FINAL REPORT

MULTI-COUNTRY STUDY TO EXAMINE RELATIONSHIPS BETWEEN THE HEALTH OF CHILDREN AND THE LEVEL OF WATER AND SANITATION SERVICE, DISTANCE TO WATER, AND TYPE OF WATER USED

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EXECUTIVE SUMMARY

Data from eight countries in Sub-Saharan Africa (Burundi, Ghana, Togo and Uganda), Asia/North Africa (Sri Lanka and Morocco) and the Americas (Bolivia and Guatemala) were analyzed for health effects (diarrhea and nutritional status) related to water and sanitation conditions. The analysis had three objectives. One, incremental improvements in water and sanitation conditions were examined for incremental improvements in health. Two, the time needed to collect water was examined to see if health status improved when water was provided closer to homes. Three, the use of improved water supplies for drinking and non-drinking needs was examined in relation to the mix of improved and unimproved water sources for drinking and non-drinking needs.

Data from the eight countries were combined so rural and urban samples could be analyzed separately. A nationally representative (random) sample of ever-married women, 15-49 years of age with or without children, were interviewed in all countries, and children from these women, 3-36 months of age with weight and height data, were included in the analyses. Following adjusted analyses of each country, all eight country data sets were merged to create one data set. For the first objective, incremental improvements in sanitation, flush toilets and pit latrines were compared to unimproved sanitation, and an unimproved water source was compared to water on the premises and public water supplies. Multiple regression analysis controlled for maternal, household and child level variables in addition to the inclusion of dummy variables for each country.

Overall for objective 1 three main findings were reached. First, the health effects from sanitation were much larger than for improved water supplies, and the effects for improved water supplies were not always found. Second, flush toilets provided the largest health benefits, significantly greater than pit latrines, which in turn were significantly better than no improved sanitation. Third, for water supplies, water on the premises was usually associated with better health compared to no improved water or public supplies, but public supplies were not associated with better health.

For instance, for diarrhea in urban areas in the two weeks preceding data collection flush toilets were associated with 17% less diarrhea, pit latrines with 8.5% less diarrhea, and improved water supplies with no reduction in diarrhea compared to a situation with no improved water or sanitation facilities. For height-for-age, or stunting, flush toilets were associated with a 48% reduction in stunting, pit latrines with a 29% reduction, water on the premises with a 5% reduction and public water supplies with no reduction, again compared to a situation with no improved water and sanitation. Flush toilets, compared to no improved sanitation, were associated with an improved child growth of 1.82

cm (95% Confidence Interval; 1.44 cm to 2.18 cm) and 0.37 kg (0.25 kg to 0.71 kg) for a typical boy or girl 18 months of age. This is equivalent to half of the height deficit observed in urban children in these eight countries.

For rural children, flush toilets, compared to a situation with unimproved water and sanitation conditions, were associated a 5% reduction in diarrhea (previous two weeks), pit latrines with a 4% reduction, water on the premises with a 2% reduction, and public water supplies with a 1% reduction in diarrhea. These effects were smaller than for urban areas. The effects for nutritional status were more striking. Flush toilets, again compared to no improved water and sanitation, reduced stunting by 21%, pit latrines by 8%, water on the premises by 9%, and public water supplies by 1%. The actual differences in height for an 18-month old child were: 1.01 cm (0.71 cm to 1.31 cm) for a flush toilet versus no improved sanitation. Children 18 months of age with a pit latrine were 0.34 cm (0.15 cm to 0.53 cm) taller compared to children without improved sanitation. This corresponded to a difference in height of 0.67 cm (0.36 cm to 0.97 cm) for a children with flush toilets compared to children with a pit latrine in rural areas. Those children with a water supply on the premises were 0.49 cm (0.21 cm to 0.76 cm) taller compared to children without improved water supplies. For weight the corresponding difference between children with a flush toilet and no improved sanitation was 0.34 kg (0.24 kg to 0.43 kg), and for a pit latrine versus no sanitation it was 0.11 kg (0.04 kg to 0.17 kg).

In summary, flush toilets provided the largest health benefit in both urban and rural areas, and pit latrines provided a more modest, but significant, benefit in health. For water supplies, only water on the premises was associated with better health, and public supplies provided only marginal benefits, when benefits were identified. The effect of pit latrines was comparable to the effect of water on the premises.

For objective 2, time of round trip water collection, data were available from three countries (Burundi, Morocco and Sri Lanka), and the analyses were done for urban and rural areas separately. Time was divided into three groups: briefest (less than five minutes), intermediate (5-29 minutes) and longest (30 minutes or more) round trip travel times. Overall, briefer round trip water collection time was associated with better child health, particularly nutritional status, compared to intermediate and longer round trip water collection times.

In urban areas time of collection was significantly associated with linear growth, height-for-age Z-scores and proportion of children stunted, after adjusting for confounding. Children with the best nutritional status came from the group whose round trip water collection time was less than five minutes.

This group was significantly taller than the intermediate group (0.88 cm; 0.15 cm to 1.61 cm) and longest group (0.77 cm; -0.17 to 1.72 cm). For stunting, a 40% reduction in stunting was associated with the comparison of the longest to the briefest group, and it was 34% when the intermediate group was compared to the briefest group. Although underweight and wasting were not significantly different across comparison groups, the percent reduction from the longest to the briefest times were 29% and 31%, respectively. Small differences were found for diarrhea, and only for diarrhea in the two weeks prior to data collection.

In rural areas significant differences were found for both diarrhea and nutritional status. A 12% reduction in diarrhea (14 day recall) was found when the longest to the briefest round trip water collection times were compared. No significant difference was found between the intermediate and briefest groups. The effect was much less, and not significant, when diarrhea in the previous 24 hours was examined. For height-for-age, the highest Z-scores were found in the group with the briefest collection time compared to the intermediate (0.13; 0.00 to 0.26) and the longest time (0.14; 0.00 to 0.28). A similar result occurred for weight-for-age. The briefest time was associated with 0.13 (0.02 to 0.24) higher Z-scores compared to the longest time and 0.10 (-0.01 to 0.20) higher Z-scores compared to the intermediate time. This is equivalent to about 120 to 150 g, or 10% of the deficit in weight.

For the <u>third objective</u>, use of improved and unimproved drinking and non-drinking water supplies, four groups were compared: a) improved drinking water/improved non-drinking water source, b)) improved drinking water/unimproved non-drinking water source, c) unimproved drinking water/improved non-drinking water source, and d) unimproved drinking water/unimproved non-drinking water source. The lowest rates of diarrhea and malnutrition were found among group b. This was equally true in urban and rural areas. These differences were not statistically significant.

Overall, there were several reasons why the effects of nutritional status were stronger and more consistent than for diarrhea. First, diarrhea was poorly defined not only across countries, but probably across respondents within a country. This can result in misclassification of diarrhea, which biases results toward no differences. Anthropometry, on the other hand, was measured by standard procedures for all children in all countries. A second reason is that diarrhea prevalence may be a relatively insensitive indicator of improvements in water and sanitation because the severity of diarrhea is not captured in prevalence data. If the severity of diarrheal episodes is decreased, but not incidence, prevalence data may not detect this. Anthropometry, particularly height-for-age and weight-for-age, at any point in time will capture all past nutritional effects from conception to the current measurement (e.g., repeated bouts of diarrhea). Third, diarrhea is only one of several illnesses that can be affected by improvements in water and sanitation. Intestinal helminths, which are associated with malnutrition, can be reduced by improvements in water and sanitation. Thus, nutritional status can be increased with improvements in water and sanitation without changes in diarrhea. Fourth, when water is brought closer to people's homes, women may spend more time preparing food and feeding children, which could be measured by weight and height, but not by changes in diarrhea. Thus, for improvements in water and sanitation, anthropometry may be a more sensitive indicator than diarrhea.

Taken together, the following recommendations should be considered. First, improvements in sanitation should receive a new priority, sometimes over improvements in water supplies. Second, flush toilets should receive priority over pit latrines when such an option is available. Third, improved water supplies should be provided to people on the premises. Following the recommendations argue against the guiding principle of the New Delhi statement: "some for all, rather than more for some." However, some service for all may result in no benefits for any. Thus, public water supplies should be targeted to areas where health benefits are likely to occur. Finally, anthropometry should be considered as a measure of health impact following sanitation and water interventions, whether or not diarrhea is measured.

ACKNOWLEDGEMENTS

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1. INTRODUCTION

1.1 Overview

In the past 15-20 years many epidemiologic studies have examined the role of improved water and sanitation on pre-school child health, by measuring child diarrhea, nutrition and mortality parameters. In general health benefits have been found from these improvements (Esrey et al, 1991). The magnitude of the benefits, though, are variable. Ideally, maximum health benefits from improved water and sanitation should be sought, yet we know relatively little about how to achieve them. Achieving maximum impacts may be a function of many factors, some of which include: type of service available (e.g., water or sanitation); level of improvement (e.g., communal or household water); or distance to service.

Clarification of these factors is important to understand what maximizes health impacts for several reasons. A primary reason is that in an era of dwindling resources, the least cost solution may be sought. For example, water is generally cheaper that sanitation, and a communal tap is cheaper than a household connection. Although an intermediate level of service (e.g., communal tap or pit latrine) may be the first step in the goal of an optimum level of service (e.g., household connections), intermediate services will have little value if benefits do not occur. A focus on communal water supplies, primarily to provide safe water, may lead to a least impact solution.

The New Delhi Consultation has promoted the concept of some for all, rather than all for some. This would increase coverage of "cheap" solutions, such as communal water supplies, at the expense of "costly" solutions, such as household connections and water-based sanitation systems. But the New Delhi concept is more a prescription to maximize coverage and access to water and sanitation, rather than to maximize health impacts.

A second reason for examining these issues is to seek corroboration of other reports that sanitation has larger impacts than water supplies. This is important because the gap in sanitation coverage is widening, partly at the expense of increasing water supply coverage.

Until recently, answers to these issues have remained unknown because many projects usually provide only one type of service (e.g., water or sanitation), and that service has only been provided at one level (e.g., communal taps). The recent Demographic and Health Survey data provide an opportunity to examine these issues and understand how to maximize health impacts.

1.2 Water and Sanitation Coverage Estimates

The most recent global figures on the number of people with adequate water and sanitation (Figure 1) are from 1991. The projections about coverage in the year 2000 are based on the rate of coverage during the 1980s.

Two facts stand out from the WHO figures. First, water supply coverage is greater than sanitation, and coverage is catching up with population increases. Second, sanitation coverage is slipping; in the year 2000 more people will be without adequate sanitation than in 1980 if present rates of coverage continue. Not shown is that coverage is greater in urban than in rural areas, and about 80% of the urban population has access to improved water supplies at present. Without renewed interest in installing new systems or covering the new urban poor who migrate from rural areas, urban coverage will be expected to decrease by the year 2000. Rural sanitation is woefully inadequate: fewer than 20% of the rural population has access to adequate sanitation facilities.

Figure 2 shows how the 1990 coverage figures break down by region. West Asia and the Middle East have the most extensive coverage in the developing world. Asia and the Pacific have the most people without adequate water and sanitation.

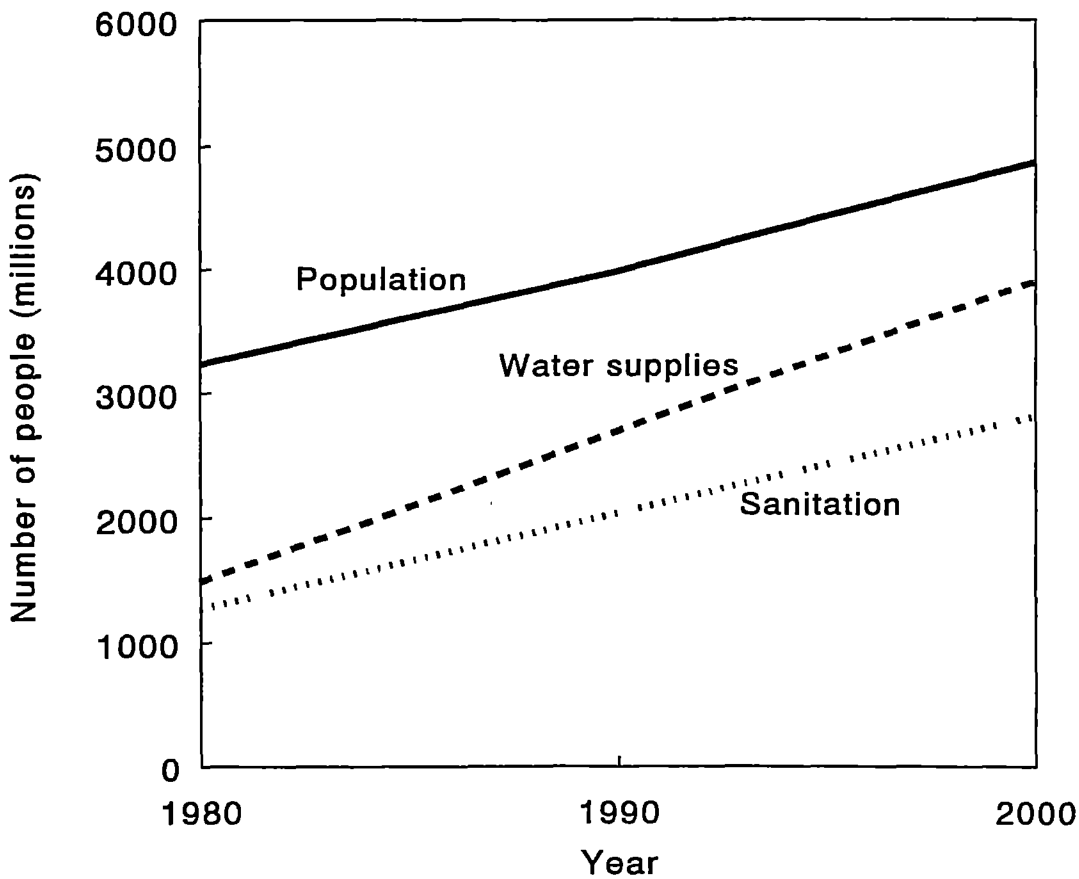
People without coverage rely on unimproved water supplies, i.e., those which have not been upgraded to improve the quality or quantity of water available. Such supplies include rivers, ponds, lakes, and unprotected springs. For sanitation, unimproved facilities include holes in the ground, bushes and other places in which defecation is not contained to prevent it from contaminating the environment.

People who are considered to have improved water and sanitation do not all have the same services. There is wide variation in type of service, but, for the purpose of this study, service is classed as "intermediate" or "optimum."

Intermediate-type water supply facilities are communal. Safe water is available from a centrally located handpump, tap, or well. For sanitation, intermediate service is a pit latrine or similar fecal disposal system. Optimum water supplies are those located on the premises or inside the household. For sanitation, a water-based system or a flush toilet is considered the best, or the optimum, type of system.

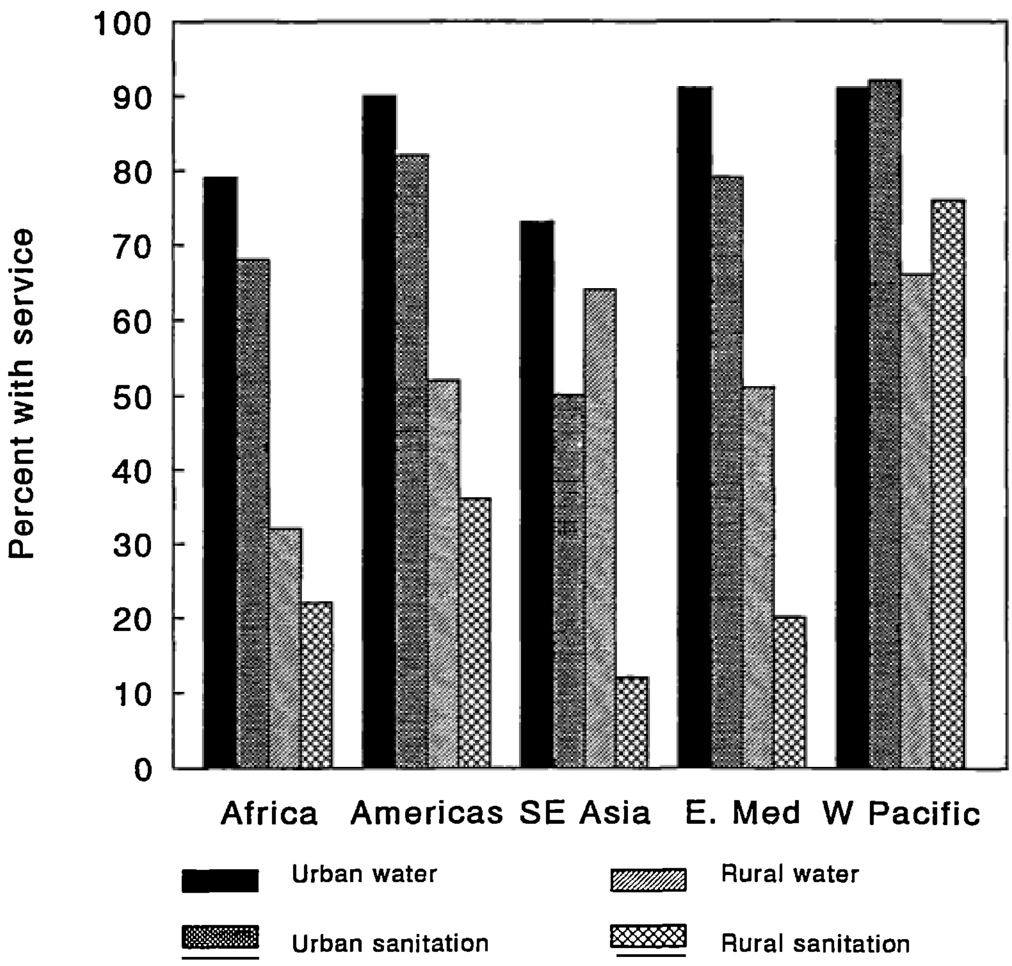
from health point of view?!

Figure 1: Coverage of sanitation and water supplies by population from 1980 to 2000



Source: WHO, 1993

Figure 2: Water and sanitation coverage by region in urban and rural areas



1.3 Limitations of Studies of the Impact of Water and Sanitation on Health

A recent review of studies in the professional literature on the health effects of improvements in water and sanitation reported decreases in diarrhea, ascariasis, schistosomiasis, guinea worm, trachoma, improvements in nutritional status, and reductions in mortality (Esrey *et al.*, 1991). The magnitude of the benefits vary widely; in some cases improvements in health were substantial, while in others no benefits were found.

There are several explanations for the negative findings reported in the literature. Sometimes the population being studied is already relatively healthy. Sometimes the water and sanitation interventions may be insufficient to produce health impacts. The size of the sample studied may be too small, or it may prove impossible to remove the influence of potential confounding factors. Because of these limitations, many studies fail to provide useful information on the relationship between water and sanitation and health.

The present study was designed to overcome these limitations. Several countries were included to boost sample sizes. The countries selected (Bolivia, Burundi, Ghana, Guatemala, Morocco, Sri Lanka, Togo, and Uganda) were known to have problems with diarrhea and malnutrition. In addition potential confounding variables were included in the analyses.

This study also addresses another important limitation: the failure to make a distinction between types of interventions. For example, many studies do not distinguish between a communal water supply and water brought into individual families' yards or patios. However, it may be that only those with water close to the home will realize health benefits. Grouping the two kinds of services together may hide the true benefit of water close to the home.

2. OBJECTIVES OF THE STUDY

The main objectives of this study all relate to issues concerning type and quality of the intervention, which have not been adequately addressed in the literature.

Objective 1 is to examine whether incremental improvements in water and sanitation will result in incremental improvements in health. With regard to water, it is expected that health impacts will improve as people upgrade from less accessible, poor quality water to community facilities and finally to household connections. With regard to sanitation, it is expected that health status will be best with flush toilets, next best with pit latrines, and worse without facilities.

Objective 2 is to examine whether there is a correlation between improvements in health and shorter distances to the drinking water supply. It is expected that as water collection time is reduced health benefits will increase.

Objective 3 is to examine whether the use of improved water sources for all water needs has more of an impact on health than the use of one source for drinking and another for all other needs. It is expected that improved water used for all purposes will be associated with better health than improved water used only for drinking and cooking.

