	124
Chawlia Patti	0.43	0.15	0.04	0.62	53
Lalbagh	0.22	0.16	0.31	0.69	49
Sabji Bagan	0.08	0.08	0.25	0.42	24
Rajbati	0.33	0.15	0.06	0.54	33

Table A3. Improved latrine use by type and community, Dinajpur, Bangladesh, 2003 [N= 553].

2003	Improved				
	Sealed	Unsealed hygienic	Community toilet	Subtotal of all households	N
Total	0.45	0.05	0.10	0.60	553
Uttar Gosaipur	0.20	0.02	0.26	0.48	46
Shersa Para	0.47	0.05	-	0.52	19
Jogen Babur Mat	0.56	-	0.15	0.71	27
Kuli *Basti*	0.50	-	-	0.50	6
Sweeper Colony	0.29	0.14	0.43	0.86	21
Dhibi Para	0.29	0.07	0.57	0.93	14
Kabiraj Para	0.64	0.07	-	0.71	14
South Balubari	0.48	0.07	0.07	0.62	56
Daptari Para	0.59	0.03	0.04	0.65	78
Baluadanga	0.44	0.13	0.01	0.58	115
Chawlia Patti	0.49	0.02	0.04	0.55	51
Lalbagh	0.33	0.02	0.14	0.49	49
Sabji Bagan	0.46	-	0.29	0.75	24
Rajbati	0.55	-	0.03	0.58	33

Table A4. Unimproved latrine use by type and community, Dinajpur, Bangladesh, 2003 [N= 553].

2003	Unimproved				
	Unsealed	Hanging/ Katcha	Open Space	Subtotal of all households	N
Total	0.21	0.05	0.12	0.38	553
Uttar Gosaipur	0.15	0.02	0.35	0.52	46
Shersa Para	0.11	0.16	0.21	0.48	19
Jogen Babur Mat	0.22	0.04	0.04	0.29	27
Kuli *Basti*	0.17	0.33	-	0.50	6
Sweeper Colony	0.10	-	0.05	0.14	21
Dhibi Para	0.07	-	-	0.07	14
Kabiraj Para	0.14	0.07	0.07	0.28	14
South Balubari	0.23	0.11	0.04	0.38	56
Daptari Para	0.23	0.01	0.10	0.34	78
Baluadanga	0.24	0.04	0.14	0.42	115
Chawlia Patti	0.29	0.08	0.08	0.45	51
Lalbagh	0.16	0.12	0.22	0.50	49
Sabji Bagan	0.13	-	0.13	0.26	24
Rajbati	0.33	0.03	0.06	0.42	33

Table A5. Change in proportion of households using improved latrines by subtype and community, Dinajpur, Bangladesh, 2002-2003 [N= 559].

Change 2002 to 2003	Improved				Change in N
	Sealed	Unsealed hygienic	Community toilet	Total Change	
Total	0.10	0.05	0.10	0.25	(30)
	-	-	-	-	-
Uttar Gosaipur	0.02	0.02	0.26	0.30	(3)
Shersa Para	0.26	0.05	-	0.31	-
Jogen Babur Mat	0.18	-	0.15	0.33	(2)
Kuli *Basti*	0.50	-	-	0.50	-
Sweeper Colony	-	0.14	0.43	0.57	-
Dhibi Para	(0.07)	0.07	0.57	0.57	-
Kabiraj Para	0.07	0.07	-	0.14	-
South Balubari	0.28	0.07	0.07	0.42	(4)
Daptari Para	0.15	0.03	0.04	0.21	(10)
Baluadanga	0.07	0.13	0.01	0.21	(9)
Chawlia Patti	0.11	0.02	0.04	0.17	(2)
Lalbagh	0.02	0.02	0.14	0.18	-
Sabji Bagan	(0.12)	-	0.29	0.17	-
Rajbati	0.10	-	0.03	0.13	-

Table A6. Change in proportion of households using unimproved latrines by subtype and community, Dinajpur, Bangladesh, 2002-2003 [N= 559].

Change 2002 to 2003	Unimproved				Change in N
	Unsealed	Hanging/ Katcha	Open Space	Subtotal	
Total	(0.12)	(0.10)	(0.05)	(0.27)	(30)
	-	-	-	-	-
Uttar Gosaipur	0.11	(0.10)	(0.30)	(0.29)	(3)
Shersa Para	(0.36)	0.11	(0.05)	(0.30)	-
Jogen Babur Mat	(0.19)	(0.13)	0.00	(0.32)	(2)
Kuli *Basti*	(0.33)	0.16	(0.33)	(0.50)	-
Sweeper Colony	(0.39)	(0.14)	(0.05)	(0.57)	-
Dhibi Para	-	(0.07)	(0.50)	(0.57)	-
Kabiraj Para	(0.22)	0.07	-	(0.15)	-
South Balubari	(0.32)	(0.14)	0.04	(0.42)	(4)
Daptari Para	(0.09)	(0.13)	-	(0.22)	(10)
Baluadanga	(0.08)	(0.15)	0.01	(0.22)	(9)
Chawlia Patti	(0.14)	(0.07)	0.04	(0.17)	(2)
Lalbagh	(0.06)	(0.04)	(0.09)	(0.19)	-
Sabji Bagan	0.05	(0.08)	(0.12)	(0.16)	-
Rajbati	-	(0.12)	-	(0.12)	-

Table A7. Proportion of households using improved latrines, by household type, and community, Dinajpur, Bangladesh, 2002 [N=583 households].

	2002			
Proportion using improved latrines	All households	Households with children < 5	Households with no children <5	N
Total	0.35	0.33	0.34	583
Uttar Gosaipur	0.18	0.07	0.32	49
Shersa Para	0.21	0.11	0.27	19
Jogen Babur Mat	0.38	0.37	0.36	29
Kuli *Basti*	0.00	0.00	0.00	6
Sweeper Colony	0.29	0.33	0.24	21
Dhibi Para	0.36	0.50	0.25	14
Kabiraj Para	0.57	0.60	0.50	14
South Balubari	0.20	0.24	0.15	60
Daptari Para	0.44	0.38	0.45	88
Baluadanga	0.37	0.35	0.34	124
Chawlia Patti	0.38	0.43	0.32	53
Lalbagh	0.30	0.22	0.36	49
Sabji Bagan	0.60	0.60	0.55	24
Rajbati	0.45	0.47	0.39	33

Table A8. Proportion of households using improved latrines, by household type, and community, Dinajpur, Bangladesh, 2003 [N=553].

	2003			
Proportion using improved latrines	All households	Households with children < 5	Households with no children <5	N
Total	0.61	0.60	0.62	553
Uttar Gosaipur	0.48	0.38	0.59	46
Shersa Para	0.53	0.33	0.62	19
Jogen Babur Mat	0.70	0.76	0.60	27
Kuli *Basti*	0.50	0.75	0.00	6
Sweeper Colony	0.86	0.86	0.86	21
Dhibi Para	0.93	1.00	0.92	14
Kabiraj Para	0.71	0.75	0.70	14
South Balubari	0.63	0.64	0.61	56
Daptari Para	0.65	0.68	0.64	78
Baluadanga	0.58	0.59	0.58	115
Chawlia Patti	0.55	0.61	0.50	51
Lalbagh	0.49	0.32	0.63	49
Sabji Bagan	0.75	0.79	0.70	24
Rajbati	0.58	0.50	0.65	33

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