3. DESIGN OF THE STUDY

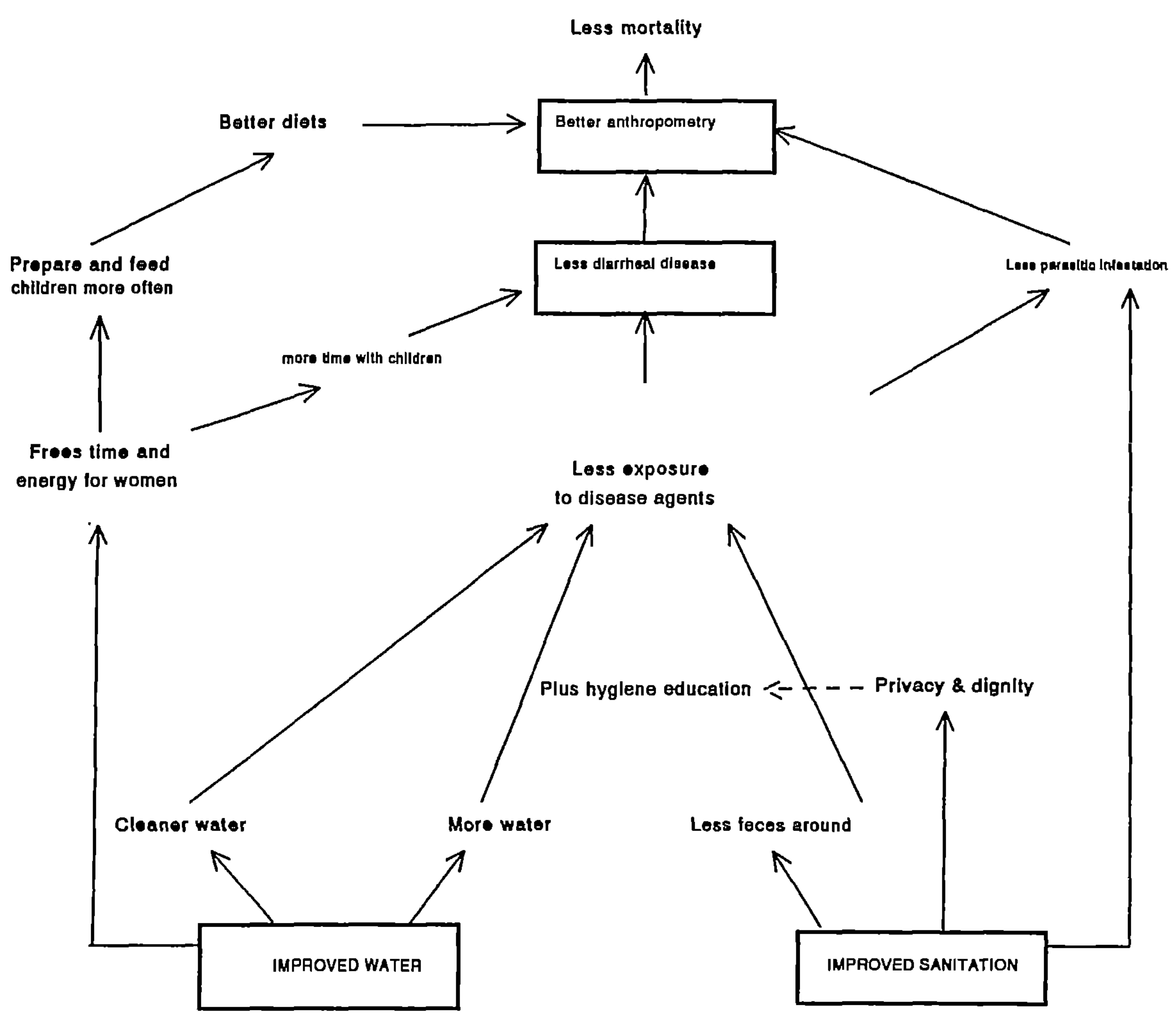
3.1 Measures of Health Status Used in the Study

Improvements in water and sanitation are thought to improve health, primarily by reducing exposure to disease agents, but they improve health through other mechanisms as well (Figure 3). Rigorous and anecdotal evidence have been accumulated in the last several years to suggest that several mechanisms operate to improve child health. For example, improved water supplies have been shown to increase water use (White, Bradley, & White) improve its quality (Esrey, Feachem, and Hughes, 1985), and save women time (Burger and Esrey, 1994) and energy (Diaz et al, 1994). Improved sanitation has been shown to reduce fecal contamination of the environment (Roberts et al, 1994) and provide privacy and dignity to women (P Wan, 1994). Strong evidence exists that improved water supplies reduce exposure to disease agents, as shown by lower disease rates and larger reductions in disease severity than disease prevalence (Esrey, et al, 1991). Direct evidence exists that improved sanitation reduces transmission (Roberts, 1994). A number of studies have reported that when women have more time, they spend it in food related activities, including feeding their children more frequently (Burger et al, 1994; Hurtado et al, 1994)). Less diarrhea, less intestinal helminths and better dietary practices are well known to improve child nutritional status.

As shown in figure 3, the health improvements in water and sanitation can be measured by diarrhea, malnutrition and death rates, but they can usually be measured best by diarrhea and nutritional status. During the 1980s water and sanitation facilities were installed at a rapid pace, so that when mortality events were recalled over several years, it was difficult to know if the death occurred prior to or after the improvement of water or sanitation. This is not a problem for current rates of diarrhea. Also, changes in mortality rates generally require a much larger sample size than do the measures of morbidity and nutritional status. Nutrition captures more of the total benefits of water and sanitation than do diarrhea. Thus, both diarrhea and nutritional status will be examined.

The eight countries had anthropometric data on children 3-36 months of age ranging from nearly 1300 in Togo to 2500 in Morocco and Bolivia. In total, about 17,000 children were available for analysis, nearly 5,000 of them urban.

Figure 3: Working model of how improved water and sanitation improve child health



3.2 Selection of the Countries

Representative data from eight countries were analyzed. The countries selected were based on available data sets from the Demographic and Health Surveys as of March 15, 1992.

The Demographic and Health Surveys (DHS) is a program funded by the U.S. Agency for International Development (A.I.D.) and implemented by the Institute for Resource Development (IRD), Macro Systems, with assistance from the Population Council. It was originally a five-year program (1984-1989) but was extended to 1994 to assist governments and private agencies in developing countries with implementing demographic and health surveys. The program objectives were 1) to provide leaders in survey countries with population and health data useful for informed decision-making, 2) to develop, in participating countries, the skills and resources necessary to conduct high-quality demographic and health surveys, 3) to improve survey methods used to analyze populations in developing countries, and 4) to expand and improve the worldwide body of information on population and health.

Thirty data sets were available from the DHS. Appendix A gives the complete list of data sets with sample sizes, indicating which have information on distance to water source and other variables necessary for the analysis: source of drinking and non-drinking water, type of sanitation facility, and diarrheal and anthropometry data for young child. A number of factors went into the choice of the eight to be analyzed. Several countries were eliminated automatically: Egypt requires permission to use its data, and it was feared that might delay the study; nine countries do not have anthropometric data (Botwsana, Kenya, Liberia, Sudan, Indonesia, Nepal, Ecuador, Mexico, Peru); some sample sizes were too low for the study (Mali, Trinidad and Tobago, and N.E. Brazil); and two data sets (Ondo State, Nigeria, and Nigeria) came from the same country.

The eight were chosen from the 14 remaining data sets. Four countries were selected after discussions with the Canadian International Development Agency (CIDA), which expressed an interest in certain countries where it had carried out prior activities. These were Bolivia, Morocco, Ghana, and Uganda. The four additional countries were chosen on the basis of the size of their samples and their location, with some preference being given to Africa because it is in worse condition than the other parts of the world in providing water and sanitation.

The eight countries selected for analysis, and the regions in which they are located, are as follows: AFRICA (Burundi, Ghana, Togo, and Uganda), L.A./CARIBBEAN (Bolivia and Guatemala), and ASIA/N.AFRICA (Morocco and Sri

Lanka). The estimated sample size available for analysis from these eight countries is around 17,000 children, 3-36 months of age.

The most recent coverage figures for these countries was published by the World Health Organization and are representative of coverage figures in 1990 (see Table 1). Figures were not available for Bolivia or Morocco, and figures for Sri Lanka were incomplete.

Global trends, discussed earlier, are true for the countries in the study also: higher coverage in urban than in rural areas; water more widely available than sanitation in urban areas; and the vast majority with inadequate sanitation and water in rural areas.

Table 1: Water and sanitation coverage in urban and rural areas of selected countries included in this report

		Percent coverage			
	Percent	Urban		Rural	
Country	Urbanized	Water	Sanitation	Water	Sanitation
Bolivia	51%	76	38	30	14
Burundi	7%	92	64	43	16
Ghana	33%	63	63	-	60
Guatemala	38%	92	72	43	52
Morocco	46%	100	100	18	-
Sri Lanka	21%	80	68	55	45
Togo	-	-	-	-	-
Uganda	11%	60	32	30	60

Source: WHO. The International Drinking Water and Sanitation Decade: End of Decade Review (as at December, 1990), Published August, 1992.

3.3 Data Analyzed

Two major types of health outcomes were examined: diarrhea and nutritional status, as measured by anthropometry.

The DHS data were collected from nationally representative (random) samples in each country of ever-married women, 15-49 years of age with or without children. Children 3-36 months of age from these women were included in the analysis.

The data on diarrhea were obtained by asking mothers about the occurrence of diarrhea in their children in the previous 24 hours and in the last two weeks. The term "diarrhea" was not defined uniformly across all countries or from mother to mother within a country. Each mother used her own judgement about whether diarrhea was present. Therefore, the data pertaining to diarrhea may not be uniform across all countries or across all subgroups within a country.

The figures of diarrhea in the last two weeks are higher than for the previous 24 hours, because any child who had diarrhea the day before the interview also had diarrhea in the last two weeks, but the reverse is not necessarily true. Assuming that both were measured equally well, which cannot be confirmed, diarrhea in the last two weeks would be a more sensitive indicator of the association between water and sanitation than would diarrhea in the previous 24 hours. This is because diarrhea in the previous two weeks is a period prevalence, which would result in a more precise classification of those who were likely to have had or not to have had diarrhea given their living conditions.

The DHS data on anthropometry were obtained by data collectors who weighed and measured children using standard UNICEF techniques in which they had been trained. Children were weighed in hanging scales which went up to 25 kilograms in 100 gram increments. Their height was measured with portable measuring boards which went up to 120 centimetres in 0.1 centimeter increments. Children under the age of 24 months were measured in a supine position, while older children were measured standing.

For nutritional status, three indices were created from knowledge of a child's age, sex, weight and stature: height-for-age, weight-for-age, and weight-for-height. For each of the three indices, the data were considered as continuous (Z-scores) and as a percent below -2 Z-scores. The Z-scores are based on the U.S. National Centers for Health Statistics, which are recommended by the U.S. Centers for Disease Control and the World Health Organization (Dibley, 1987). Z-scores provide a measure of the relative severity of the nutritional status, including a measure of variability around a mean, while the percent below a cut-off of -2.00 Z-scores provides a measure of the percent of children who would be considered moderately or severely malnourished, i.e., stunted, underweight, or wasted. Because those below -2.00 Z-scores are at a higher risk of dying, the percent below the cut-off are equally important to examine as the difference in Z-scores.

Height-for-age is a measure of the cumulative insults to nutritional status (e.g., repeated bouts of diarrhea), whereas weight-for-height provides an indication of recent nutritional insults (e.g., diarrhea in the previous 24 hours). Because the severity of any diarrheal episode or the cumulative incidence of diarrhea over the time-span of a child's life were not known, both height-for-age and weight-for-height are complementary indices that identify different situations. Weight-for-age is less specific than the other two nutritional indices because it captures both current (weight-for-height) and past (height-for-age) insults to nutritional status, without distinguishing between the two if both are present.

In a normal (Gaussian) population, the distribution of children is such that about 95% will be between -2.00 and 2.00 standard deviation scores (Z-scores). These children would be considered to be normal or mildly malnourished. Thus, children whose Z-score was below -2.00 were coded as stunted (height-for-age), wasted (weight-for-height), or underweight (weight-for-age). Wildly high or low Z-scores more likely reflect measurement error than anything else. The ranges vary for indicator; for height-for-age they are values less than -6.00 or greater than 6.00. Those outside of the recommended range were excluded from the analysis.

The purpose of creating Z-scores is not to compare children to a reference value, although this can be accomplished, but to facilitate the comparison of weights and heights of children in different groups (e.g., improved versus unimproved water). Standardizing children according to age and sex allows for easier interpretation of nutritional status, and has favorable statistical qualities.

3.4 File Creation

Data from each country were provided in an ASCII format. By using SAS-PC, selected variables were extracted from each country's data set, as follows (see Appendix B for a complete list of variables and codes):

OUTCOME VARIABLES
- diarrhea
- weight-for-age
- height-for-age
- weight-for-height

HYPOTHESIZED VARIABLES

- drinking and non-drinking water supply
- sanitation
- round-trip time to collect water

COMMUNITY/COUNTRY VARIABLES

- country
- residence (urban or rural)

HOUSEHOLD VARIABLES

- soap on premises
- socioeconomic variables such as electricity, radio, television, car
- husband's occupation
- husband's education
- religion
- ethnicity
- number of children under five

MATERNAL VARIABLES

- education
- literacy
- age
- mother currently pregnant
- parity
- preceding birth interval
- succeeding birth interval
- marital status

CHILD VARIABLES

- age
- sex
- currently breast feeding
- bottle fed
- currently living with grandparents

Thus, the SAS data set contained about 50 variables (see Appendix C for an example of the programming code). Once a SAS-PC file was created this was converted to SYSTAT (Wilkinson, 1991) and STATA (STATA Corp, 1993), which were used for the analyses, including statistics, frequencies, and multiple regressions.

3.5 Variable Creation

Variables were further defined from their original codes (see Appendix D). For example, the variable water supply generally distinguished among nine possible types: piped into residence; piped into yard or plot; public tap; well with handpump; well without handpump; river, spring, surface water; tanker, truck, other vendor; rainwater; and other.

From these nine types, three new categories were created: PREMISE (water in the home or on the premises); PUBLIC (an improved source communally located); and NOWAT (an unimproved source). Similarly, the many types of sanitation facilities were reduced to FLUSH (a flush toilet), PIT (some type of latrine), and NOSAN (unimproved sanitation).

Of the 16,925 children in the sample, 11,970 were rural and 4,955 were urban. The urban and rural samples were analyzed separately because of general differences in urban and rural living conditions that could not be captured in this analysis (e.g., exposure to new ideas, exposure to different forms of pollution or density of living conditions).

3.6 Statistical methods used

3.6.1 Type of package

Several software packages were used for this report. Word processing was done with WordPerfect (WordPerfect, 1991). Figures and graphs were prepared with Slide Write Plus (Advanced Graphics Software, 1992). SAS was used for initial programming in which all the data were converted from ASCII numerical data to the variables to be used in the analyses below. SYSTAT and STATA were used for most of the statistical analyses, and a supplemental logistic regression package for SYSTAT data files was also used (Steinberg, 1992). QUATTRO PRO (Borland International, 1992) was used for certain functions such as rapid assessment of percent reductions as well as estimations of means based on the regression output and means for variables included in the regression. DBMSCOPY (Conceptual Systems Software, 1991) was used to convert files from one package to another (i.e. back and forth from SAS-PC, SYSTAT, STATA and QUATTRO PRO).

3.6.2 Criteria for decision making

For tests in which a continuous outcome variable was analyzed (i.e., Z-scores) ordinary least squares (OLS) techniques were used. For analyses of binary outcomes (i.e., diarrhea prevalence or stunting) logistic regression was employed. For the individual country data analysis, OLS was used for binary outcomes for three reasons. First, with large sample sizes, OLS provides inferences similar to those of logistic regression. Second, OLS is faster than iterative calculations in logistic regression. Third, the relative risk was not sought for individual countries; the analyses were used only to identify potential confounding factors. All statistical testing was done using a Type I error of 0.5, two-tailed. All confidence intervals are, therefore, 95%.

4. ANALYSIS OF DATA

4.1 Country level analysis

All country data were analyzed separately before the files were appended to each other. This was true for objectives 1 (incremental improvements in water and sanitation) and 3 (use of improved water for all water needs). For objective 2 (time to water), this was not possible, because only three of the eight countries had information on round-trip water collection time.

4.1.1 Objective 1

For each country, simple descriptive means were obtained, and the crude relationship between the incremental improvements and the hypothesized effects on diarrhea and nutritional status were analyzed. This allowed for two further types of analyses. One was to compare the change in the magnitude and direction of the health effect associated with the level of service from the unadjusted effect to the adjusted effect (after adjusting for potential confounding factors (such as maternal education status). The other was to compare potential confounders individually with the independent variables. Health outcomes in all eight countries were diarrhea (last 14 days and last two weeks) and nutritional status (Z-scores and percent below a cut-off of -2.00 Z-scores), as represented by height-for-age, weight-for-height, and weight-for-age were analyzed in this manner.

Multiple regression was performed for each country. Similar variables, coded identically, were used in all countries. First, all potential confounders were included in a full regression model. If any variable was found to be insignificant ($P>0.20$) that variable was dropped from further analyses, and a final reduced model was obtained for that country. The variables from the eight final reduced models were identified so as to be included in the multiple country regression analysis. If all countries but one had an important variable, that variable was retained. If two or more countries were missing an important variable, that variable was not included in the multiple country analysis.

4.1.2 Objective 2

For objective 2, time to collect water, the sample was analyzed by urban and rural areas, as in objective 1. Only three of the countries had data on this variable. They were pooled for the analysis and no individual country analysis was done. A more complete description of how these data were analyzed is given below, in the section on multiple country analysis.

4.1.3 Objective 3

Two new variables, each with two possibilities were established for objective 3. Those with either PREMISE or PUBLIC water were coded as having a good source of drinking water (GOODWAT). Similarly, those who had PREMISE or PUBLIC for their non-drinking water needs, were coded as having a good source of non-drinking water, NGOODWAT. Thus, for each of the newly created variables two choices existed, yes or no, for whether or not the drinking and non-drinking water sources were improved.

4.2 Multiple country analysis

4.2.1 Rationale

One of the prime reasons for doing a multiple country analysis was to analyze urban and rural populations separately. All multiple country regressions were, therefore, analyzed separately by urban and rural areas. A dummy variable for each country was created to include in the multiple regression as follows:

BO	0	Data not from Bolivia
	1	Data from Bolivia
BU	0	Data not from Burundi
	1	Data from Burundi
GH	0	Data not from Ghana
	1	Data from Ghana
GU	0	Data not from Guatemala
	1	Data from Guatemala
MA	0	Data not from Morocco
	1	Data from Morocco
SL	0	Data not from Sri Lanka
	1	Data from Sri Lanka
TO	0	Data not from Togo
	1	Data from Togo
UG	0	Data not from Uganda
	1	Data from Uganda

Bolivia (BO) was included as the reference country for the multiple regression. All other variables were kept in their original codes.

4.2.2 Creation of Data Set

Based on the results from each country analysis, the variables found to be *a priori* important potential confounders were included in the multiple country file. Some of these variables were found to be significant for all countries analyzed separately, others for only some countries. In some instances, a variable was found to be important in one country, was unavailable in another country. In such instances, the variable was included in the multiple country file, but it was not used when all countries were analyzed simultaneously.

4.2.3 Objective 1

The urban and rural samples were analyzed separately. The urban sample was nearly 5,000, whereas the rural sample was about 12,000. The four independent variables (FLUSH, PIT, PREMISE and PUBLIC) were analyzed individually, then with all variables included in the multiple regression. For all eight outcomes, ordinarily least squares was used. For the dichotomous variables (i.e., DIAR14D, DIAR24, STUNTED, UNDERWT, and WASTED) logistic regression was also used. A reduced model was not run for the multiple country analysis because those variables included had already been identified as important confounding variables. Thus, the full regression models were used for interpretation.

4.2.4 Objective 2

The variable, TIME, which represented the round trip water collection time had several possible outcomes, ranging from 0 minutes to over 600 minutes. After looking at sample sizes within the urban and rural samples, in which there were clusters of responses around 5, 30, and 60 minutes, this variable was used to created several new variables. They are described as follows:

NEW NAME	CODE	DESCRIPTION
TIME_4	0	Round trip collection was ≥ 5 minutes
	1	Round trip collection was < 5 minutes
TIME4_29	0	Round trip time was less than 6 or greater than 30 minutes
	1	Round trip time was 5 to 29 minutes
TIME30	0	Round trip time was less than 30 minutes
	1	Round trip time was 30 minutes or more

The newly created variable, TIME_4 included some who were coded as having water on the premises and others who reported that round trip collection time was five minutes of less.

4.2.5 Objective 3

The comparison of GOODWAT and NGOODWAT was carried out for the urban and rural samples separately.

5. SUMMARY OF MAJOR RESULTS

5.1 Objective 1

Objective 1 is to find out whether incremental improvements in service result in incremental improvements in health, as measured by diarrheal incidence and nutritional status. The hypothesis upon which the study was based is that health impacts would increase as people upgraded their systems. In other words, one would expect health status to be better in homes with water on the premises than in those with a pump a half an hour away or in homes with a flush toilet versus those with a pit latrine.

The expected result in diarrhea and nutritional status was found for sanitation. Improvements in sanitation were found to have significant benefits for both diarrhea and nutritional status. Flush toilets were associated with lower rates of diarrhea and better nutritional status compared to pit latrines, which in turn were associated with lower rates of diarrhea and better nutritional status compared with no improved sanitation facilities.

In contrast, incremental improvements in water supplies did not result in incremental improvements in health. Water on the premises was associated with better nutritional status (particularly weight of children) but only weakly with lower diarrhea rates. The presence of a communal water supply was only marginally associated or not associated at all with better health.

These results were true for both rural and urban locations, but the association between water and sanitation improvements and health was larger and more consistent in urban than in rural areas. The unadjusted effects were larger than the adjusted effects, but the relative magnitude of the health benefits still remained after adjusting for a number of confounding factors. Therefore, they are less likely to be explained by some uncontrolled factor. See Appendix H for a detailed explanation of confounding.

For instance, in urban areas for diarrhea in the two weeks preceding data collection, flush toilets were associated with 17% less diarrhea, pit latrines with 8.5% less diarrhea, and improved water supplies with no reduction in diarrhea compared to a situation with no improved water or sanitation facilities. For height-for-age, or stunting, flush toilets were associated with a 48% reduction in stunting, pit latrines with a 29% reduction, water on the premises with a 5% reduction, and public water supplies with no reduction, again compared to a situation with no improved water and sanitation. Flush toilets, compared to no improved sanitation, were associated with an improved child growth of 1.82

cm (95% confidence interval (CI); 1.44 cm to 2.18 cm) and 371 g (246 g to 706 g) for a typical boy or girl 18 months of age. This is equivalent to half of the height deficit observed in urban children in these countries.

For rural children, flush toilets, compared to a situation with unimproved water and sanitation conditions, were associated with a 5% reduction in diarrhea (previous two weeks), pit latrines with a 4% reduction, water on the premises with a 2% reduction, and public water supplies with a 1% reduction in diarrhea. These effects were smaller than for urban areas. The effects for nutritional status were more striking. Flush toilets, again compared to no improved water and sanitation, reduced stunting by 21%, pit latrines by 8%, water on the premises by 9%, and public water supplies by 1%. The actual differences in height for an 18-month old child were: 1.01 cm (0.71 cm to 1.31 cm) for a flush toilet versus no improved sanitation. Children 18 months of age with a pit latrine were 0.342 cm (0.153 to 0.531 cm) taller compared to children without improved sanitation. This corresponded to a difference in height of 0.67 cm (0.36 cm to 0.97 cm) for children with a flush toilet compared to children with a pit latrine in rural areas. Those children with a water supply on the premises were 0.49 cm (0.21 cm to 0.76 cm) taller compared to children without improved water supplies. For weight the corresponding difference between children with a flush toilet and no improved sanitation was 0.34 kg (0.24 kg to 0.43 kg), and for a pit latrine versus no sanitation it was 0.11 kg (0.04 kg to 0.17 kg).

In summary, flush toilets provided the largest health benefit in both urban and rural areas, and pit latrines provided a more modest, but significant, benefit in health. For water supplies, only water on the premises was associated with better health, and public supplies provided only marginal benefits, when benefits were identified.

5.2 Objective 2

Objective 2 is to find out if child health status is related to distance to the household water source. The expectation was that as water collection time goes down, health benefits are higher. Three countries (Burundi, Morocco and Sri Lanka) were analyzed for urban and rural areas separately. Time was divided into three groups: briefest (less than five minutes), intermediate (5-29 minutes) and longest (30 minutes or more) round trip travel times. Overall, briefer round trip water collection time was associated with better child health, particularly nutritional status, compared to intermediate and longer round trip water collection times.

In urban areas time of collection was significantly associated with linear growth, height-for-age Z-scores and proportion of children stunted, after adjusting for confounding. Children with the best nutritional status came from the group whose round trip water collection time was less than five minutes. This group was significantly taller than the intermediate group (0.88 cm; 0.15 cm to 1.61 cm) and longest group (0.77 cm; -0.17 to 1.72 cm). For stunting, a 40% reduction in stunting was associated with the comparison of the longest to the briefest group, and it was 34% when the intermediate group was compared to the briefest group. Although underweight and wasting were not significantly different across comparison groups, the percent reduction from the longest to the briefest times were 29% and 31%, respectively. Small differences were found for diarrhea, and only for diarrhea in the two weeks prior to data collection.

In rural areas significant differences were found for both diarrhea and nutritional status. A 12% reduction in diarrhea (14 day recall) was found when the longest to the briefest round trip water collection times were compared. No significant difference was found between the intermediate and briefest groups. The effect was much less, and not significant, when diarrhea in the previous 24 hours was examined. For height-for-age, the highest Z-scores were found in the group with the briefest collection time compared to the intermediate (0.13; 0.00 to 0.26) and the longest time (0.14; 0.00 to 0.28). A similar result occurred for weight-for-age. The briefest time was associated with 0.13 (0.02 to 0.24) higher Z-scores compared to the longest time and 0.10 (-0.01 to 0.20) higher Z-scores compared to the intermediate time. This is equivalent to about 120 to 150 g, or 10% of the deficit in weight.

5.3 Objective 3

Objective 3 was to see if the use of improved water sources for all water needs had a larger effect on health than the use of improved water sources for drinking and cooking and unimproved sources for other uses. It was expected that the use of improved water sources exclusively would be associated with better health.

The results of the analysis did not confirm the expectations. Use of improved water supplies for all water needs did not result in large health benefits. In both the urban and rural samples, the lowest rates of diarrhea and lowest nutritional status were generally found among children whose families had an improved drinking water supply and an unimproved non-drinking water supply. However, the sample size for those with mixed sources was small in all countries.

When those with an improved water source for all needs were compared with those with unimproved sources, diarrhea rates were lower and nutritional status was better in the improved water group. The improvements in health were generally small, however. Because the differences found were generally small and no clear trend emerged among the four comparison groups, it seems reasonable to conclude that improved water supplies for all water needs may not be necessary.

6. DETAILED RESULTS

6.1 Individual Country Results

The body of this report focuses on the multi-country analysis. Analyses of individual countries are given in Appendices E (Objective 1--sanitation), F (Objective 1--water), and G (Objective 3). The results for the individual country analyses include the urban and rural samples together because in some countries there were too few children in specific subgroups (e.g., water on the premises in rural areas). The multi-country analyses present urban and rural data separately.

6.2 Objective 1

6.2.1 Summary of Outcome and Confounding Variables

Table 1-1 summarizes the results for diarrhea and nutritional status for rural and urban areas. Note that the rates of diarrhea were similar in the urban and rural samples. The nutritional status of children was better in urban than in rural areas. This was true for all three indices: height-for-age, weight-for-age, and weight-for-height.

Table 1-1: Summary of outcome variables used in analyses

	URBAN	RURAL
DIARRHEA		
last 14 days	33.7% (1647)	29.1% (3539)
last 24 hours	17.9% (875)	16.3% (1982)
NUTRITION - Z-SCORES		
Height-for-age	-1.19 ± 1.45	-1.69 ± 1.46
Weight-for-age	-0.79 ± 1.25	-1.32 ± 1.23
Weight-for-height	-0.04 ± 1.08	-0.31 ± 1.06
NUTRITION - PERCENT MALNOURISHED		
Stunted	27.1% (1333)	40.8% (4947)
Underweight	15.7% (772)	29.4% (3565)
Wasted	3.2% (157)	5.1% (618)

Other variables showed rural-urban differences (Table 1-2). Although the majority in the sample came from families with improved water and sanitation, in the urban sample, the majority of children came from families with optimal service, whereas in the rural areas the majority had intermediate service. In urban areas, the smallest sample size occurred among the reference groups (unimproved sanitation (n=846) and unimproved water (n=500)). In rural areas each comparison group had more than 1000 children available for analysis.

The rural-urban breakdown differed greatly from country to country; therefore some countries were disproportionately represented in the urban sample. Bolivia and Morocco each contributed more than 20% of the urban sample; Burundi, Sri Lanka, Togo, and Uganda, all predominantly rural countries, each contributed less than 10% of the total urban sample. Each country contributed seven to 16% of the rural sample.

Of the potential confounding variables deemed important, the ones that were similar for rural and urban children were as follows: presence of a bicycle, household size, percent of mothers that were married, percent of mothers that were pregnant, age of mothers, percent of children born with a short birth interval, sex of the child, percent of children who were twins, and age of the child. However, in the urban sample, more mothers were educated, fewer children were under five years of age lived in the family, children were breastfed for a shorter duration, and there were more children who were first born.

In the analysis, the results were adjusted to eliminate the effect of the potential confounding factors. In the unadjusted computations, only FLUSH and PIT entered into the regression; for water, only PREMISE and PUBLIC. In the adjusted computations, each of the remaining variables in table 1-2 were added to the regression model in addition to those variables for the country.

Table 1-2: Potential confounding variables among urban and rural samples

VARIABLE	URBAN		RURAL	
INDEPENDENT VARIABLES				
Flush	46.5%	(2300)	9.2%	(1127)
Pit	36.4%	(1800)	49.3%	(6043)
Premise	58.8%	(2908)	10.1%	(1238)
Public	31.1%	(1538)	54.1%	(6629)
COUNTRY				
Bolivia	28.3%	(1401)	9.9%	(1213)
Burundi	5.0%	(247)	13.3%	(1630)
Ghana	10.5%	(520)	10.8%	(1324)
Guatemala	12.6%	(624)	13.1%	(1606)
Morocco	21.8%	(1079)	16.3%	(1998)
Sri Lanka	6.3%	(312)	13.1%	(1606)
Togo	7.8%	(386)	7.6%	(932)
Uganda	7.8%	(386)	16.0%	(1961)
HOUSEHOLD CHARACTERISTICS				
Bicycle	21.7%	(1073)	22.5%	(2757)
Motorcycle	10.5%	(519)	3.7%	(453)
Household size				
≤ 4 people	23.1%	(1143)	19.3%	(2366)
5-7 people	43.9%	(2173)	42.4%	(5197)
8-10 people	21.6%	(1069)	23.8%	(2917)
≥ 11 people	11.4%	(564)	14.5%	(1777)
One or more children < 5 years of age in household	34.4%	(1702)	26.0%	(3187)
MATERNAL VARIABLES				
Maternal education				
None	28.6%	(1414)	54.1%	(6630)
Primary	38.6%	(1909)	34.4%	(4216)
Secondary or higher	32.7%	(1617)	11.5%	(1409)
Mother married	91.6%	(4533)	93.3%	(11435)
Mother pregnant	9.3%	(460)	11.6%	(1422)
Maternal age				
≤ 19 year	6.7%	(332)	6.9%	(846)
20-29 years	55.1%	(2727)	52.5%	(6435)
30-39 years	32.8%	(1623)	33.3%	(4082)
≥ 40 years	5.4%	(267)	7.3%	(895)
Pregnancy interval ≤ 18 months				
Previous child	9.3%	(460)	7.5%	(919)
Subsequent child	4.4%	(218)	3.1%	(380)
CHILD VARIABLES				
Male	50.7%	(2509)	50.2%	(6153)
Twin	2.0%	(99)	2.1%	(257)
Percent of life breastfed	67.5%	(4926)	80.2%	(12130)
First born	22.4%	(1109)	17.9%	(2194)
Child's age				
3-6 months	12.8%	(633)	13.2%	(1618)
7-12 months	19.6%	(970)	19.4%	(2378)
13-24 months	34.9%	(1727)	35.6%	(4363)
25-36 months	32.7%	(1618)	31.8%	(3898)

6.2.2 Results for Urban Areas

6.2.2.1 Impact on Diarrhea

Table 1-3 summarizes the results of the analysis of the effect of improved water and sanitation on health as measured by the incidence of childhood diarrhea in the previous two-week period in urban areas.

In the urban sample about 34% of children had diarrhea in the two week period preceding the interview (Table 1-1). Both flush toilets and pit latrines were associated with less diarrhea than if no sanitation facilities were present. The unadjusted effects were larger than the adjusted effects. The prevalence of diarrhea in the previous two weeks was 7.6 (3.3 to 11.9) percentage points higher among children with no improved sanitation than among those with a flush toilet available. Having a pit latrine was also associated with less diarrhea than no sanitation facilities, but this difference was not significant. The difference between a flush toilet and a pit latrine was 3.9 percentage points (0.2 to 7.6), which was significant.

The results from the logistic regression provided similar conclusions. Children without improved sanitation were 1.42 (1.16 to 1.74) times more likely to have had diarrhea in the previous two weeks than those with a flush toilet available. Children with a pit latrine were 1.16 (0.96 to 1.41) times more likely to have had diarrhea in the previous two weeks than those with no improved facility. Those with a pit latrine were 1.22 times (1.42/1.16) more likely to have had diarrhea in the last two weeks than those with a flush toilet.

For different types of water supplies, no significant differences were found in the prevalence of diarrhea or the risk of having diarrhea. The difference in diarrhea rates between improved water on the premises and an unimproved water supply was less than 1 percentage point. For a public water source versus an unimproved one, the difference was only 2.7 percentage points, which was not significant. The chance of having diarrhea was similar no matter what type of water people used.

Table 1-4 summarizes the results for those with diarrhea in the previous 24 hours in urban areas. About 17% of children had diarrhea in the 24 hours prior to the time of data collection. Because all children that had diarrhea in the previous 24 hours also had diarrhea in the previous two weeks, the results for the analysis of diarrhea in the previous 24 hours were analogous for those who had diarrhea in the previous two weeks.

As sanitation facilities were upgraded from none to pits to flush toilets the percent of children having diarrhea and the risk of diarrhea declined incrementally. The percent of children with diarrhea in the previous 24 hours was 5.6 (2.1 to 9.1) percentage points less if a flush toilet was present versus none and 2.8 (-0.5 to 6.1) percentage points less if a pit toilet was available versus none. The corresponding increase in risk of diarrhea was 1.46 (1.14 to 1.86) for flush toilets and 1.17 (0.93 to 1.47) for pit latrines. Those with pit latrines were 1.25 times more likely to have had diarrhea than children with flush toilets.

No significant associations were found between type of water supply and diarrhea in the past 24 hours, as none were found for diarrhea in the previous two weeks. Although no differences were found for water on the premises versus no improved water, those with a public water supply actually had more diarrhea (2.2; -1.7 to 6.1) than those without improved water supplies. But this difference was not statistically significant. Similarly, no increased risk of diarrhea was found when different types of water supplies were compared.

Table 1-3:

Effect of improved sanitation and water on the attributable and relative risk of having had diarrhea (14-day recall) among urban children in eight countries (Bolivia, Burundi, Ghana, Guatemala, Morocco, Sri Lanka, Togo, and Uganda).

	OLS		LOGISTIC	
	UNADJUSTED (n=4885)	ADJUSTED (n=4857)	UNADJUSTED (n=4885)	ADJUSTED (n=4857)
UNIMPROVED SANITATION VERSUS				
Flush	-0.109 (-0.146,-0.072)	-0.076 (-0.119,-0.033)	1.61 (1.36,1.89)	1.42 (1.16,1.74)
Pit	-0.081 (-0.120,-0.042)	-0.037 (-0.078, 0.004)	1.41 (1.19,1.67)	1.16 (0.96,1.41)
UNIMPROVED WATER VERSUS				
Premise	0.001 (-0.044, 0.046)	0.006 (-0.039, 0.051)	1.00 (0.81,1.22)	0.97 (0.78,1.21)
Public	-0.003 (-0.050, 0.044)	0.027 (-0.022, 0.076)	1.01 (0.82,1.26)	0.88 (0.69,1.11)

Table 1-4:

Effect of improved sanitation and water on the attributable and relative risk of having had diarrhea (24-hour recall) among urban children in eight countries (Bolivia, Burundi, Ghana, Guatemala, Morocco, Sri Lanka, Togo, and Uganda).

	OLS		LOGISTIC	
	UNADJUSTED (n=4885)	ADJUSTED (n=4857)	UNADJUSTED (n=4885)	ADJUSTED (n=4857)
UNIMPROVED SANITATION VERSUS				
Flush	-0.073 (-0.104,-0.042)	-0.056 (-0.091,-0.021)	1.59 (1.31,1.94)	1.46 (1.14,1.86)
Pit	-0.057 (-0.088,-0.026)	-0.028 (-0.061, 0.005)	1.42 (1.16,1.73)	1.17 (0.93,1.47)
UNIMPROVED WATER VERSUS				
Premise	-0.008 (-0.045, 0.029)	-0.002 (-0.039, 0.035)	1.05 (0.82,1.35)	1.02 (0.78,1.33)
Public	-0.006 (-0.045, 0.033)	0.022 (-0.017, 0.061)	1.04 (0.80,1.36)	0.85 (0.64,1.13)

6.2.2.2 Impact on Height-for-Age

Table 1-5 summarizes the results of the analysis of the effect of water and sanitation on nutritional status as measured by height-for-age in urban areas. Among urban children in the eight countries, the average height-for-age Z-score was -1.19 ± 1.45, and 27% of these children were considered to be stunted (Z-scores less than -2.00).

Improved sanitation was associated with improvements in height-for-age indices. For instance, an urban child that came from a family with a flush toilet had a height-for-age Z-score that was 0.604 (0.481 to 0.727) units higher than that of a child from a family without improved sanitation. This is equivalent to an increase in height of 1.82 cm (1.44 cm to 2.18 cm) for an 18 month old child. Correspondingly, a child from a family without a flush toilet available was 2.72 (2.17 to 3.40) times more likely to be stunted than one for whom a flush toilet was available.

A pit latrine was also associated with taller children. Children with a pit latrine had Z-scores that were 0.324 (0.208, 0.440) units higher than children without any improved sanitation facility. This difference corresponds to an increase in height of 1.0 cm (0.6 cm to 1.3 cm). Similarly, the risk of being stunted is 1.77 (1.44 to 2.17) times more for a child with unimproved sanitary facilities compared to those with a pit latrine. The difference in height-for-age Z-scores between those with a flush toilet and those with a pit latrine was 0.280 (0.175 to 0.385), and the increase risk of being stunted was 1.54 times more for children with a pit latrine compared to children with a flush toilet.

For improved water supplies, the benefits were much less than they were for sanitation. Children from a family with water on the premises had Z-scores that were 0.018 (-0.111 to 0.147) higher than those of children with an unimproved water source, whereas children from families with a public water supply were shorter (-0.065; -0.202 to 0.072 Z-scores) than those with an unimproved water source. Neither of these differences, which were small, were significant. The corresponding risk of being stunted was 1.14 (0.90 to 1.45) and 0.86 (0.67 to 1.10) for water on the premises and public water supplies, respectively, compared to those without an improved water supply.

Table 1-5:

Effect of improved sanitation and water on the height-for-age Z-scores and the relative risk of being stunted among urban children in eight countries (Bolivia, Burundi, Ghana, Guatemala, Morocco, Sri Lanka, Togo and Uganda).

	OLS		LOGISTIC	
	UNADJUSTED (n=4916)	ADJUSTED (n=4888)	UNADJUSTED (n=4916)	ADJUSTED (n=4888)
UNIMPROVED SANITATION VERSUS				
Flush	0.769 (0.657, 0.881)	0.604 (0.481, 0.727)	3.25 (2.73, 3.86)	2.72 (2.17, 3.40)
Pit	0.309 (0.193, 0.425)	0.324 (0.208, 0.440)	1.67 (1.41, 1.98)	1.77 (1.44, 2.17)
UNIMPROVED WATER VERSUS				
Premise	0.232 (0.095, 0.369)	0.018 (-0.111, 0.147)	1.44 (1.17, 1.77)	1.14 (0.90, 1.45)
Public	-0.062 (-0.207, 0.083)	-0.065 (-0.202, 0.072)	0.90 (0.72, 1.12)	0.86 (0.67, 1.10)

6.2.2.3 Impact on Weight-for-Age

Table 1-6 shows the effect of improvements in water and sanitation on the weight-for-age or urban children. Among urban children in the eight countries, the average weight-for-age Z-score was -0.79 ± 1.25, and nearly 16% of the children were considered to be underweight (Z-scores less than -2.00).

Improved sanitation was associated significantly with improvements in weight-for-age indices, but the effects were less than for height. A child that came from a family with a flush toilet in urban areas had a weight-for-age Z-score that was 0.309 (0.205 to 0.588) units higher than that of a child from a family without improved sanitation. This was equivalent to 0.371 kg (0.246 kg to 0.706 kg) more weight for an 18 month old child. Correspondingly, a child who came from a family without improved sanitation available was 1.95 (1.47 to 2.57) times more likely to be underweight than a child with a flush toilet available.

A pit latrine was also associated with heavier children. Children with pit latrines had Z-scores that were 0.143 (0.045 to 0.241) units higher than those of children without any improved sanitation facility. This difference corresponded to 0.172 kg (0.054 kg to 0.289 kg) in increased weight. Similarly, the risk of being underweight was 1.40 (1.10 to 1.78) times more for a child with unimproved sanitary facilities compared to those with a pit latrine. The difference in weight-for-age Z scores between those with a flush toilet and a pit latrine was 0.166 (0.077 to 0.255), and the increased risk of being underweight was 1.39 times more for children with a pit latrine compared to children with a flush toilet.

For improved water supplies, the benefits were again much less than they were for sanitation. Furthermore, the benefits were found only for those with water on the premises, not for those with an improved public water source. Children from a family with a water supply on the premises had Z-scores that were 0.079 (-0.031 to 0.189) units higher than those of children with an unimproved water source, whereas children from families with a public water supply were lighter (-0.041; -0.157 to 0.075 Z-scores) than those with an unimproved water source. Neither of these differences, which were small, were significant. The corresponding risk of being underweight was 1.24 (0.94 to 1.63) for those without an improved water supply compared to those with a supply on the premises and 1.03 (0.77 to 1.37) for those without a supply compared to those with access to public water supplies. Those with water on the premises were 0.120 kg (0.035 kg to 0.205 kg) heavier compared to those with access to an improved public water supply. This corresponds to an increase in the risk of being under weight of 1.20.

Table 1-6:

Effect of improved sanitation and water on the weight-for-age Z-scores and the relative risk of being under weight among urban children in eight countries (Bolivia, Burundi, Ghana, Guatemala, Morocco, Sri Lanka, Togo and Uganda).

	OLS		LOGISTIC	
	UNADJUSTED (n=4916)	ADJUSTED (n=4888)	UNADJUSTED (n=4916)	ADJUSTED (n=4888)
UNIMPROVED SANITATION VERSUS				
Flush	0.461 (0.365, 0.557)	0.309 (0.205, 0.588)	2.23 (1.80, 2.76)	1.95 (1.47, 2.57)
Pit	0.024 (-0.076, 0.124)	0.143 (0.045, 0.241)	1.08 (0.88, 1.32)	1.40 (1.10, 1.78)
UNIMPROVED WATER VERSUS				
Premise	0.222 (0.104, 0.340)	0.079 (-0.031, 0.189)	1.62 (1.26, 2.08)	1.24 (0.94, 1.63)
Public	-0.140 (-0.263,-0.017)	-0.041 (-0.157, 0.075)	0.89 (0.69, 1.15)	1.03 (0.77, 1.37)

6.2.2.4 Impact on Weight-for-Height

Table 1-7 shows the effect of water and sanitation on the weight-for-height of urban children. In the urban sample, few children were considered to be thin (or wasted). The average weight-for-height Z-score was -0.04, well within the normal range, and only 3.2% were considered wasted, less than -2.00 Z-scores. In the reference population about 2.5 percent of children would be expected to be below -2.00 standard deviations.

Because of the low rates of wasting or thinness, neither improved sanitation nor improved water had much of an effect on weight-for-height Z-scores, or the risk of being wasted. Both flush toilets and pit latrines were associated with weight-for-height Z-scores about 0.05 less than if no sanitation was available. For weight-for-height it did not matter if flush or pit toilets were available, as there was no difference between the two types of facilities on weight-for-height Z-scores. Similarly, there was no difference in the risk of being wasted according to the type of sanitation facility.

Water on the premises had a larger effect on weight-for-height Z-scores than did sanitation. The difference between those children with water on or in the premises and those without an improved water supply was 0.098 (-0.002 to 0.198) Z-scores. This is equivalent to 78 g (-1.6 g to 158 g) for a child 80 cm in length. The corresponding risk of being wasted was 1.36 (0.78 to 2.39). A public water supply resulted in similar weight-for-height Z-scores compared to those without an improved water supply, and the increased risk was near one, indicating that public water supplies were not protective against thinness relative to unimproved water supplies. The lack of more positive findings for weight-for-height should not be interpreted as a failure of improved water and sanitation to affect weight-for-height, but rather that no intervention would be likely to affect weight-for-height because it is already within a normal range.

Table 1-7:

Effect of improved sanitation and water on the weight-for-height Z-scores and the relative risk of being wasted among urban children in eight countries (Bolivia, Burundi, Ghana, Guatemala, Morocco, Sri Lanka, Togo and Uganda).

	OLS		LOGISTIC	
	UNADJUSTED (n=4916)	ADJUSTED (n=4888)	UNADJUSTED (n=4916)	ADJUSTED (n=4888)
UNIMPROVED SANITATION VERSUS				
Flush	0.016 (-0.068, 0.100)	-0.052 (-0.146, 0.042)	1.24 (0.79, 1.95)	0.94 (0.52, 1.68)
Pit	-0.187 (-0.275,-0.099)	-0.056 (-0.146, 0.034)	0.90 (0.57, 1.39)	1.08 (0.65, 1.80)
UNIMPROVED WATER VERSUS				
Premise	0.116 (0.014, 0.218)	0.098 (-0.002, 0.198)	1.52 (0.90, 2.58)	1.36 (0.78, 2.39)
Public	-0.107 (-0.217, 0.003)	0.017 (-0.089, 0.123)	0.78 (0.46, 1.32)	1.03 (0.58, 1.82)

6.2.3 Results for Rural Areas

6.2.3.1 Impact on Diarrhea

In rural areas about 30% of children had diarrhea in the previous two weeks and 16% in the 24 hours preceding the survey. These rates were similar to those found in the urban sample.

In rural areas the effect of improved water and sanitation on diarrhea was virtually nil. The differences in diarrhea, whether in the previous 24 hours or two weeks, between any type of system (e.g., flush versus pit versus none) were less than 1 percentage point. Correspondingly, no increase or decrease in risk of diarrhea was found.

Table 1-8 summarizes the results of the analysis of the effect of improved water and sanitation on health as measured by the prevalence of childhood diarrhea in the previous two weeks and Table 1-9 in the previous 24 hours among rural children.

Table 1-8:

Effect of improved sanitation and water on the attributable and relative risk of having had diarrhea (14-day recall) among rural children in eight countries (Bolivia, Burundi, Ghana, Guatemala, Morocco, Sri Lanka, Togo and Uganda).

	OLS		LOGISTIC	
	UNADJUSTED (n=12158)	ADJUSTED (n=12025)	UNADJUSTED (n=12158)	ADJUSTED (n=12025)
UNIMPROVED SANITATION VERSUS				
Flush	-0.095 (-0.124,-0.066)	-0.002 (-0.035, 0.031)	1.61 (1.38,1.87)	1.01 (0.84,1.21)
Pit	-0.059 (-0.077,-0.041)	0.001 (-0.021, 0.023)	1.33 (1.22,1.44)	0.99 (0.89,1.11)
UNIMPROVED WATER VERSUS				
Premise	0.027 (-0.002, 0.056)	0.008 (-0.023, 0.039)	0.88 (0.76,1.01)	0.96 (0.81,1.12)
Public	0.019 (0.001, 0.037)	0.012 (-0.006, 0.030)	0.91 (0.84,0.99)	0.94 (0.85,1.04)

Table 1-9:

Effect of improved sanitation and water on the attributable and relative risk of having had diarrhea (24-hour recall) among rural children in eight countries (Bolivia, Burundi, Ghana, Guatemala, Morocco, Sri Lanka, Togo and Uganda).

	OLS		LOGISTIC	
	UNADJUSTED (n=12158)	ADJUSTED (n=12025)	UNADJUSTED (n=12158)	ADJUSTED (n=12025)
UNIMPROVED SANITATION VERSUS				
Flush	-0.044 (-0.068,-0.020)	0.011 (-0.016, 0.038)	1.36 (1.14, 1.63)	0.90 (0.73, 1.12)
Pit	-0.054 (-0.068,-0.040)	-0.004 (-0.022, 0.014)	1.48 (1.34, 1.64)	1.04 (0.91, 1.19)
UNIMPROVED WATER VERSUS				
Premise	0.040 (0.016, 0.064)	0.006 (-0.019, 0.031)	0.75 (0.64, 0.89)	0.97 (0.80, 1.17)
Public	0.014 (0.000, 0.028)	-0.003 (-0.019, 0.013)	0.90 (0.81, 1.00)	1.02 (0.91, 1.16)

6.2.3.2 Impact on Height-for-Age

Table 1-10 shows the association between height-for-age and improvements in water and sanitation among rural children. The height-for-age values for rural children were less than for urban children. The mean Z-score was -1.69, and 41% of the children were considered to be stunted (less than -2.00 Z-scores). These levels of nutritional status are considerably lower than for urban children.

Improved sanitation was associated with better height-for-age Z-scores. The Z-scores of children with a flush toilet were 0.336 (0.236 to 0.436) higher than those of children with no improved sanitation. This corresponded to a difference in height of 1.01 cm (0.71 cm to 1.31 cm). Similarly, the increased risk of being stunted was 1.69 (1.41 to 2.02). The effect of a pit latrine on the height of children was also significant, but less so than for flush toilets. Children with a pit latrine had Z-scores that were 0.114 (0.051 to 0.177) higher than those of children without improved sanitation. This corresponded to a 0.342 cm (0.153 cm to 0.531 cm) increase in height. The difference between a flush toilet and a pit latrine was 0.222 (0.120 to 0.324) Z-scores, which was also significant. This corresponded to a difference in height of 0.67 cm (0.36 cm to 0.97 cm). The increased risk of being stunted with a pit latrine compared to a flush toilet was 1.46.

Improved water supplies also had a positive effect on the height of children, but the effect was less than for improved sanitation. For example, water on the premises was associated with 0.162 (0.070 to 0.254) higher Z-scores than if no improved water supplies were available. This was equivalent to 0.49 cm (0.21 cm to 0.76 cm) in height. The risk of being stunted was elevated for those without improved water supplies compared to those with water on the premises, 1.19 (1.01 to 1.39), but the level of risk was comparable to the elevated risk of pit latrines. A public water supply, although associated with taller children, was not significantly different from not having an improved water supply.

Table 1-10:

Effect of improved sanitation and water on the height-for-age Z-scores and the relative risk of being stunted among rural children in eight countries (Bolivia, Burundi, Ghana, Guatemala, Morocco, Sri Lanka, Togo and Uganda).

	OLS		LOGISTIC	
	UNADJUSTED (n=12122)	ADJUSTED (n=11992)	UNADJUSTED (n=12122)	ADJUSTED (n=11992)
UNIMPROVED SANITATION VERSUS				
Flush	0.637 (0.541, 0.733)	0.336 (0.236, 0.436)	2.57 (2.20, 2.99)	1.69 (1.41, 2.02)
Pit	-0.001 (-0.056, 0.054)	0.114 (0.051, 0.177)	1.00 (0.93, 1.08)	1.16 (1.05, 1.29)
UNIMPROVED WATER VERSUS				
Premise	0.124 (0.032, 0.216)	0.162 (0.070, 0.254)	1.09 (0.96, 1.24)	1.19 (1.01, 1.39)
Public	0.070 (0.013, 0.127)	0.027 (-0.028, 0.082)	1.05 (0.98, 1.14)	1.03 (0.94, 1.13)

6.2.3.3 Impact on Weight-for-Age

Table 1-11 shows the effect of water and sanitation improvements on weight-for-age of rural children. Among rural children the average weight-for-age Z-score was -1.32, which was 0.53 Z-scores lower than for urban children. The percent of children considered to be underweight was 29% in the rural sample versus 16% among urban children.

Weight-for-age of children was made significantly better by improvements in sanitation, both flush and pit systems. For flush toilets, children in Z-scores were 0.280 (0.198 to 0.362) higher than if no sanitation was available. This is equivalent to 0.34 kg (0.24 kg to 0.43 kg) more in weight for a child 18 months of age. A child without improved sanitation was 1.38 (1.14 to 1.66) times more likely to be underweight than a child whose family had a flush toilet. For a pit latrine the improvement in Z-scores was 0.090 (0.037 to 0.143) compared to no sanitation system. This translated to a difference in weight of 0.11 kg (0.04 kg to 0.17 kg). The corresponding risk of being underweight was 1.11 (0.99 to 1.24). The difference in weight-for-age Z-scores between children with a flush toilet and a pit latrine was 0.190 (0.105 to 0.275). This translated to a difference in weight of 0.23 kg (0.13 kg to 0.33 kg). The increased risk of being underweight between a flush toilet and a pit latrine was 1.24.

Of the improvements in water supply, only water on the premises was associated significantly with improvements in weight-for-age of children. If water was on the premises children had Z-scores that were 0.159 (0.081 to 0.237) higher than if improved water was unavailable. This is equivalent to a difference in weight of 0.19 kg (0.10 kg to 0.28 kg). The increase in risk associated with a water supply on the premises was 1.35 (1.14 to 1.61). A public water supply was not associated with differences in weight-for-age when these children were compared to children without an improved water supply. However, a significant difference was found between those children with a water supply on the premises versus those children with a public water supply. For instance, the difference in weight-for-age Z-scores was 0.135 (0.062 to 0.208). This translated to a difference in weight of 0.162 kg (0.074 kg to 0.25 kg) for an 18 month old child. Correspondingly, the increased risk of being underweight was 1.26.

Table 1-11:

Effect of improved sanitation and water on the weight-for-age Z-scores and the relative risk of being underweight among rural children in eight countries (Bolivia, Burundi, Ghana, Guatemala, Morocco, Sri Lanka, Togo and Uganda).

	OLS		LOGISTIC	
	UNADJUSTED (n=12122)	ADJUSTED (n=11992)	UNADJUSTED (n=12122)	ADJUSTED (n=11992)
UNIMPROVED SANITATION VERSUS				
Flush	0.265 (0.185, 0.345)	0.280 (0.198, 0.362)	1.38 (1.18, 1.62)	1.38 (1.14, 1.66)
Pit	-0.121 (-0.166,-0.076)	0.090 (0.037, 0.143)	0.86 (0.79, 0.93)	1.11 (0.99, 1.24)
UNIMPROVED WATER VERSUS				
Premise	0.355 (0.277, 0.433)	0.159 (0.081, 0.237)	1.70 (1.46, 1.98)	1.35 (1.14, 1.61)
Public	0.107 (0.060, 0.154)	0.024 (-0.023, 0.071)	1.16 (1.06, 1.26)	1.07 (0.97, 1.17)

6.2.3.4 Impact on Weight-for-Height

Table 1-12 shows the relationship between water and sanitation improvements and the weight-for-height of rural children. In the rural areas, children's weight-for-height Z-scores were -0.31 with only 5.1% considered to be moderately or severely wasted. These values were within a normal range (2.8% to 7.4%). Nevertheless, benefits in weight-for-height were found for improvements in both sanitation and water, but only for flush toilets and water on the premises. For flush toilets, weight-for-height Z-scores were 0.078 (0.005, 0.151) units higher compared to no improved sanitation. This translated to 62 g (4 g to 121 g) for a child 80 cm in length. The risk of being wasted was 1.41 for children without sanitation versus those with a flush toilet. No significant difference was found for children with a pit latrine compared to those with no sanitation. Although children with a flush toilet had higher weight-for-height Z-scores than children with a pit latrine, this difference was not significant.

Water on the premises and public water were associated with better weight-for-height Z-scores, but these differences were not statistically significant.

Table 1-12:

Effect of improved sanitation and water on the weight-for-height Z-scores and the relative risk of being wasted among rural children in eight countries (Bolivia, Burundi, Ghana, Guatemala, Morocco, Sri Lanka, Togo and Uganda).

	OLS		LOGISTIC	
	UNADJUSTED (n=12122)	ADJUSTED (n=11992)	UNADJUSTED (n=12122)	ADJUSTED (n=11992)
UNIMPROVED SANITATION VERSUS				
Flush	-0.179 (-0.250,-0.108)	0.078 (0.005, 0.151)	0.81 (0.62, 1.08)	1.41 (1.02, 1.97)
Pit	-0.143 (-0.182,-0.104)	0.021 (-0.024, 0.066)	1.01 (0.85, 1.20)	1.17 (0.94, 1.46)
UNIMPROVED WATER VERSUS				
Premise	0.360 (0.293, 0.427)	0.081 (-0.014, 0.148)	1.66 (1.19, 2.30)	0.84 (0.58, 1.22)
Public	0.092 (0.051, 0.133)	0.019 (-0.020, 0.058)	1.11 (0.94, 1.32)	1.00 (0.83, 1.22)

6.3 Objective 2

6.3.1 Summary Data on Water Collection Times

Data sets from Burundi, Morocco and Sri Lanka contained information on the round trip time to collect water. The data from the three countries were combined and analyzed by urban and rural residence.

Table 2-1 shows the number of urban and rural children in families with various round-trip water collection times. In urban areas, about one-third of those who collected water spent less than five minutes or less in round-trip water collection time. Children whose families spent from 5 to 29 minutes collecting water comprised nearly 50% of the urban sample. Only 16% urban children came from families which reported that round trip travel time took 30 minutes or more. In rural areas, 16% of residents obtained their water within five minutes, and an additional 44% obtained their water within five to 29 minutes. Forty percent of rural residents spent 30 minutes or more in round trip water collection time.

Table 2-1: Number of children according to travel time to collect water and return in urban and rural areas, based on data from Burundi, Morocco, and Sri Lanka

Time	Urban	Rural
<5 minutes	260	784
5-29 minutes	397	2140
≥30 minutes	123	1938

6.3.2 Urban Areas

Table 2-2 shows the health parameters of children in urban areas. Fifteen percent of the children were reported to have had diarrhea in the previous 24 hours, and 29% in the previous two weeks. Nearly one in four children were stunted, one in five underweight, and seven percent wasted. Generally, the group with the best health status was comprised of children whose water was on the premises (less than five minutes round-trip collection time). This was true for diarrhea and height-for-age, but less so for weight-for-age and weight-for-height. For diarrhea in the previous 24 hours, the percent was 37% less when round trip water collection time was less than five minutes compared to 30 minutes or more. For diarrhea in the previous two weeks, the percent reduction was 43%. For height-for-age, the difference in Z-scores was 0.434, and 46% fewer children were stunted when round trip water collection time was less than 5 minutes versus 30 minutes or more. Little difference in health, however, appeared to occur when water was 5-29 minutes versus 30 minutes or more from the home.

Table 2-2: Unadjusted rates of diarrhea and nutritional status according to round trip time to collect water among 760 children 3-36 months of age in urban areas, based on data from Burundi, Morocco, and Sri Lanka

Indicator	Round trip travel time (minutes) <5	5-29	≥30	All
Sample size	(260)	(377)	(123)	(760)
Diarrhea				
last 14 days	21.2%	32.4%	37.4%	29.3
last 24 hours	11.2%	17.0%	17.9%	15.1
Nutritional status: Z-score				
Height/age	-0.818* (1.266)	-1.271 (1.408)	-1.252 (1.573)	-1.113 (1.404)
Weight/age	-0.865 (1.228)	-0.995 (1.262)	-0.978 (1.140)	-0.948 (1.232)
Weight/height	-0.422 (1.129)	-0.246 (1.140)	-0.245 (1.080)	-0.306 (1.128)
Nutritional status: Percent <-2 Z-scores				
Stunted	15.7%	28.9%	28.9%	24.4%
Underweight	16.9%	20.5%	18.2%	18.9%
Wasted	6.7%	7.0%	5.0%	6.6%

* Mean (Standard deviation)

These results were not adjusted for potential confounding variables. The adjusted results are shown in table 2-3. The differences between groups were attenuated after adjusting for potential confounding variables.[1] In general, those with the briefest round trip collection time (< 5 minutes) had the best health parameters with one exception, diarrhea in the last 24 hours.

The only significant difference found between any health parameters and round trip water collection time, however, was for height-for-age Z-scores and

1 Variables considered when adjusting for differences in round trip water collection time were: maternal education, pregnancy status, marital status, mother's age, household size, possession of radio, car, motorcycle, type of floor, presence of another child under 5 years of age, husbands profession, type of sanitation, child's age and sex, birth order, proportion of life breast fed, previous and subsequent birth interval less than 18 months, whether or not the child was a twin, and a dummy code for the country.

proportion stunted. For height-for-age Z-scores, the difference between those children in the less than five minute group and those in the 5-29 minute group was 0.293 (0.051 to 0.535). This is equivalent to a difference of 0.879 cm (0.153 cm to 1.605 cm). The difference in Z-scores between those closest and farthest was 0.258 (-0.058 to 0.574). For the proportion of children who were stunted, 11.8% (1.7% to 21.8%) fewer children were stunted when round trip collection time was less than five minutes versus 30 or more minutes. This is equivalent to 40% reduction in the proportion of stunted children. A significant difference was also found between the two closest times, a difference of 9.1% (1.5% to 16.7%). The percent reduction in the proportion of stunted children from the 5-29 minutes group to the less than 5 minute group was 33.7%.

Table 2-3: Adjusted rates of diarrhea and nutritional status according to round trip time to collect water among children 3-36 months of age in urban areas, based on data from Burundi, Morocco, and Sri Lanka

Indicator	Round trip travel time (minutes) 0-5	6-30	+30
Diarrhea			
last 14 days	27.3%	29.7%	31.3%
last 24 hours	16.2%	14.7%	14.0%
Nutritional status: Z-score			
Height/age	-0.812*	-1.105	-1.070
Weight/age	-0.851	-0.979	-1.067
Weight/height	-0.097	-0.081	-0.198
Nutritional status: Percent <-2 Z-scores			
Stunted	17.9%	27.0%	29.7%
Underweight	15.3%	20.4%	21.4%
Wasted	5.2%	7.6%	7.5%

For diarrhea in the previous two weeks, the percent difference from longest (≥30 minutes) to briefest (<5 minutes) round trip collection time was 3.9% (-6.4% to 14.3%). This is equivalent to a 12.8% reduction in diarrhea. For the proportion of underweight children, the difference was 6.1% (-3.2% to 15.4%), equivalent to a reduction in underweight children of 28.5%. For wasting, the difference was 2.4% (-3.5% to 8.3%), which was a 30.7% reduction in proportion of wasted children.

In summary, in urban areas, water on the premises was associated with better health compared to water five or more minutes from the home. The difference in health was little when those with round-trip water collection times of 5-30 minutes were compared to those with round-trip collection times of more than 30 minutes.

6.3.3 Rural Areas

Table 2.4 shows that the travel time to collect water was an important determinant of health status in rural areas. The lowest rates of diarrhea and chronic malnutrition were found among those who spent less than five minutes collecting water. This was to be expected, given the importance of water on the premises compared to other types of supplies, and the fact that these values were not adjusted for potential confounding variables. The adjusted values (see footnote on page 41) are shown in table 2.5.

Table 2-4: Unadjusted rates of diarrhea and nutritional status according to round trip time to collect water among 4862 children 3-36 months of age in rural areas, based on data from Burundi, Morocco, and Sri Lanka

Indicator	Round trip travel time (minutes) 0-5	6-30	30-60	Total
Sample size	(784)	(2140)	(1938)	(4862)
Diarrhea				
last 14 days	12.1%	22.4%	29.4%	23.5%
last 24 hours	6.3%	12.9%	16.6%	13.3%
Nutritional status: Z-score				
Height/age	-1.218* (1.237)	-1.593 (1.446)	-1.628 (1.485)	-1.550 (1.439)
Weight/age	-1.448 (1.111)	-1.431 (1.228)	-1.380 (1.262)	-1.412 (1.225)
Weight/height	-0.856 (0.949)	-0.530 (1.090)	-0.432 (1.049)	-0.540 (1.062)
Nutritional status: Percent <-2 Z-scores				
Stunted	23.0%	37.3%	40.4%	36.4%
Underweight	32.6%	32.8%	31.7%	32.3%
Wasted	9.5%	8.0%	6.2%	7.5%

* Mean (Standard deviation)

Significant differences were found for both diarrhea and nutritional status. Those with the briefest water collection times (less than five minutes) had less diarrhea and better nutritional status, and as time to collect water increased so did diarrhea and nutritional status deteriorated. For diarrhea in the last 14 days, 3.1% (0.6% to 5.7%) fewer children had diarrhea when water collection time was less than 30 minutes compared to 30 minutes or more. This is equivalent to a 12% reduction in diarrhea. No difference was found between children whose family water collection time was less than five minutes versus five to 29 minutes.

Table 2-5: Adjusted rates of diarrhea and nutritional status according to round trip time to collect water among children 3-36 months of age in rural areas, based on data from Burundi, Morocco, and Sri Lanka

Indicator	Round trip travel time (minutes) 0-5	6-30	30-60
Sample size	(784)	(2140)	(1938)
Diarrhea			
last 14 days	22.3%	22.2%	25.4%
last 24 hours	12.2%	12.1%	12.9%
Nutritional status: Z-score			
Height/age	-1.438*	-1.569	-1.575
Weight/age	-1.327	-1.426	-1.455
Weight/height	-0.208	-0.216	-0.239
Nutritional status: Percent <-2 Z-scores			
Stunted	33.2%	36.2%	37.2%
Underweight	30.9%	32.8%	33.3%
Wasted	6.2%	8.2%	7.5%

For height-for-age, the biggest difference in Z-scores (0.138; -0.001 to 0.276) was between children whose families round trip time was less than five minutes versus those children whose families round trip collection time was 30 minutes or more. This is equivalent to a 0.4 cm difference (0.1 cm to 0.8 cm), or 10% of the deficit in height for the average child in the sample. A significant difference in Z--scores, 0.131 (0.003 to 0.259), was found between the briefest group (< 5 minutes) and the intermediate group (5-29 minutes). No differences were found between five to 29 minutes and 30 or more minutes. Significant differences were also found for weight-for-age. From the longest to the briefest water collection times, the difference was 0.128 Z-scores (0.015 to 0.240). This is equivalent to 154 g (18 g to 288 g). A similar difference 0.099 (-0.005 to 0.203) in Z-scores was found for the group with round trip collection time of less than five minutes versus five to 29 minutes, a difference equivalent to 119 g (-6 g to 244 g).

In summary, in rural areas a clear trend toward better health was found as the time spent collecting water was reduced. The benefits were measured in both diarrhea and linear growth. The benefits also increased in magnitude the less time people spent collecting water.

6.4 Objective 3

To analyze the data for this objective four categories of children were created with two variables, GOODWAT AND NGOODWAT. GOODWAT refers to the source of drinking water; if it is improved, it is labelled yes, if unimproved it is labelled no. NGOODWAT refers to the source of non-drinking water. If it is improved, it is labelled yes, and if it is unimproved it is labelled no. The best situation is use of an improved water supply for drinking and non-drinking purposes. This is labelled as GOODWAT=YES and NGOODWAT=YES in Tables 3-1 and 3-2. The worst situation is no improved water for drinking or any other purpose. This is labelled as GOODWAT=NO and NGOODWAT=NO. Between these two extremes are children with an improved source of drinking water/unimproved source of non-drinking water (GOODWAT=YES/NGOODWAT=NO) and an unimproved drinking water source/improved non-drinking water source (GOODWAT=NO/ NGOODWAT=YES). The latter group comprises only a few children in most countries, while the first group comprises the majority. Results from the multi-country analyses for Objective 3 are reported here.

Tables 3-1 (urban areas) and 3-2 (rural areas) show the results for all eight health outcomes for the four water supply groups. Because the number in the two groups that used a combination of improved and unimproved supplies were small, even after combining data from all countries, more stable estimates of the effects on diarrhea and nutritional status may be found by comparing the two extremes: those using improved supplies exclusively and those with no improved supplies. Thus, the analysis will be confined to comparing the group with unimproved water supply for all water needs and the group with improved water supplies for all water needs.

In the urban areas (Table 3-1) the vast majority of children had an improved water supply for drinking and non-drinking water needs (87%). The majority of the rest of the children had unimproved water for drinking and non-drinking needs (8%). The rates of diarrhea were lower and nutritional status was better in the improved group compared to the unimproved group for all countries and all indices. The differences, however, were generally small and not statistically significant. Diarrhea in the previous 14 days was one percentage point less in the improved group and 1.6 percentage points less for diarrhea in the previous 24 hours. The reduction in diarrhea from the unimproved to the improved group was 3% for diarrhea in the last 14 days and 8% for diarrhea in the previous 24 hours, again small differences.

For nutritional status, Z-scores for all indices were less in the improved group compared to the unimproved group, but none of the differences was statistically significant. The difference for height-for-age Z-scores was 0.12 (-0.02 to 0.26), for weight-for-age Z-scores it was 0.11 (-0.01 to 0.23) and for weight-for-height Z-scores it was 0.07 (-0.04 to 0.18). The percent of children stunted and underweight was significantly less in the improved group compared to the unimproved group. The difference for stunting was 4.6 percentage points (0.1 to 9.1) and for underweight 4.7 (1.0 to 8.4) percentage points. The corresponding difference in percent reduction was 15% for stunting and 24% for being underweight. These indices may be more indicative of the cumulative insults to health that occur in the unimproved group compared to the improved group. No significant differences in weight-for-height Z-scores or percent wasted was found, even though the degree of thinness or wasting was less in the improved group compared to the unimproved group.

In the rural areas (Table 3-2) the majority of children had improved water for drinking and non-drinking needs (51%) or an unimproved water supply for all water needs (35%). Little difference in diarrhea or nutritional status was found between those with an improved water supply for drinking and non-drinking needs compared to those with an unimproved water supply for drinking and non-drinking needs. Diarrhea rates were less in the unimproved group compared to the improved group, but these differences were small and insignificant.

For nutritional status among rural children, the only indicator that was significantly different in the improved group compared to the unimproved group was weight-for-age, with a difference in the percent being underweight of 4.8 percentage points (3.0 to 6.6). This was equivalent to a reduction of 15%. Although the other indices were better in the improved group none of the differences were statistically significant.

Table 3.1:

Comparison of use of improved and unimproved water sources for drinking and non-drinking needs among 4918 urban children, 3-36 months of age in 8 countries: Bolivia, Burundi, Ghana, Guatemala, Morocco, Sri Lanka, Togo and Uganda.

HEALTH OUTCOME	GOODWAT= No NGOODWAT= No (n=408)	GOODWAT= No NGOODWAT=Yes (n= 95)	GOODWAT=Yes NGOODWAT= No (n=139)	GOODWAT=Yes GOODWAT=Yes (n=4276)
DIAR14D	34.9%	28.5%	24.5%	33.9%
DIAR24	19.4%	14.7%	15.8%	17.8%
HTAGEZ	-1.295 (1.490)	-1.385 (1.513)	-1.434 (1.733)	-1.173 (1.346)
WTAGEZ	-0.885 (1.246)	-0.868 (1.481)	-1.110 (1.305)	-0.774 (1.169)
WTHTZ	-0.095 (1.094)	0.015 (0.989)	-0.261 (1.150)	-0.027 (1.095)
STUNTED	30.9%	29.4%	40.1%	26.3%
UNDERWT	19.9%	14.8%	21.9%	15.2%
WASTED	4.2%	1.0%	6.6%	3.0%

Table 3.2:

Comparison of the use of improved and unimproved water sources for drinking and non-drinking needs among 12,138 rural children, 3-36 months of age in 8 countries: Bolivia, Burundi, Ghana, Guatemala, Morocco, Sri Lanka, Togo and Uganda

HEALTH OUTCOME	GOODWAT= No NGOODWAT= No (n=4196)	GOODWAT= No NGOODWAT=Yes (138)	GOODWAT=Yes NGOODWAT= No (n=1668)	GOODWAT=Yes GOODWAT=Yes (n=6136)
DIAR14D	27.7%	29.0%	28.0%	30.3%
DIAR24	15.2%	14.5%	17.5%	16.9%
HTAGEZ	-1.748 (1.481)	-1.458 (1.460)	-1.694 (1.763)	-1.650 (1.433)
WTAGEZ	-1.419 (1.223)	-1.266 (1.317)	-1.323 (2.077)	-1.252 (1.290)
WTHTZ	-0.400 (0.975)	-0.413 (1.053)	-0.305 (1.703)	-0.255 (1.114)
STUNTED	42.3%	26.1%	41.2%	40.1%
UNDERWT	32.3%	29.0%	29.1%	27.5%
WASTED	5.7%	4.3%	5.6%	4.6%

7. DISCUSSION

7.1 Strengths and Weaknesses of the Analysis

This study had several advantages over other studies reporting on water and sanitation and their health effects on young children. First, because eight countries were studied, the sample sizes were large. For this reason, non-significant differences cannot be discounted because of the small sizes of the sample. Surprisingly, when statistically significant differences were found, the magnitudes of the differences were important biologically. For example, an average difference in height of 1.0 cm, found among children with sanitation compared to those without, is a large difference; differences of such magnitude are not always found following nutrition interventions.

Confounding variables were controlled in the analyses for Objectives 1 and 2. Although it is impossible to measure or even control for all confounding factors, the major confounding variables identified in other studies were controlled in this study. The adjusted effects were nearly always less than the unadjusted effects, sometimes the effects were cut in half. Nevertheless, the differences were still significant and relevant for policy considerations.

The results held up across eight different locations in three different continents, under very diverse climates, religions, altitudes, seasons, and other factors. The rates of diarrhea varied from under 5% to nearly 50% in some settings, and the rates of malnutrition also varied widely. Thus, the results suggest that improved sanitation could have important health benefits in diverse locations with different health status of populations. Similarly, benefits from water piped to the premises should be realizable in a variety of locations.

One weakness, common to all studies of water and sanitation, was that people who have certain water and sanitation conditions were not randomized into one or another group. This requires a control for confounding. While confounding was controlled, it is never possible to know if all important confounding variables were adequately controlled. Also, the countries included in these analyses were not randomly selected from a large number of countries. Countries with Demographic and Health Surveys are countries where the USAID has programs. These may not be representative of all countries in the developing world.

A cross-sectional survey is sometimes not as powerful as a longitudinal study. Longitudinal studies allow for the measurement of incidence and severity of diarrhea, or other diseases, as well as growth of children. Cross-sectional data may, therefore, miss important health effects, not because they were not present, but because the studies were not designed to measure severity and incidence of health events.

Although health benefits from water on the premises were found, it was not known if these benefits were due to improvement in the quality of water or to the use of more copious quantities of water. Evidence from other studies suggest that use of water for hygiene is more important than quality of drinking water (Esrey et al, 1991).

Although one of the major benefits of, or justifications for, installing improved water and sanitation in developing countries is to reduce the diarrheal disease burden, there are two problems with relying on diarrhea data to demonstrate health impacts. First, data on diarrhea prevalence may be too insensitive to measure changes in incidence or severity of diarrhea. Second, because diarrhea is only one of several reported health benefits from improvements in water and sanitation, relying on diarrhea data alone could underestimate the health benefits from these improvements. Anthropometry, which is a more comprehensive measure of child health, may be more sensitive than diarrhea.

Access to and use of improved sanitation facilities are not synonymous. It is reasonable to assume that in households with improved facilities available, their use by all family members, including the young children, is unlikely. Thus, encouraging use of the facilities by all family members at all times, including the appropriate disposal of feces of young children, should increase the magnitude of the health effects from sanitation improvements.

7.2 Policy Implications and Recommendations

Present policies for intervening with water and sanitation should be reconsidered. Several issues should be addressed in light of the above findings of this study.

- First, improved sanitation appears to be overwhelmingly of more benefit to health than improving water supplies.

- Second, flush toilets are better than pit latrines, even though pit latrines have important benefits also.

- Third, if water supplies are to be improved, strong consideration should be given to providing piped water on the premises. This is particularly true in urban areas.

- Fourth, public water supplies have marginal health benefits at best and the policy of providing only public water supplies should be reconsidered.

- Fifth, bringing water close to people's home is important in rural areas. Ideally, water should be brought to the household, but, at a minimum, if it takes more than 30 minutes to collect water, that time should be reduced.

- Sixth, improved water supplies may not be required for all water needs. However, it is difficult to know if the benefits of water close to the home are due to improvements in the quality of water consumed or increases in the amount of water used for hygienic purposes.

7.3 Operational Suggestions for CIDA and Other External Support Agencies

When planning and designing future water and sanitation projects, the following suggestions should be considered.

- Future water supply projects should require a sanitation component.

- Anthropometric indices, particularly height-for-age, are more sensitive indicators of overall health improvements than is diarrhea. Thus, in future projects, anthropometry should be required as a measurement for evaluation.

7.4 Recommendations for Future Study

- The limitations of this study do not permit conclusions to be made about the differential effects of water quality versus water quantity, or even personal hygiene practices. Previous research suggests that water quality is less important than water quantity, and this may be reflected by the benefits of water near or in the home, but not for intermediate levels of service. Nevertheless, this should be investigated in future research projects.

- Although reducing the time for collecting water was associated with health benefits, it was not known how this savings in time was translated into better child health. Possible mechanisms could be a) more time for child care, including breast-feeding and weaning practices; b) more time for income-generating activities that allow for the purchase of better health care or better diets or both; and c) more time to learn about new ways to care for children (e.g., attend clinics) or participate in activities designed to improve child health (e.g., attend mother's clubs). The way in which women use their time and energy that are saved should be explored.

REFERENCES

Advanced Graphics Software, Slide Write for Windows, Version 1.10. Carlsbad, CA, 1992.

Burger SE, Esrey SA. Water and sanitation: health and nutrition benefits to children, Chapter 9. In: Beyond Child Survival: Enhancing child growth and nutrition in developing countries, Ed. by, P Pinstrup-Andersen, D Pelletier, H Aldermann, Cornell University Press (In Press), 1994.

Conceptual Systems Software. DBMS/COPY Plus 3.0. SPSS Inc, Chicago, IL 1991.

Diaz E, Hurtado E, Ramirez V, et al. Energy expenditure in Guatemalan rural women: the effect of water availability, FASEB, 1994.

Dibley MJ, Staehling N, Nieburg P, et al. Interpretation of Z-score anthropometric indicators derived from the international growth reference. American Journal of Clinical Nutrition, 1987;46:749-762.

Dibley MJ, Goldsby JB, Staehling NW, et al. Development of normalized curves for the international growth reference: historical and technical considerations. American Journal of Clinical Nutrition, 1987;46:749-762

Esrey SA, Feachem RG, Hughes JM. Interventions for the control of diarrhoeal diseases among young children: improving water supplies and excreta disposal facilities. Bulletin of the World Health Organization, 63(4):757-772.

Esrey SA, Potash J, Roberts L, et al. Effects of improved water supply and sanitation on ascariasis, diarrhoea, dracunculiasis, hookworm infection, schistosomiasis, and trachoma. Bulletin of the World Health Organization, 1991; 69(5):609-621.

Ghana Statistical Service, Ghana Demographic and Health Survey, Institute for Resource Development/Macro Systems, Inc., Columbia, Maryland, 1988.

Hurtado E, Diaz E, Burdick E, et al. Maternal time management and nutritional status of children in Guatemala, FASEB, 1994.

Instituto de Nutrición de Centro América y Panama, Guatemala Demographic and Health Survey, Institute for Resource Development/Macro Systems, Inc., Columbia, Maryland, 1987.

Instituto Nacional de Estadistica, Bolivia Demographic and Health Survey, Institute for Resource Development/Macro Systems, Inc., Columbia, Maryland, 1989.

Ministère de l'Intérieur, Département de la Population, Burundi Demographic and Health Survey, Institute for Resource Development/Macro Systems, Inc., Columbia, Maryland, 1987.

QUATTRO PRO. Version 4.0, Borland International, Scott's Valley, CA, 1992.

Royaume du Maroc, Ministère de la Santé Publique, Service des Etudes et de L'Information Sanitaire, Enquête Nationale sur la Planification Familiale, la Fécondité et la Santé de la Population au Maroc (ENPS), Morocco Demographic and Health Survey, Institute for Resource Development/Macro Systems, Inc., Columbia, Maryland, 1987.

Roberts L, Esrey SA, Gilman RH, et al. The influence of chicken coops on fecal transmission: measuring fecal transmission in a Peruvian shantytown. Submitted for Publication. 1994.

STATA Corporation, Stata Reference Manual: Release 3.1. 6th ed. College Station, TX, 1993

Steinberg D, Colla P. LOGIT: A supplementary module for SYSTAT, Evanston, IL: SYSTAT Inc., 1991.

SYSTAT for Windows: Version 5 Edition, Evanston, IL, SYSTAT, Inc., 1992.

Ugandan Ministry of Health, Uganda Demographic and Health Survey, Institute for Resource Development/Macro Systems, Inc., Columbia, Maryland, 1988/1989.

Unité de Recherche Démographique, Direction de la Statistique, Direction Générale de la Santé, Enquête Démographique et de Santé au Togo, Togo Demographique and Health Survey, Institute for Resource Development/Macro Systems, Inc., Columbia, Maryland, 1988.

Wan P. Personnel communication, 1994.

White GF, Bradley DJ, White AU. Drawers of Water: Domestic water use in East Africa, The University of Chicago Press, Chicago, 1972..

APPENDICES

A. List of available countries (March 15, 1992)
B. List of variables and codes
C. SAS programming to create variables
D. SYSTAT programming to create variables
E. Country analysis for objective 1 - sanitation
F. Country analysis for objective 1 - water supplies
G. Country analysis for objective 3
H. Influence of confounding and rationale for its control

APPENDIX A - LIST OF COUNTRIES AVAILABLE (March 15, 1992)

Country	Sample size	Distance or Time	Appropriate variables*
AFRICA			
Botswana	-	-	-
Burundi	1889	t	√
Ghana	1795	-	√
Kenya	-	-	-
Liberia	-	-	-
Mali	909	-	-
Nigeria	3000	d	√
Ondo State, Nigeria	1378	-	√
Senegal	635	-	-
Togo	1281	-	√
Uganda	2327	d	√
Zimbabwe	1496	d	-
NORTH AFRICA/NEAR EAST			
Egypt	1907	t	√
Morocco	2523	t	√
Sudan	-	-	-
Tunisia	1996	-	-
ASIA			
Indonesia	-	-	-
Nepal	-	-	-
Sri Lanka	2003	t	√
Thailand	1808	t	√
LATIN AMERICA & CARIBBEAN			
Bolivia	2512	-	√
N.E. Brazil	571	-	-
Colombia	1301	t	√
Dominican Republic	1768	t	√
Ecuador	-	-	-
Guatemala	2207	t	√
Mexico	-	-	-
Paraguay	3500	d	√
Peru	-	-	-
Trinidad and Tobago	817	-	-

* A check indicates that the following variables are included: source of drinking water, source of non-drinking water, and type of sanitation facility, diarrhea, and anthropometry.

\- A dash indicates that the appropriate variables are not available. For example, under sample size a - means no anthropometry data were collected. When a sample size is given and a - under appropriateness is given, some variables for the analysis were not available (usually other water source).

APPENDIX B - LIST OF VARIABLES AND CODES

Variable	Code values	Code description
OUTCOME VARIABLES		
Diarrhea	0-2	0 = no 1 = yes, last 24 hours 2 = yes, last 2-14 days
Weight/age	xxx	Z-scores (continuous)
Height/age	xxx	Z-scores (continuous)
Weight/Length	xxx	Z-scores (continuous)
HYPOTHESIZED VARIABLES		
Water supply+ Drinking	1-9	1 = piped into residence 2 = piped into yard or plot 3 = public tap 4 = well with hand pump 5 = well without hand pump 6 = river, spring, surface water 7 = tanker, truck, other vendor 8 = rain water 9 = other
Water supply+ Non-drinking	1-9	1 = piped into residence 2 = piped into yard or plot 3 = public tap 4 = well with hand pump 5 = well without hand pump 6 = river, spring, surface water 7 = tanker, truck, other vendor 8 = rain water 9 = other
Sanitation	0-6	0 = no facilities 1 = flush 2 = water seal 3 = pit 4 = bucket 5 = other 6 = bush
Maternal literacy	0-1	0 = cannot read 1 = can read (with or without difficulty
Time to water round trip	0-xxx 996	minutes (continuous) on premises (will be recorded as 5)
COMMUNITY/COUNTRY VARIABLES		
Country	0-1	0 = no 1 = yes
Residence	0-1	0 = urban 1 = rural

HOUSEHOLD VARIABLES

Soap	0-1	0 = no soap on premises 1 = yes, soap on premises
Socioeconomic variables++	0-1	0 = no 1 = yes
Husband occup	0-1	0 = non-wage 1 = wage earner
Husband educ	0-1	0 = does not read 1 = can read
Religion	0-n	0 = minor religious group n = major religious group
Ethnicity	0-n	0 = minor ethnic group n = major ethnic
Household number		continuous
Children < 5		continuous

MATERNAL VARIABLES

Maternal educ+++	0-3	0 = no education 1 = primary 2 = secondary 3 = higher educ
Maternal age	1-6	1 = 15-19 years 2 = 20-24 years 3 = 25-29 years 4 = 30-34 years 5 = 35-39 years 6 = >= 40 years
Mother currently pregnant	0-1	0 = no 1 = yes
Parity	1-9	1 = first born 2 = second born 3 = third born 4 = fourth born 5 = fifth born 6 = sixth born 7 = seventh born 8 = eighth born 9 = ninth or greater born
Preceding birth interval	0-1	0 = > 15 months 1 = <= 15 months
Succeeding birth interval	0-1	0 = > 15 months 1 = <= 15 months
Maternal marital status	0-1	0 = not married 1 = married

CHILD VARIABLES

Age (months)	0-36	continuous variable
Sex	0-1	0 = male 1 = female
Currently breast feeding	0-1	0 = no 1 = yes
Bottle fed	0-1	0 = no 1 = yes
Currently living with grandparents	0-1	0 = no 1 = yes

\+ These variables will be coded as piped (0) and non-piped (0). Countries may have other systems not listed above, and these will be coded as 0 or 1 also.

++ These include electricity, radio, television, refrigerator, bicycle, motorcycle, car, and tractor.

+++ The more powerful predictor of maternal education and maternal literacy will be used. The other variable will not be used.

APPENDIX C - SAS PROGRAMMING TO CREATE VARIABLES

Example for GHANA:

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libname GHANA '.';
OPTIONS PS=58 LS=78;

DATA GHANA;
INFILE 'F:\DHS1\GHIR02RT.DAT' MISSOVER;
INPUT

CASEID $ 1-15 V000 $ 18-19 V001 20-27 V002 28-31 V003 32-34 V004 35-38
              V005   39-46 V012 63-64 V013 65-65 /
             V101 18-18 V102 19-19 V106 24-24 V107 25-26 V108 27-27
             V113 32-33 V114 34-35 V115 36-38 V116 39-39 V118 42-42
             V119 43-43 V120 44-44 V121 45-45 V122 46-46 V123 47-47
             V124 48-48 V125 49-49 V126 50-50 V127 51-51 V128 52-52
             V129 53-53 V130 54-54 V131 55-56 V136 62-63 V137 64-65 /
BORD_01 20-21 B0_01 22-22 B4_01 31-31 B8_01 38-39 B11_01 42-44  B12_01 45-47 /
BORD_02 20-21 B0_02 22-22 B4_02 31-31 B8_02 38-39 B11_02 42-44  B12_02 45-47 /
BORD_03 20-21 B0_03 22-22 B4_03 31-31 B8_03 38-39 B11_03 42-44  B12_03 45-47 /
BORD_04 20-21 B0_04 22-22 B4_04 31-31 B8_04 38-39 B11_04 42-44  B12_04 45-47 /
BORD_05 20-21 B0_05 22-22 B4_05 31-31 B8_05 38-39 B11_05 42-44  B12_05 45-47 /
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V213 41-41 /
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M4_01 22-23 M5_01 24-25 /
M4_02 22-23 M5_02 24-25 /
M4_03 22-23 M5_03 24-25 /
M4_04 22-23 M5_04 24-25 /
M4_05 22-23 M5_05 24-25 /
M4_06 22-23 M5_06 24-25 /
V404 21-21 V407 24-25 V408 26-27 V409 28-28 V410 29-29 V411 30-30 V412 31-31
V413 32-32 V414 33-33 V415 34-34 /
H11_01 77-77 /
H11_02 77-77 /
H11_03 77-77 /
H11_04 77-77 /
H11_05 77-77 /
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H11_06 77-77 /
HW1_01 19-20 HW2_01 21-23 HW3_01 24-27 HW5_01 32-35 HW8_01 45-48 HW11_01 58-61 /
HW1_02 19-20 HW2_02 21-23 HW3_02 24-27 HW5_02 32-35 HW8_02 45-48 HW11_02 58-61 /
HW1_03 19-20 HW2_03 21-23 HW3_03 24-27 HW5_03 32-35 HW8_03 45-48 HW11_03 58-61 /
HW1_04 19-20 HW2_04 21-23 HW3_04 24-27 HW5_04 32-35 HW8_04 45-48 HW11_04 58-61 /
HW1_05 19-20 HW2_05 21-23 HW3_05 24-27 HW5_05 32-35 HW8_05 45-48 HW11_05 58-61 /
HW1_06 19-20 HW2_06 21-23 HW3_06 24-27 HW5_06 32-35 HW8_06 45-48 HW11_06 58-61 /
V501   18-18 V502   19-19 V523   50-50 /
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V701   18-18 V704 22-24 V705 25-26 /
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CASEID 1-15 V000 18-19 V001 20-27 V002 28-31 V003 32-34 V004 35-38
            V005 39-46 V006 47-48 V007 49-50 V008 51-54 V009 55-56
            V010 57-58 V011 59-62 V012 63-64 V013 65-65 V014 66-66
            /
            V101 18-18 V102 19-19 V103 20-20 V104 21-22 V105 23-23
            V106 24-24 V107 25-26 V108 27-27 V109 28-28 V110 29-29
            V111 30-30 V112 31-31 V113 32-33 V114 34-35 V115 36-38
            V116 39-39 V117 40-41 V118 42-42 V119 43-43 V120 44-44
            V121 45-45 V122 46-46 V123 47-47 V124 48-48 V125 49-49
            V126 50-50 V127 51-51 V128 52-52 V129 53-53 V130 54-54
            V131 55-56 V132 57-57 V133 58-59 V134 60-60 V135 61-61
            V136 62-63 V137 64-65 V138 66-67
            /

BIDX_01 18-19 BORD_01 20-21 B0_01  22-22 B1_01 23-24 B2_01 25-26 B3_01 27-30
B4_01   31-31 B5_01   32-32 B6_01  33-35 B7_01 36-37 B8_01 38-39 B9_01 40-40
B10_01  41-41 B11_01  42-44 B12_01 45-47 /

BIDX_02 18-19 BORD_02 20-21 B0_02  22-22 B1_02 23-24 B2_02 25-26 B3_02 27-30
B4_02   31-31 B5_02   32-32 B6_02  33-35 B7_02 36-37 B8_02 38-39 B9_02 40-40
B10_02  41-41 B11_02  42-44 B12_02 45-47 /

BIDX_03 18-19 BORD_03 20-21 B0_03  22-22 B1_03 23-24 B2_03 25-26 B3_03 27-30
B4_03   31-31 B5_03   32-32 B6_03  33-35 B7_03 36-37 B8_03 38-39 B9_03 40-40
B10_03  41-41 B11_03  42-44 B12_03 45-47 /

BIDX_04 18-19 BORD_04 20-21 B0_04  22-22 B1_04 23-24 B2_04 25-26 B3_04 27-30
B4_04   31-31 B5_04   32-32 B6_04  33-35 B7_04 36-37 B8_04 38-39 B9_04 40-40
B10_04  41-41 B11_04  42-44 B12_04 45-47 /

BIDX_05 18-19 BORD_05 20-21 B0_05  22-22 B1_05 23-24 B2_05 25-26 B3_05 27-30
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B4_05   31-31 B5_05   32-32 B6_05  33-35 B7_05 36-37 B8_05 38-39 B9_05 40-40
B10_05  41-41 B11_05  42-44 B12_05 45-47 /

BIDX_06 18-19 BORD_06 20-21 B0_06  22-22 B1_06 23-24 B2_06 25-26 B3_06 27-30
B4_06   31-31 B5_06   32-32 B6_06  33-35 B7_06 36-37 B8_06 38-39 B9_06 40-40
B10_06  41-41 B11_06  42-44 B12_06 45-47 /

BIDX_07 18-19 BORD_07 20-21 B0_07  22-22 B1_07 23-24 B2_07 25-26 B3_07 27-30
B4_07   31-31 B5_07   32-32 B6_07  33-35 B7_07 36-37 B8_07 38-39 B9_07 40-40
B10_07  41-41 B11_07  42-44 B12_07 45-47 /

BIDX_08 18-19 BORD_08 20-21 B0_08  22-22 B1_08 23-24 B2_08 25-26 B3_08 27-30
B4_08   31-31 B5_08   32-32 B6_08  33-35 B7_08 36-37 B8_08 38-39 B9_08 40-40
B10_08  41-41 B11_08  42-44 B12_08 45-47 /

BIDX_09 18-19 BORD_09 20-21 B0_09  22-22 B1_09 23-24 B2_09 25-26 B3_09 27-30
B4_09   31-31 B5_09   32-32 B6_09  33-35 B7_09 36-37 B8_09 38-39 B9_09 40-40
B10_09  41-41 B11_09  42-44 B12_09 45-47 /

BIDX_10 18-19 BORD_10 20-21 B0_10  22-22 B1_10 23-24 B2_10 25-26 B3_10 27-30
B4_10   31-31 B5_10   32-32 B6_10  33-35 B7_10 36-37 B8_10 38-39 B9_10 40-40
B10_10  41-41 B11_10  42-44 B12_10 45-47 /

BIDX_11 18-19 BORD_11 20-21 B0_11  22-22 B1_11 23-24 B2_11 25-26 B3_11 27-30
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RC123  43-43 RC124    44-44 RC125A   45-45 RC125E 46-46 RC126D 47-47
RC130  48-49 RC131    50-50 RC223    51-52 RC224  53-54 RC320  55-56
RC321A 57-57 RC321B   58-58 RC321C   59-59 RC321D 60-60 RC321E 61-61
RC321F 62-62 RC321G   63-63 RC321H   64-64 RC416C 65-65 RC416D 66-66
RC416E 67-67 RC416G   68-68 RC501    69-70 RC502  71-71 RC516  72-72
RC517A 73-73 RC517B   74-74 RC517C   75-75 RC517D 76-76 RC523  77-77
RC524  78-78 RC611G   79-80 RC611F   81-82 RC710  83-83 RC718  84-85
RC719A 86-86 RC719B   87-87 RC719C   88-88 RC719D 89-89 RC719E 90-90
RC719F 91-91 /

IDX92_01 18-19 RC515_01 20-21 /
IDX92_02 18-19 RC515_02 20-21 /
IDX92_03 18-19 RC515_03 20-21 /
IDX92_04 18-19 RC515_04 20-21 /
IDX92_05 18-19 RC515_05 20-21 /
IDX92_06 18-19 RC515_06 20-21 /
IDX92_07 18-19 RC515_07 20-21 /
IDX92_08 18-19 RC515_08 20-21 /
IDX92_09 18-19 RC515_09 20-21 /
IDX92_10 18-19 RC515_10 20-21 /
IDX92_11 18-19 RC515_11 20-21 /
IDX92_12 18-19 RC515_12 20-21 /
IDX92_13 18-19 RC515_13 20-21 /
IDX92_14 18-19 RC515_14 20-21 /
IDX92_15 18-19 RC515_15 20-21 /
IDX92_16 18-19 RC515_16 20-21 /
IDX92_17 18-19 RC515_17 20-21 /
IDX92_18 18-19 RC515_18 20-21 /
IDX92_19 18-19 RC515_19 20-21 /
IDX92_20 18-19 RC515_20 20-21 /

IDX94_01 18-18 RC402_01 19-20 RC403_01 21-22 RC405_01 23-24 /
IDX94_02 18-18 RC402_02 19-20 RC403_02 21-22 RC405_02 23-24 /
IDX94_03 18-18 RC402_03 19-20 RC403_03 21-22 RC405_03 23-24 /
IDX94_04 18-18 RC402_04 19-20 RC403_04 21-22 RC405_04 23-24 /
IDX94_05 18-18 RC402_05 19-20 RC403_05 21-22 RC405_05 23-24 /
IDX94_06 18-18 RC402_06 19-20 RC403_06 21-22 RC405_06 23-24 /

IDX95_01 18-18 RC427_01 19-19 RC427_01 20-20 RC427_01 21-21 RC427_01 22-22
RC427_01 23-23 RC427_01 24-24 RC427_01 25-25 RC427_01 26-26 RC427_01 27-27
RC427_01 28-28 RC427_01 29-29 RC428_01 30-30 RC429_01 31-31 RC430_01 32-32
RC430_01 33-33 RC430_01 34-34 RC430_01 35-35 RC430_01 36-36 RC430_01 37-37
RC430_01 38-38 RC430_01 39-39 RC430_01 40-40 RC430_01 41-41 RC431_01 42-42
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RC432_01 43-43 RC433_01 44-44 RC433_01 45-45 RC433_01 46-46 RC433_01 47-47
RC433_01 48-48 RC433_01 49-49 RC433_01 50-50 RC433_01 51-51 RC433_01 52-52
RC433_01 53-53 RC433_01 54-54 RC433_01 55-55 RC434_01 56-56 RC435_01 57-57
RC436_01 58-58 RC436_01 59-59 RC436_01 60-60 RC436_01 61-61 RC436_01 62-62
RC436_01 63-63 RC436_01 64-64 RC436_01 65-65 RC436_01 66-66 RC436_01 67-67
RC436_01 68-68 RC436_01 69-69 /

IDX95_02 18-18 RC427_02 19-19 RC427_02 20-20 RC427_02 21-21 RC427_02 22-22
RC427_02 23-23 RC427_02 24-24 RC427_02 25-25 RC427_02 26-26 RC427_02 27-27
RC427_02 28-28 RC427_02 29-29 RC428_02 30-30 RC429_02 31-31 RC430_02 32-32
RC430_02 33-33 RC430_02 34-34 RC430_02 35-35 RC430_02 36-36 RC430_02 37-37
RC430_02 38-38 RC430_02 39-39 RC430_02 40-40 RC430_02 41-41 RC431_02 42-42
RC432_02 43-43 RC433_02 44-44 RC433_02 45-45 RC433_02 46-46 RC433_02 47-47
RC433_02 48-48 RC433_02 49-49 RC433_02 50-50 RC433_02 51-51 RC433_02 52-52
RC433_02 53-53 RC433_02 54-54 RC433_02 55-55 RC434_02 56-56 RC435_02 57-57
RC436_02 58-58 RC436_02 59-59 RC436_02 60-60 RC436_02 61-61 RC436_02 62-62
RC436_02 63-63 RC436_02 64-64 RC436_02 65-65 RC436_02 66-66 RC436_02 67-67
RC436_02 68-68 RC436_02 69-69 /

IDX95_03 18-18 RC427_03 19-19 RC427_03 20-20 RC427_03 21-21 RC427_03 22-22
RC427_03 23-23 RC427_03 24-24 RC427_03 25-25 RC427_03 26-26 RC427_03 27-27
RC427_03 28-28 RC427_03 29-29 RC428_03 30-30 RC429_03 31-31 RC430_03 32-32
RC430_03 33-33 RC430_03 34-34 RC430_03 35-35 RC430_03 36-36 RC430_03 37-37
RC430_03 38-38 RC430_03 39-39 RC430_03 40-40 RC430_03 41-41 RC431_03 42-42
RC432_03 43-43 RC433_03 44-44 RC433_03 45-45 RC433_03 46-46 RC433_03 47-47
RC433_03 48-48 RC433_03 49-49 RC433_03 50-50 RC433_03 51-51 RC433_03 52-52
RC433_03 53-53 RC433_03 54-54 RC433_03 55-55 RC434_03 56-56 RC435_03 57-57
RC436_03 58-58 RC436_03 59-59 RC436_03 60-60 RC436_03 61-61 RC436_03 62-62
RC436_03 63-63 RC436_03 64-64 RC436_03 65-65 RC436_03 66-66 RC436_03 67-67
RC436_03 68-68 RC436_03 69-69 /

IDX95_04 18-18 RC427_04 19-19 RC427_04 20-20 RC427_04 21-21 RC427_04 22-22
RC427_04 23-23 RC427_04 24-24 RC427_04 25-25 RC427_04 26-26 RC427_04 27-27
RC427_04 28-28 RC427_04 29-29 RC428_04 30-30 RC429_04 31-31 RC430_04 32-32
RC430_04 33-33 RC430_04 34-34 RC430_04 35-35 RC430_04 36-36 RC430_04 37-37
RC430_04 38-38 RC430_04 39-39 RC430_04 40-40 RC430_04 41-41 RC431_04 42-42
RC432_04 43-43 RC433_04 44-44 RC433_04 45-45 RC433_04 46-46 RC433_04 47-47
RC433_04 48-48 RC433_04 49-49 RC433_04 50-50 RC433_04 51-51 RC433_04 52-52
RC433_04 53-53 RC433_04 54-54 RC433_04 55-55 RC434_04 56-56 RC435_04 57-57
RC436_04 58-58 RC436_04 59-59 RC436_04 60-60 RC436_04 61-61 RC436_04 62-62
RC436_04 63-63 RC436_04 64-64 RC436_04 65-65 RC436_04 66-66 RC436_04 67-67
RC436_04 68-68 RC436_04 69-69 /

IDX95_05 18-18 RC427_05 19-19 RC427_05 20-20 RC427_05 21-21 RC427_05 22-22
RC427_05 23-23 RC427_05 24-24 RC427_05 25-25 RC427_05 26-26 RC427_05 27-27
RC427_05 28-28 RC427_05 29-29 RC428_05 30-30 RC429_05 31-31 RC430_05 32-32
RC430_05 33-33 RC430_05 34-34 RC430_05 35-35 RC430_05 36-36 RC430_05 37-37
RC430_05 38-38 RC430_05 39-39 RC430_05 40-40 RC430_05 41-41 RC431_05 42-42
RC432_05 43-43 RC433_05 44-44 RC433_05 45-45 RC433_05 46-46 RC433_05 47-47
RC433_05 48-48 RC433_05 49-49 RC433_05 50-50 RC433_05 51-51 RC433_05 52-52
RC433_05 53-53 RC433_05 54-54 RC433_05 55-55 RC434_05 56-56 RC435_05 57-57
RC436_05 58-58 RC436_05 59-59 RC436_05 60-60 RC436_05 61-61 RC436_05 62-62
RC436_05 63-63 RC436_05 64-64 RC436_05 65-65 RC436_05 66-66 RC436_05 67-67
RC436_05 68-68 RC436_05 69-69 /

IDX95_06 18-18 RC427_06 19-19 RC427_06 20-20 RC427_06 21-21 RC427_06 22-22
RC427_06 23-23 RC427_06 24-24 RC427_06 25-25 RC427_06 26-26 RC427_06 27-27
RC427_06 28-28 RC427_06 29-29 RC428_06 30-30 RC429_06 31-31 RC430_06 32-32
RC430_06 33-33 RC430_06 34-34 RC430_06 35-35 RC430_06 36-36 RC430_06 37-37
RC430_06 38-38 RC430_06 39-39 RC430_06 40-40 RC430_06 41-41 RC431_06 42-42
RC432_06 43-43 RC433_06 44-44 RC433_06 45-45 RC433_06 46-46 RC433_06 47-47
RC433_06 48-48 RC433_06 49-49 RC433_06 50-50 RC433_06 51-51 RC433_06 52-52

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RC433_06 53-53 RC433_06 54-54 RC433_06 55-55 RC434_06 56-56 RC435_06 57-57
RC436_06 58-58 RC436_06 59-59 RC436_06 60-60 RC436_06 61-61 RC436_06 62-62
RC436_06 63-63 RC436_06 64-64 RC436_06 65-65 RC436_06 66-66 RC436_06 67-67
RC436_06 68-68 RC436_06 69-69 /

RCNUN_01 18-18 RC505_01 19-20 RC506_01 21-21 RC507_01 22-23 RC507_01 24-25
RC508_01 26-27 RC509_01 28-29 RC510_01 30-30 RC511_01 31-31 RC512_01 32-32 /

RCNUN_02 18-18 RC505_02 19-20 RC506_02 21-21 RC507_02 22-23 RC507_02 24-25
RC508_02 26-27 RC509_02 28-29 RC510_02 30-30 RC511_02 31-31 RC512_02 32-32 /

RCNUN_03 18-18 RC505_03 19-20 RC506_03 21-21 RC507_03 22-23 RC507_03 24-25
RC508_03 26-27 RC509_03 28-29 RC510_03 30-30 RC511_03 31-31 RC512_03 32-32 /

RCNUN_04 18-18 RC505_04 19-20 RC506_04 21-21 RC507_04 22-23 RC507_04 24-25
RC508_04 26-27 RC509_04 28-29 RC510_04 30-30 RC511_04 31-31 RC512_04 32-32 /

RCNUN_05 18-18 RC505_05 19-20 RC506_05 21-21 RC507_05 22-23 RC507_05 24-25
RC508_05 26-27 RC509_05 28-29 RC510_05 30-30 RC511_05 31-31 RC512_05 32-32

;
*/

FILE'F:\DHS1\GHANA.ASC';
PUT CASEID $ 1-15  V000 $ 18-19  V001   V002   V003   V004   V005   V012    V013  V101
     V102    V106   V107   V108   V113   V114   V115   V116    V118  V119
     V120    V121   V122   V123   V124   V125   V126   V127    V128  V129
     V130    V131   V136   V137   V701   V704   V705   V213    V404  V407
     V408    V409   V410   V411   V412   V413   V414   V415    V501  V502
     V523    H11_01 HW1_01 HW2_01 HW8_01 HW3_01 HW5_01 HW11_01 M4_01 M5_01
     BORD_01 B0_01  B4_01  B8_01  B11_01 B12_01 /
     CASEID $ 1-15  V000 $ 18-19  V001   V002   V003   V004   V005   V012    V013  V101
     V102    V106   V107   V108   V113   V114   V115   V116    V118  V119
     V120    V121   V122   V123   V124   V125   V126   V127    V128  V129
     V130    V131   V136   V137   V701   V704   V705   V213    V404  V407
     V408    V409   V410   V411   V412   V413   V414   V415    V501  V502
     V523    H11_02 HW1_02 HW2_02 HW8_02 HW3_02 HW5_02 HW11_02 M4_02 M5_02
     BORD_02 B0_02  B4_02  B8_02  B11_02 B12_02 /
     CASEID $ 1-15  V000 $ 18-19  V001   V002   V003   V004   V005   V012    V013  V101
     V102    V106   V107   V108   V113   V114   V115   V116    V118  V119
     V120    V121   V122   V123   V124   V125   V126   V127    V128  V129
     V130    V131   V136   V137   V701   V704   V705   V213    V404  V407
     V408    V409   V410   V411   V412   V413   V414   V415    V501  V502
     V523    H11_03 HW1_03 HW2_03 HW8_03 HW3_03 HW5_03 HW11_03 M4_03 M5_03
     BORD_03 B0_03  B4_03  B8_03  B11_03 B12_03 /
     CASEID $ 1-15  V000 $ 18-19  V001   V002   V003   V004   V005   V012    V013  V101
     V102    V106   V107   V108   V113   V114   V115   V116    V118  V119
     V120    V121   V122   V123   V124   V125   V126   V127    V128  V129
     V130    V131   V136   V137   V701   V704   V705   V213    V404  V407
     V408    V409   V410   V411   V412   V413   V414   V415    V501  V502
     V523    H11_04 HW1_04 HW2_04 HW8_04 HW3_04 HW5_04 HW11_04 M4_04 M5_04
     BORD_04 B0_04  B4_04  B8_04  B11_04 B12_04 /
     CASEID $ 1-15  V000 $ 18-19  V001   V002   V003   V004   V005   V012    V013  V101
     V102    V106   V107   V108   V113   V114   V115   V116    V118  V119
     V120    V121   V122   V123   V124   V125   V126   V127    V128  V129
     V130    V131   V136   V137   V701   V704   V705   V213    V404  V407
     V408    V409   V410   V411   V412   V413   V414   V415    V501  V502
     V523    H11_05 HW1_05 HW2_05 HW8_05 HW3_05 HW5_05 HW11_05 M4_05 M5_05
     BORD_05 B0_05  B4_05  B8_05  B11_05 B12_05 /
     CASEID $ 1-15  V000 $ 18-19  V001   V002   V003   V004   V005   V012    V013  V101
     V102    V106   V107   V108   V113   V114   V115   V116    V118  V119
     V120    V121   V122   V123   V124   V125   V126   V127    V128  V129
```

```
    V130     V131   V136   V137   V701   V704   V705   V213    V404  V407
    V408     V409   V410   V411   V412   V413   V414   V415    V501  V502
    V523     H11_06 HW1_06 HW2_06 HW8_06 HW3_06 HW5_06 HW11_06 M4_06 M5_06
    BORD_06  B0_06  B4_06  B8_06  B11_06 B12_06
    ;
run;

DATA GHANA.GHANA;
INFILE 'F:\DHS1\GHANA.ASC';
INPUT  CASEID $ 1-15 V000 $ 18-19 V001   V002   V003   V004   V005   V012
       V013          V101         V102   V106   V107   V108   V113   V114
       V115          V116         V118   V119   V120   V121   V122   V123
       V124          V125         V126   V127   V128   V129   V130   V131
       V136          V137         V701   V704   V705   V213   V404   V407
       V408          V409         V410   V411   V412   V413   V414   V415
       V501          V502         V523   H11    HW1    HW2    HW8    HW3
       HW5           HW11         M4     M5     BORD   B0     B4     B8
       B11           B12;

IF HW2=. OR HW3=. THEN DELETE;
IF HW2=999 OR HW3=9999 THEN DELETE;
IDA=SUBSTR(CASEID,1,12);
IDB=SUBSTR(CASEID,13,3);
DROP CASEID;

RUN;

PROC FREQ;TABLES V000 V001 V002 V003 V004 V005 V012 V013 V101 V102 V106 V107
                 V108 V113 V114 V115 V116 V118 V119 V120 V121 V122 V123 V124
                 V125 V126 V127 V128 V129 V130 V131 V136 V137 V701 V704 V705
                 V213 V404 V407 V408 V409 V410 V411 V412 V413 V414 V415 V501
                 V502 V523 H11  M4   M5   BORD B0   B4   B8   B11  B12;
RUN;

PROC UNIVARIATE; VAR HW1 HW2 HW8 HW3 HW5 HW11;RUN;
```

APPENDIX D - SYSTAT PROGRAMMING TO CREATE VARIABLES

Example for GHANA:

```
use "d:\GHANA\GH00.sys"
save "d:\GHANA\GH01.sys"
note "This file is called GH01.CMD"
note "VARIABLE NAME PROGRAM FOR GHANA (GH01.SYS) - PAGE 1"
note " "
note "V012 is the actual age of the respondent - it was dropped"
  drop V012
note "V001 (cluster), V002 (HH#), V003 line #) were kept"
  drop V001
note "V004 (enumeration area) was dropped; it appears to be = V001"
  drop V004
note "V005 (Sample weight) was dropped; it was a constant"
  drop V005

let AGEMOTH = V013
  drop V013

note "V101 is Region - it was dropped"
  drop V101

if V102 = 1 then let URBAN = 1
  if V102 = 2 then let URBAN = 0
  drop V102

if V106 = 0 then let EDNONE = 1
  else let EDNONE = .
  if V106 = 1 or V106 = 2 or V106 = 3 then let EDNONE = 0
if V106 = 1 then let EDPRIM = 1
  else let EDPRIM = .
  if V106 = 0 or V106 = 2 or V106 = 3 then let EDPRIM = 0
if V106 = 2 or V106 = 3 then let EDSECHGH = 1
  else let EDSECHGH = .
  if V106 = 1 or V106 = 0 then let EDSECHGH = 0
  drop V106

note "V107 = Highest year of education was dropped"
  drop V107

if V108 = 3 then let MATLIT = 0
if V108 <3 then let MATLIT = 1
if V108=9 then let MATLIT=.
  drop V108

if V113 = 1 or V113=2 then let PREMISE = 1
  else let PREMISE = 0
if V113=3 or V113=4 or V113=5 then let PUBLIC = 1
  else let PUBLIC = 0
if V113=6 or V113=7 then let NOWAT=1
  else let NOWAT = 0
```

```
note "VARIABLE NAME PROGRAM FOR GHANA (GH01.SYS) - PAGE 2"

if V113 < 6 then let GOODWAT=1
  else let GOODWAT=0
  drop V113

if V114 = 1 or V114=2 then let NPREMISE = 1
  else let NPREMISE = 0
if V114=3 or V114=4 or V114=5 then let NPUBLIC = 1
  else let NPUBLIC = 0
if V114=6 or V114=7 then let NNOWAT=1
  else let NNOWAT = 0


if V114 >0 and V114<6 then let NGOODWAT=1
  else let NGOODWAT=0
  drop V114

let TIME = V115
  drop V115

if V116 = 1 then let FLUSH = 1
  else let FLUSH=0
  if V116 = 9 then let FLUSH = .
if V116 = 2 or V116=3 or V116=4 then let PIT = 1
  else let PIT=0
  if V116 = 9 then let PIT = .
if V116 = 0 or V116=5 then let NOSAN = 1
  else let NOSAN=0
  if V116 = 9 then let NOSAN = .

if V116 >0 and V116 <5 then let IMPSAN = 1
  else let IMPSAN = 0
  if V116=99 then let IMPSAN = .
  drop V116

let SOAP = V118
   if V118 = . or V118 >1 then let SOAP = .
   drop V118

let ELECTRIC = V119
   if V119 = . or V119 >1 then let ELECTRIC = .
   drop V119

let RADIO = V120
   if V120 = . or V120 >1 then let RADIO = .
   drop V120
let TELE = V121
   if V121 = . or V121 >1 then let TELE = .
   drop V121
```

```
note "VARIABLE NAME PROGRAM FOR GHANA (GH01.SYS) - PAGE 3"

let FRIDGE = V122
   if V122 = . or V122 >1 then let FRIDGE = .
   drop V122
let BICYCLE = V123
   if V123 = . or V123 >1 then let BICYCLE = .
   drop V123
let MOTORCYC = V124
   if V124 = . or V124 >1 then let MOTORCYC = .
   drop V124

let CAR = V125
   if V125 = . or V125 >1 then let CAR = .
   drop V125

let TRACTOR = V126
   if V126 = . or V126 >1 then let TRACTOR = .
   drop V126

if V127 = 2 or V127 = 3 then let FLOOR = 1
  else let FLOOR = 0
  if V127 = 9 then let FLOOR = .
  drop V127

if V128 <3 then let WALL = 1
  else let WALL = 0
  drop V128

if V129=>0 and V129 <3 then let ROOF = 1
  else let ROOF = .
  if V129 =3 or V129 = 4 then let ROOF = 0
  drop V129

if V130 = 1 or V130 = 2 then let CHRISTN = 1
  else let CHRISTN=0
if V130 = 3 then let MUSLIM = 1
  if V130 <> 3 then let MUSLIM = 0
if V130 = 4 or V130=5 or V130=6 then let RELOTHER = 1
  if V130 <4 then let RELOTHER = 0
  drop V130

note "V131 is ethnic group - it was dropped"
  drop V131

let HHNUMBER = V136
  if V136 < 5 then let HH1_4 = 1
    else let HH1_4 = 0
  if V136 > 4 and V136 <8 then let HH5_7 = 1
    else let HH5_7 = 0
  if V136 > 7 and V136 < 11 then let HH8_10 = 1
    else let HH8_10 = 0
```

```
note "VARIABLE NAME PROGRAM FOR GHANA (GH01.SYS) - PAGE 4"

  if V136 > 10 then let HH11_END = 1
    else let HH11_END = 0
  drop V136

if V137 = 0 or V137 = 1 then let CHILD0_1 = 1
  if V137 >1 then let CHILD0_1 = 0
  drop V137

if V701 = 0 then let HUSBEDUC = 0
if V701 >0 and V701 < 8 then let HUSBEDUC = 1
if V701 >= 8 or V701 = . then let HUSBEDUC = .
  drop V701

if V705 >0 and V705 <2 then let HUSBPROF = 1
  else let HUSBPROF = 0
  if V705 >8 or V705 <0 then let HUSBPROF = .
if V705 >3 and V705 <6 then let HUSBAG = 1
  else let HUSBAG = 0
  if V705 >8 or V705 < 0 then let HUSBAG = .
  drop V705

if H11 = 0 then let DIAR24 = 0
  if H11 = 1 then let DIAR24 = 1
  if H11 = 2 then let DIAR24 = 0
  if H11 >= 8 then let DIAR24 = .
if H11 = 0 then let DIAR14D = 0
  if H11 = 1 then let DIAR14D = 1
  if H11 = 2 then let DIAR14D = 1
  if H11 >= 8 then let DIAR14D = .
  drop H11

let AGECHILD = HW1
  if AGECHILD < 3 then delete

if HW1 < 7 then let AGE3_6 = 1
  else let AGE3_6=0
if HW1 >6 and HW1 < 13 then let AGE7_12 = 1
  else let AGE7_12 = 0
if HW1 >12 and HW1 < 25 then let AGE13_24 = 1
  else let AGE13_24 = 0
if HW1 >24 and HW1 <= 36 then let AGE25_36 = 1
  else let AGE25_36 = 0
  note "HW1 will be dropped at the end of the program"

let WEIGHT = HW2/10
  drop HW2

let HEIGHT = HW3/10
  drop HW3
```

```
note "VARIABLE NAME PROGRAM FOR GHANA (GH01.SYS) - PAGE 5"

let HTAGEZ = HW5/100
  if HTAGEZ >= 99.98 then delete
  if HW5 = . then let HTAGEZ = .
  if HTAGEZ < -2.00 then let STUNTED = 1
  else let STUNTED = 0
  if HTAGEZ = . then let STUNTED = .
  drop HW5
let WTAGEZ = HW8/100
  if WTAGEZ >= 99.98 then delete
  if HW8 = . then let WTAGEZ = .
  if WTAGEZ <-2.00 then let UNDERWT = 1
  else let UNDERWT = 0
  if WTAGEZ = . then let UNDERWT = .
  drop HW8
let WTHTZ = HW11/100
  if WTHTZ >= 99.98 then delete
  if HW11 = . then let WTHTZ = .
  if WTHTZ < -2.00 then let WASTED = 1
  else let WASTED = 0
  if WTHTZ = . then let WASTED = .
  drop HW11

let PREGNANT = V213
  drop V213
note "let BF = V404"
note "{steve - check how V404 and V407/V408 correlate}"
note "V407 = times breastfed at night - temporarily dropped"
  drop V407
note "V408 = times breastfed at day - temporarily dropped"
  drop V408

let WATER = V409
  if V409=9 or V409=. then let WATER = .
  drop V409

let JUICE = V410
  if V410=9 or V410=. then let JUICE = .
  drop V410

note "V411 = powdered milk was blank"
  let POWMILK = V411
  if V411=9 or V411=. then let POWMILK = .
  drop V411

note "V412 = goats milk was blank"
  let GOATMILK = V412
  if V412=9 or V412=. then let GOATMILK = .
  drop V412
```

```
note "VARIABLE NAME PROGRAM FOR GHANA (GH01.SYS) - PAGE 6"

note "V413 = other liquid was blank - temporarily dropped"
  let LIQUID = V413
  if V413=9 or V413=. then let LIQUID = .
  drop V413
let SOLID = V414
  if V414=9 or V414=. then let SOLID = .
  drop V414
let BOTTLE = V415
  if V415=9 or V415 = . then let BOTTLE=.
  drop V415

if V501 = 1 or V501=2 then let MARRIED = 1
if V501 = 0 or V501 >2 then let MARRIED = 0
  drop V501

note "V502 is similar to V501 - therefore it was dropped"
  drop V502

let GRANDPAR = V523
  if V523 = . or V523 = 9 then let GRANDPAR = .
  drop V523

let BFDUR = M4
  if M4 = 94 then let BFDUR = 0
  if M4 = 95 then let BFDUR = HW1
  if M4 = 96 then let BFDUR = .
  if M4 = 97 then let BFDUR = .
  if M4 = 98 then let BFDUR = .
  if M4 = 99 then let BFDUR = .
  drop M4

let BFMONTH = M5
  if M5 = 99 then let BFMONTH = .

if M5 < 94 then let PCTBF = M5/HW1*100
  if M5=94 then let PCTBF=0
  if M5>=97 then let PCTBF=.
  drop M5

if BORD = 1 then let BIRTHORD = 1
  else let BIRTHORD=0
  drop BORD

if B0 = 0 then let TWIN = 0
  if B0 >0 then let TWIN = 1
  drop B0

if B4 = 1 then let MALE = 1
  if B4 = 2 then let MALE = 0
  drop B4
```

```
note "VARIABLE NAME PROGRAM FOR GHANA (GH01.SYS) - PAGE 7"

note "B8 - current age of child by year 0-12,13-24, etc"
  drop B8

if B11 < 19 then let PREVINT = 1
  if B11 = . or B11 >=19 then let PREVINT = 0
  drop B11

if B12 < 19 then let NEXTINT = 1
  if B12 = . or B12 >18 then let NEXTINT = 0
  drop B12

drop V704
drop V404
drop HW1
run
quit
```

APPENDIX E - COUNTRY ANALYSIS FOR OBJECTIVE 1 - SANITATION

DIARRHEA: 24-HOUR AND TWO-WEEK RECALL

Diarrhea rates, in the previous two weeks or 24 hours, were less among those with improved sanitation compared to no sanitation in Bolivia, Burundi, Ghana, Sri Lanka, Togo, and Uganda (Table E-1). Those with flush toilets had less diarrhea than those with pit latrines in Bolivia, Burundi, Ghana, Guatemala, Sri Lanka, and Togo.

HEIGHT-FOR-AGE: Z-SCORES AND STUNTING

Height-for-age Z-scores were higher or stunting was lower among children with improved sanitation, compared to unimproved sanitation, in all eight countries (Table E-2). Flush toilets were also associated with taller children, compared to pit latrines, in all eight countries except Morocco.

WEIGHT-FOR-AGE-: Z-SCORES AND UNDERWEIGHT

Weight-for-age Z-scores were higher or percent underweight was lower in all countries among children with improved sanitation versus children with unimproved sanitation (Table E-3). Children with flush toilets also weighed more in any given age, than children with pit latrines, again, in all countries with the exception of Sri Lanka.

WEIGHT-FOR-HEIGHT: Z-SCORES AND WASTING

For wasting, improved sanitation was associated with higher weight-for-height Z-scores or lower percent wasted in all countries except Guatemala (Table E-4). Children with flush toilets were better nourished than children with pit latrines only in Burundi, Ghana, Morocco, and Togo.

Table E-1: Differences in the prevalence of diarrhea by type of sanitation among urban and rural children from 8 countries.

Improved versus unimproved sanitation for diarrhea:

Country	Previous 24 hours Differences (95% CI)	Previous 2 weeks Differences (95% CI)
Bolivia	-0.02 (-0.06, 0.02)	-0.02 (-0.14,-0.01)
Burundi	0.03 (-0.05, 0.11)	-0.06 (-0.18, 0.06)
Ghana	-0.05 (-0.12, 0.01)	-0.09 (-0.18,-0.01)
Guatemala	0.00 (-0.04, 0.04)	0.02 (-0.03, 0.06)
Morocco	0.05 (-0.01, 0.10)	0.03 (-0.03, 0.09)
Sri Lanka	-0.01 (-0.03, 0.01)	-0.01 (-0.04, 0.02)
Togo	-0.13 (-0.22,-0.04)	-0.05 (-0.16, 0.05)
Uganda	0.00 (- , -)	-0.02 (-0.11, 0.06)

Flush versus pit sanitation for diarrhea:

Country	Previous 24 hours Differences (95% CI)	Previous 2 weeks Differences (95% CI)
Bolivia	-0.06 (-0.11,-0.00)	-0.08 (-0.14,-0.01)
Burundi	-0.00 (-0.20, 0.20)	-0.07 (-0.29, 0.14)
Ghana	-0.01 (-0.12, 0.09)	-0.11 (-0.24, 0.02)
Guatemala	-0.02 (-0.07, 0.03)	-0.02 (-0.08, 0.04)
Morocco	0.08 (-0.01, 0.16)	0.07 (-0.03, 0.16)
Sri Lanka	-0.02 (-0.04, 0.01)	-0.05 (-0.08,-0.01)
Togo	-0.14 (-0.29, 0.01)	-0.04 (-0.22, 0.14)
Uganda	0.01 (-0.08, 0.09)	0.02 (-0.11, 0.14)

Table E-2: Differences in nutritional status (height-for-age) by type of sanitation among urban and rural children from 8 countries.

Improved versus unimproved sanitation for:

Country	Height-for-age Z-scores Differences (95% CI)	Percent stunted Differences (95% CI)
Bolivia	0.53 (0.40, 0.66)	-0.18 (-0.22, 0.14)
Burundi	0.17 (-0.18, 0.52)	-0.03 (-0.15, 0.09)
Ghana	0.17 (-0.18, 0.52)	-0.09 (-0.16,-0.01)
Guatemala	0.20 (0.04, 0.35)	-0.05 (-0.11, 0.01)
Morocco	-0.02 (-0.19, 0.15)	-0.02 (-0.07, 0.03)
Sri Lanka	0.11 (-0.02, 0.24)	-0.03 (-0.08, 0.03)
Togo	0.32 (0.03, 0.60)	-0.06 (-0.16, 0.04)
Uganda	0.17 (0.08, 0.41)	-0.06 (-0.17,-0.05)

Flush versus pit sanitation for:

Country	Height-for-age Z-scores Differences (95% CI)	Percent stunted Differences (95% CI)
Bolivia	0.14 (-0.04, 0.31)	-0.07 (-0.12,-0.01)
Burundi	0.37 (-0.27, 1.02)	-0.06 (-0.27, 0.16)
Ghana	0.37 (-0.27, 1.02)	-0.07 (-0.19, 0.05)
Guatemala	0.32 (0.12, 0.52)	-0.12 (-0.19,-0.04)
Morocco	-0.06 (-0.20, 0.33)	0.00 (-0.06, 0.06)
Sri Lanka	-0.12 (-0.26, 0.02)	0.03 (-0.02, 0.08)
Togo	-0.49 (0.02, 0.97)	-0.07 (-0.23, 0.10)
Uganda	0.36 (0.01, 0.71)	-0.06 (-0.13, 0.02)

Table E-3: Differences in nutritional status (weight-for-age) by type of sanitation among urban and rural children from 8 countries.

	Improved versus unimproved sanitation for:	
	Weight-for-age Z-scores	Percent underweight
Country	Differences (95% CI)	Differences (95% CI)
Bolivia	0.24 (0.14, 0.35)	-0.03 (-0.06,-0.00)
Burundi	0.12 (-0.19, 0.42)	-0.06 (-0.18, 0.05)
Ghana	0.33 (0.13, 0.52)	-0.07 (-0.15, 0.01)
Guatemala	0.10 (-0.04, 0.25)	-0.05 (-0.10, 0.01)
Morocco	0.02 (-0.14, 0.18)	0.01 (-0.03, 0.06)
Sri Lanka	0.12 (0.01, 0.23)	-0.05 (-0.10, 0.00)
Togo	0.28 (0.03, 0.54)	-0.06 (-0.15, 0.04)
Uganda	0.04 (-0.17, 0.25)	-0.01 (-0.08, 0.06)

	Flush versus pit sanitation for:	
	Weight-for-age Z-scores	Percent underweight
Country	Differences (95% CI)	Differences (95% CI)
Bolivia	0.07 (-0.08, 0.21)	-0.01 (-0.05, 0.03)
Burundi	0.17 (-0.40, 0.74)	-0.01 (-0.23, 0.20)
Ghana	0.31 (-0.00, 0.61)	-0.04 (-0.17, 0.09)
Guatemala	0.16 (0.03, 0.34)	-0.06 (-0.13, 0.01)
Morocco	0.02 (-0.23, 0.27)	0.01 (-0.07, 0.09)
Sri Lanka	-0.11 (-0.23, 0.01)	0.04 (-0.01, 0.10)
Togo	0.51 (0.08, 0.95)	-0.09 (-0.25, 0.06)
Uganda	0.06 (-0.24, 0.36)	-0.04 (-0.13, 0.06)

Table E-4: Differences in nutritional status (weight-for-height) by type of sanitation among urban and rural children from 8 countries.

	Improved versus unimproved sanitation for:	
	Weight-for-height Z-scores	Percent wasted
Country	Differences (95% CI)	Differences (95% CI)
Bolivia	-0.11 (-0.20,-0.02)	0.01 (0.00, 0.02)
Burundi	0.04 (-0.23, 0.30)	-0.02 (-0.08, 0.04)
Ghana	0.11 (-0.07, 0.28)	-0.01 (-0.06, 0.04)
Guatemala	-0.07 (-0.17, 0.03)	0.04 (-0.01, 0.02)
Morocco	0.02 (-0.12, 0.16)	-0.02 (-0.04, 0.01)
Sri Lanka	0.09 (-0.01, 0.19)	-0.02 (-0.06, 0.02)
Togo	0.11 (-0.12, 0.34)	-0.01 (-0.06, 0.05)
Uganda	0.00 (0.18, 0.19)	0.01 (-0.01, 0.04)

	Flush versus pit sanitation for:	
	Weight-for-height Z-scores	Percent wasted
Country	Differences (95% CI)	Differences (95% CI)
Bolivia	-0.03 (-0.16, 0.10)	0.01 (-0.01, 0.03)
Burundi	-0.15 (0.64, 0.35)	-0.02 (-0.12, 0.09)
Ghana	0.13 (-0.14, 0.40)	-0.03 (-0.11, 0.05)
Guatemala	-0.02 (0.15, 0.11)	0.01 (-0.01, 0.02)
Morocco	0.01 (-0.19, 0.21)	-0.02 (-0.06, 0.01)
Sri Lanka	-0.03 (-0.13, 0.07)	0.00 (0.00, 0.00)
Togo	0.30 (-0.09, 0.68)	0.02 (-0.08, 0.11)
Uganda	-0.07 (-0.32, 0.18)	0.01 (-0.03, 0.04)

APPENDIX F - COUNTRY ANALYSIS FOR OBJECTIVE 1 - WATER SUPPLIES

DIARRHEA: 24-HOUR AND TWO-WEEK RECALL

Children with improved water supplies had less diarrhea than those with no improved water supplies in only three countries: Burundi, Ghana, and Sri Lanka (Table F-1). This difference was due mostly to water on the premises versus public supplies.

HEIGHT-FOR-AGE: Z-SCORES AND STUNTING

Taller children were found in all countries, except Morocco, among children with improved water supplies versus no improved water supplies (Table F-2). Water on the premises was associated with taller children in all countries. The differences between water on the premises and public supplies was greater than the differences between improved supplies and no improved water.

WEIGHT-FOR-AGE: Z-SCORES AND UNDERWEIGHT

Improved water of any type was associated with higher weight children than unimproved water in all countries (Table F-3). Children also weighed more when water was provided to the premises compared to public water supplies.

WEIGHT-FOR-HEIGHT: Z-SCORES AND WASTING

Children with improved water supplies had higher weight-for-height values than children without improved water supplies for all countries except Uganda (Table F-4). Similar trends were found when water on the premises was compared to public water supplies. In all countries, except Morocco and Uganda, children with water on the premises were better nourished.

Table F-1: Differences in the prevalence of diarrhea by type of water supply among urban and rural children from 8 countries.

Improved versus unimproved water for diarrhea:

Country	Previous 24 hours Differences (95% CI)	Previous 2 weeks Differences (95% CI)
Bolivia	0.12 (-0.03, 0.05)	0.00 (-0.04, 0.04)
Burundi	-0.06 (-0.13, 0.01)	-0.21 (-1.41, 1.00)
Ghana	-0.04 (-0.07, 0.00)	-0.01 (-0.06, 0.04)
Guatemala	0.00 (-0.03, 0.04)	0.03 (-0.02, 0.07)
Morocco	0.03 (-0.06, 0.12)	0.01 (-0.09, 0.11)
Sri Lanka	-0.00 (-0.03, 0.02)	-0.01 (-0.05, 0.03)
Togo	0.04 (-0.05, 0.13)	0.04 (-0.07, 0.15)
Uganda	0.07 (0.01, 0.12)	0.04 (-0.02, 0.11)

Premise versus public water supplies for diarrhea:

Country	Previous 24 hours Differences (95% CI)	Previous 2 weeks Differences (95% CI)
Bolivia	0.02 (-0.02, 0.07)	0.03 (-0.03, 0.08)
Burundi	-0.12 (-0.24, 0.01)	-0.43 (-1.87, 1.01)
Ghana	0.03 (-0.02, 0.09)	-0.00 (- , -)
Guatemala	-0.02 (-0.06, 0.01)	0.00 (- , -)
Morocco	0.00 (-0.05, 0.06)	0.01 (-0.05, 0.07)
Sri Lanka	-0.02 (-0.05, 0.01)	-0.00 (-0.05, 0.05)
Togo	0.08 (-0.07, 0.23)	-0.07 (-0.25, 0.11)
Uganda	0.09 (-0.01, 0.18)	0.00 (- , -)

Table F-2: Differences in nutritional status (height-for-age) by type of water supply among urban and rural children from 8 countries.

	Improved versus unimproved water for:	
	Height-for-age Z-scores	Percent stunted
Country	Differences (95% CI)	Differences (95% CI)
Bolivia	-0.13 (-0.26, 0.00)	0.04 (-0.01, 0.08)
Burundi	0.07 (-0.25, 0.40)	-0.07 (-0.18, 0.04)
Ghana	0.07 (-0.25, 0.40)	-0.00 (-0.04, 0.04)
Guatemala	0.08 (-0.05, 0.21)	-0.01 (-0.06, 0.04)
Morocco	0.02 (-0.26, 0.31)	0.01 (-0.08, 0.09)
Sri Lanka	-0.07 (-0.23, 0.08)	0.03 (-0.03, 0.09)
Togo	-0.02 (-0.11, 0.07)	0.07 (-0.03, 0.17)
Uganda	0.34 (0.15, 0.53)	-0.11 (-0.17,-0.04)

	Premise versus public water supplies for:	
	Height-for-age Z-scores	Percent stunted
Country	Differences (95% CI)	Differences (95% CI)
Bolivia	-0.04 (-0.18, 0.11)	0.01 (-0.03, 0.06)
Burundi	0.27 (-0.31, 0.86)	-0.15 (-0.35, 0.05)
Ghana	0.27 (-0.31, 0.86)	-0.06 (-0.13,-0.00)
Guatemala	0.23 (0.10, 0.36)	-0.07 (-0.12,-0.05)
Morocco	-0.03 (-0.18, 0.11)	-0.00 (-0.05, 0.04)
Sri Lanka	-0.05 (-0.28, 0.18)	-0.01 (-0.08, 0.07)
Togo	-0.02 (-0.09, 0.05)	0.09 (-0.08, 0.25)
Uganda	0.25 (-0.09, 0.58)	-0.09 (-0.20, 0.02)

Table F-3: Differences in nutritional status (weight-for-age) by type of water supply among urban and rural children from 8 countries.

Country	Improved versus unimproved water for: Weight-for-age Z-scores Differences (95% CI)	Percent underweight Differences (95% CI)
Bolivia	-0.00 (-0.11, 0.11)	-0.02 (-0.05, 0.01)
Burundi	0.22 (-0.05, 0.48)	-0.04 (-0.14, 0.07)
Ghana	0.04 (-0.07, 0.16)	-0.01 (-0.05, 0.04)
Guatemala	0.09 (-0.03, 0.21)	-0.01 (-0.05, 0.04)
Morocco	0.16 (-0.11, 0.43)	-0.02 (-0.11, 0.06)
Sri Lanka	-0.01 (-0.14, 0.11)	-0.02 (-0.08, 0.04)
Togo	0.12 (-0.15, 0.38)	0.00 (-0.10, 0.10)
Uganda	0.12 (0.04, 0.29)	-0.04 (-0.10, 0.01)

Country	Premise versus public water supplies for: Weight-for-age Z-scores Differences (95% CI)	Percent underweight Differences (95% CI)
Bolivia	0.09 (-0.03, 0.21)	-0.03 (-0.07, 0.00)
Burundi	0.54 (0.07, 1.01)	-0.05 (-0.25, 0.14)
Ghana	0.02 (-0.14, 0.19)	-0.06 (-0.12, 0.01)
Guatemala	0.26 (0.14, 0.38)	-0.06 (-0.11,-0.01)
Morocco	-0.05 (-0.19, 0.09)	0.02 (-0.03, 0.06)
Sri Lanka	0.04 (-0.15, 0.23)	-0.05 (-0.13, 0.04)
Togo	0.09 (-0.34, 0.52)	0.06 (-0.10, 0.21)
Uganda	0.03 (-0.26, 0.31)	-0.02 (-0.11, 0.08)

Table F-4: Differences in nutritional status (weight-for-height) by type of water supply among urban and rural children from 8 countries.

	Improved versus unimproved water for:	
	Weight-for-height Z-scores	Percent wasted
Country	Differences (95% CI)	Differences (95% CI)
Bolivia	0.10 (0.00, 0.20)	-0.01 (-0.02, 0.00)
Burundi	0.17 (-0.05, 0.40)	0.02 (-0.04, 0.07)
Ghana	0.08 (-0.03, 0.19)	0.00 (-0.03, 0.03)
Guatemala	0.10 (0.01, 0.19)	0.01 (-0.01, 0.02)
Morocco	0.11 (-0.13, 0.34)	0.02 (-0.02, 0.07)
Sri Lanka	0.07 (-0.04, 0.18)	-0.02 (-0.06, 0.02)
Togo	0.25 (0.02, 0.48)	-0.01 (-0.07, 0.04)
Uganda	-0.06 (-0.20, 0.08)	0.01 (-0.01, 0.03)

	Premise versus public water supplies for:	
	Weight-for-height Z-scores	Percent wasted
Country	Differences (95% CI)	Differences (95% CI)
Bolivia	0.10 (-0.01, 0.20)	-0.01 (-0.03, 0.00)
Burundi	0.33 (-0.08, 0.74)	0.02 (-0.09, 0.12)
Ghana	-0.00 (-0.18, 0.17)	-0.02 (-0.07, 0.02)
Guatemala	0.16 (0.06, 0.25)	-0.00 (-0.01, 0.01)
Morocco	-0.07 (-0.20, 0.07)	0.04 (0.02, 0.06)
Sri Lanka	0.10 (-0.07, 0.26)	-0.06 (-0.12, 0.00)
Togo	0.33 (-0.06, 0.71)	0.00 (-0.00, 0.00)
Uganda	-0.06 (-0.29, 0.18)	0.03 (-0.01, 0.06)

APPENDIX G: COUNTRY ANALYSIS FOR OBJECTIVE 3

DIARRHEA - 24-HOUR and 2-WEEK RECALL

In general, the lowest rates of diarrhea were found among children who had an improved water supply, but not in all countries (Tables G-1 and G-2). Furthermore, in those countries where the rates were lowest in the improved drinking water group, the rates were sometimes lower in the unimproved non-drinking water group. This was true in Bolivia, Ghana, Morocco, Sri Lanka, Togo and Uganda, sometimes for diarrhea in the previous 24 hours, other times for diarrhea in the previous two weeks.

If only the best and worst groups are compared, due to smaller samples in the two mixed water supply groups, diarrhea in the previous two weeks was lower in the improved group for Bolivia, Ghana, Morocco, and Sri Lanka. It was lower in the unimproved group for Burundi, Guatemala, Togo and Uganda. In no country were the differences in rates of diarrhea in the last two weeks more than 4.1, a small difference. For diarrhea in the previous 24-hours, the rates were lower in the improved group compared to the unimproved group in all countries except Uganda. However, the largest difference in prevalence of diarrhea was 2.8 when the unimproved group in Ghana had a higher diarrhea rate than the improved group.

HEIGHT-FOR-AGE - Z-SCORES AND STUNTING

For all three anthropometric indices, height-for-age (Tables G-3 and G-6), weight-for-height (Tables G-4 and G-7), and weight-for-age (Tables G-5 and G3-8) access to an improved drinking water source for all water needs did not coincide with the lowest rates of malnutrition.

The height-for-age Z-scores were usually lowest in the groups with an unimproved drinking water supply, usually those groups with an unimproved drinking water supply and an improved non-drinking water supply. This was true in Bolivia, Burundi, Guatemala, Sri Lanka, Togo, and Uganda, but the sample sizes in these countries for this group ranged from 3 in Burundi to only 49 in Guatemala.

When the unimproved group was compared to the improved group, excluding the two mixed groups, height-for-age Z-scores were lower in the improved group in all countries except Morocco, which had the least proportion of short children among all eight countries. A similar trend was found for the percent stunted, with reductions in stunting ranging from 5% in Burundi to 21% in Uganda. For these seven countries, the average reduction in stunting was 13%.

WEIGHT-FOR-AGE - Z-SCORES AND UNDERWEIGHT

Results similar to those for height-for-age were found for weight-for-age (Tables G-4 and G-7). Z-scores were generally lowest in the group with fewest children, unimproved drinking water/improved non-drinking water. When the unimproved drinking and non-drinking water supply groups were compared to the improved drinking and non-drinking water supply groups, the rates were lowest in the improved group in all countries, except Morocco. Reduction in underweight ranged from 8% in Burundi and Ghana to 37% in Bolivia, going from unimproved to improved water supplies. The average reduction in percent underweight children for the seven countries, except Morocco, was 20%.

WEIGHT-FOR-HEIGHT - Z-SCORES AND WASTING

Weight-for height Z-scores (Table G-5) were generally within a normal range for all countries, except Sri Lanka, Burundi, and Ghana, where the Z-scores averaged -1.0, -0.5, and -0.7, respectively. Thus, height-for-age Z-scores were similar across all comparison groups. The same was generally true for the percent of children considered to be wasted (less than -2.0 Z-scores). The percent wasted went down in Bolivia (46%), Sri Lanka (22%), Togo (31%), and Uganda (31%), going from unimproved to improved water supplies. Although these reductions seem large, they are due to the small rates of wasting in these countries. It is easier to show large reductions when the percentages are small to start with than when they are large.

Table G-1: Prevalence of diarrhea in the previous 2 weeks according to source of drinking and non-drinking water by country

HEALTH	GOODWAT= No NGOODWAT=No	GOODWAT= No NGOODWAT=Yes	GOODWAT=Yes NGOODWAT=No	GOODWAT=Yes NGOODWAT=Yes
BOLIVIA	41.1 (591)	37.8 (37)	35.5 (136)	39.5 (1736)
BURUNDI	22.8 (527)	33.2 (3)	26.1 (221)	23.2 (1123)
GHANA	34.4 (960)	45.5 (11)	35.3 (34)	33.3 (832)
GUATEMALA	19.9 (452)	16.3 (49)	24.4 (291)	23.3 (1436)
MOROCCO	40.5 (79)	46.9 (32)	37.1 (690)	38.9 (2260)
SRI LANKA	10.1 (703)	6.3 (48)	8.1 (459)	8.5 (958)
TOGO	34.5 (325)	50.0 (10)	29.6 (27)	38.4 (943)
UGANDA	31.0 (993)	36.4 (44)	33.8 (68)	35.1 (1236)

Table G-2: Prevalence of diarrhea in the previous 24 hours according to source of drinking and non-drinking water by country

HEALTH	GOODWAT= No NGOODWAT=No	GOODWAT= No NGOODWAT=Yes	GOODWAT=Yes NGOODWAT=No	GOODWAT=Yes NGOODWAT=Yes
BOLIVIA	22.7 (591)	21.6 (37)	19.9 (136)	22.0 (1736)
BURUNDI	11.2 (527)	33.3 (3)	14.0 (221)	10.9 (1123)
GHANA	18.4 (960)	27.3 (11)	11.8 (34)	15.6 (832)
GUATEMALA	14.2 (452)	10.2 (49)	15.8 (291)	13.6 (1436)
MOROCCO	24.1 (79)	25.0 (32)	25.2 (690)	23.7 (2260)
SRI LANKA	3.0 (703)	2.1 (48)	4.1 (459)	2.6 (958)
TOGO	19.7 (325)	30.0 (10)	14.8 (27)	18.0 (943)
UGANDA	17.8 (993)	11.4 (44)	25.0 (68)	18.9 (1236)

Table G-3: Height-for-age Z-scores according to source of drinking and non-drinking water by country

HEALTH	GOODWAT= No NGOODWAT=No	GOODWAT= No NGOODWAT=Yes	GOODWAT=Yes NGOODWAT=No	GOODWAT=Yes NGOODWAT=Yes
BOLIVIA	-1.7 (624)	-1.2 (38)	-2.0 (141)	-1.4 (1805)
BURUNDI	-1.8 (528)	-1.3 (3)	-1.7 (221)	-1.8 (1123)
GHANA	-1.3 (962)	-1.6 (11)	-1.0 (34)	-1.3 (834)
GUATEMALA	-2.6 (452)	-1.6 (49)	-2.5 (291)	-2.1 (1437)
MOROCCO	-0.9 (79)	-1.4 (32)	-1.5 (690)	-1.1 (2271)
SRI LANKA	-1.5 (660)	-1.3 (46)	-1.6 (428)	-1.3 (869)
TOGO	-1.5 (326)	-0.7 (10)	-1.5 (27)	-1.3 (946)
UGANDA	-1.9 (1001)	-1.7 (45)	-1.4 (68)	-1.6 (1238)

Table G-4: Weight-for-age Z-scores according to source of drinking and non-drinking water by country

HEALTH	GOODWAT= No NGOODWAT=No	GOODWAT= No NGOODWAT=Yes	GOODWAT=Yes NGOODWAT=No	GOODWAT=Yes NGOODWAT=Yes
BOLIVIA	-0.9 (624)	-0.5 (38)	-1.1 (141)	-0.7 (1805)
BURUNDI	-1.6 (528)	-0.8 (3)	-1.5 (221)	-1.5 (1123)
GHANA	-1.4 (962)	-1.7 (11)	-1.0 (34)	-1.4 (834)
GUATEMALA	-1.7 (452)	-1.1 (49)	-1.6 (291)	-1.4 (1437)
MOROCCO	-0.5 (79)	-0.9 (32)	-1.0 (690)	-0.7 (2271)
SRI LANKA	-1.7 (660)	-1.7 (46)	-1.8 (428)	-1.5 (869)
TOGO	-1.3 (326)	-0.4 (10)	-1.1 (27)	-1.1 (946)
UGANDA	-1.2 (1001)	-1.1 (45)	-1.0 (68)	-1.0 (1238)

Table G-5: Weight-for-height Z-scores according to source of drinking and non-drinking water by country

HEALTH	GOODWAT= No NGOODWAT=No	GOODWAT= No NGOODWAT=Yes	GOODWAT=Yes NGOODWAT=No	GOODWAT=Yes NGOODWAT=Yes
BOLIVIA	0.1 (624)	0.3 (38)	0.2 (141)	0.2 (1805)
BURUNDI	-0.5 (528)	0.2 (3)	-0.4 (221)	-0.5 (1123)
GHANA	-0.7 (962)	-1.0 (11)	-0.5 (34)	-0.7 (834)
GUATEMALA	-0.1 (452)	-0.1 (49)	-0.0 (291)	-0.0 (1437)
MOROCCO	0.0 (79)	-0.1 (32)	-0.1 (690)	-0.0 (2271)
SRI LANKA	-1.0 (662)	-1.1 (46)	-1.0 (428)	-0.9 (869)
TOGO	-0.4 (326)	-0.1 (10)	-0.2 (27)	-0.3 (946)
UGANDA	-0.0 (1001)	0.0 (45)	-0.2 (68)	-0.0 (1238)

Table G-6: Prevalence of stunting according to source of drinking and non-drinking water by country

HEALTH	GOODWAT= No NGOODWAT=No	GOODWAT= No NGOODWAT=Yes	GOODWAT=Yes NGOODWAT=No	GOODWAT=Yes NGOODWAT=Yes
BOLIVIA	40.5 (624)	26.3 (38)	53.9 (141)	32.2 (1805)
BURUNDI	47.7 (528)	0.0 (3)	42.1 (221)	45.7 (1123)
GHANA	31.2 (962)	36.4 (11)	20.6 (34)	28.8 (834)
GUATEMALA	67.3 (452)	26.5 (49)	65.3 (291)	54.3 (1437)
MOROCCO	16.5 (79)	34.4 (32)	36.4 (690)	24.2 (2271)
SRI LANKA	30.3 (660)	17.4 (46)	36.0 (428)	26.4 (869)
TOGO	33.1 (326)	10.0 (10)	40.7 (27)	30.5 (946)
UGANDA	48.3 (1001)	37.8 (45)	38.2 (68)	38.1 (1238)

Table G-7: Prevalence of underweight according to source of drinking and non-drinking water by country

HEALTH	GOODWAT= No NGOODWAT=No	GOODWAT= No NGOODWAT=Yes	GOODWAT=Yes NGOODWAT=No	GOODWAT=Yes NGOODWAT=Yes
BOLIVIA	17.3 (624)	7.9 (38)	19.9 (141)	10.9 (1805)
BURUNDI	38.4 (528)	33.3 (3)	33.5 (221)	35.1 (1123)
GHANA	31.5 (962)	36.4 (11)	20.6 (34)	29.1 (834)
GUATEMALA	40.0 (452)	20.4 (49)	38.1 (291)	30.4 (1437)
MOROCCO	7.6 (79)	18.8 (32)	22.1 (690)	15.0 (2271)
SRI LANKA	41.2 (660)	41.3 (46)	42.8 (428)	33.4 (869)
TOGO	32.2 (326)	0.0 (10)	33.3 (27)	24.0 (946)
UGANDA	26.5 (1001)	24.4 (45)	22.1 (68)	21.7 (1238)

Table G-8: Prevalence of wasting according to source of drinking and non-drinking water by country

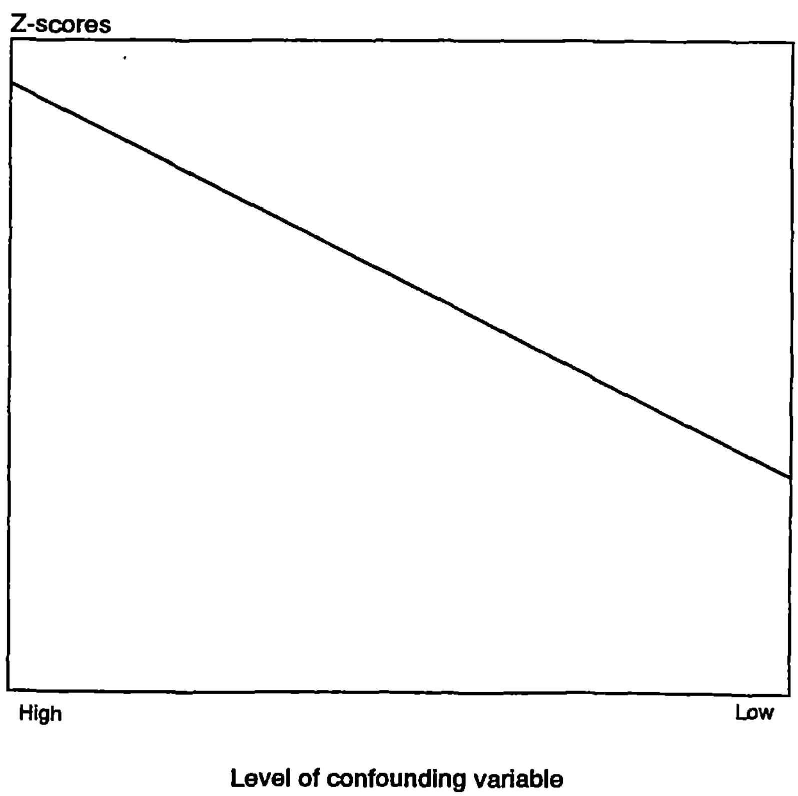
HEALTH	GOODWAT= No NGOODWAT=No	GOODWAT= No NGOODWAT=Yes	GOODWAT=Yes NGOODWAT=No	GOODWAT=Yes NGOODWAT=Yes
BOLIVIA	2.6 (624)	0.0 (38)	3.5 (141)	1.4 (1805)
BURUNDI	5.5 (528)	0.0 (3)	5.4 (221)	6.0 (1123)
GHANA	7.7 (962)	18.2 (11)	11.8 (34)	7.7 (834)
GUATEMALA	1.1 (452)	2.0 (49)	2.1 (291)	1.2 (1437)
MOROCCO	0.0 (79)	0.0 (32)	3.8 (690)	3.8 (2271)
SRI LANKA	12.5 (662)	8.7 (46)	13.1 (428)	9.7 (869)
TOGO	7.4 (326)	0.0 (10)	0.0 (27)	5.2 (946)
UGANDA	2.6 (1001)	0.0 (45)	1.5 (68)	1.8 (1238)

APPENDIX H: INFLUENCE OF CONFOUNDING AND RATIONALE FOR CONTROL

Confounding refers to the effect that one variable, in whole or part, accounts for the apparent effect of the association between two other variables, the independent (e.g., sanitation) and the outcome (e.g., nutritional status) variables. An apparent, or lack of an apparent, association between the independent and outcome variable can be due to another, confounding variable. A confounding variable must satisfy two conditions. First, it must be associated with the independent variable, but not a consequence of it. Second, the confounding variable must have an independent effect on the outcome variable.

An example of the association between the outcome (e.g., nutritional status) and the confounding (e.g., education) variable is shown in figure H-1. At high levels of the confounding variable (High on the X-axis) nutritional status (e.g., Z-scores) is higher than for low levels of the confounding variable (Low on the X-axis). This is shown by the downward sloping line in figure H-1; as education level decreases, nutritional status also deteriorates.

Figure H-1: Influence of confounding on outcome variable



Those with improved sanitation are likely to be more educated, while those without sanitation are likely to have less education. The association between improved sanitation and no sanitation on height is shown in figure H-2. For the purposes of illustration, we can consider two levels of education, literate and illiterate. Literate people are more likely to have adequate sanitation than illiterate people. To state it in other terms, a higher proportion of literate people with have better sanitation than illiterate people. Those with better sanitation have healthier children than those without sanitation.

If confounding was not considered, those with a flush toilet (F on the X-axis) would be associated with a height-for-age Z-score of F on the Y-axis. The corresponding effect of no improved sanitation (N on the X-axis) on height-for-age is shown by N on the Y-axis. Without adjusting for confounding, the difference in height-for-age would be F minus N.

Adjusting for confounding assigns the same level of the confounding variable to the two comparison groups (flush versus no sanitation). This is usually the mean of the confounding variable for the sample. The average level of the confounding variable (C on the X-axis) corresponds to an adjusted effect of flush toilets on height-for-age (C_f on the Y-axis) and no improved sanitation on height-for-age (C_n on the Y-axis). The adjusted difference is C_f minus C_n, which is less that the unadjusted effect of F minus N.

If the effect of confounding is strong, the unadjusted effects can change drastically after adjusting for confounding. When confounding is controlled, any remaining association between the independent variable (e.g., improved sanitation) and the outcome variable (e.g., height-for-age) can no longer be due to the potential confounding variables that were adjusted.

Figure H-2: Influence of confounding - example of sanitation