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Are improved water supply and sanitation always safe for children?
Implications for attaining the MDGs in the Philippines

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Title: **Are *improved* water supply and sanitation always safe for children? Implications for attaining the MDGs in the Philippines**

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Abstract

In 2010, the Philippines appeared to be on track to attain by 2015 its target for Millennium Development Goals 4 (Reduce child mortality), but less so for Goal 7 (Ensure environmental sustainability). In pursuit of the latter, the government expands its provision of water and services to more households. Applying propensity score matching technique on the data from the four rounds of a nationwide survey, such interventions are found to reduce the incidence of child diarrhea, a persistent top cause of child mortality, though not always. The impact of improved sources of drinking water is 1.3% to 2.6% in 1993 and 2.9% to 4.6% in 2003, but none is found in 1998 and 2008. The impact of improved sanitation is 1.2% to 2.1% in 1993 and 3.1% to 4.7% in 2008; but none is found in 1998 and 2003. In addition to health interventions, the regular monitoring of the quality of water and sanitation at the household level is suggested to achieve Goal 4.

Key words: Water and sanitation, child health, MDGs, Philippines

JEL Codes: I12, I18, O53

1. INTRODUCTION

In 2010, the World Health Organization (WHO) and the UNICEF reported a mixed prospect for attaining by 2015 the Millennium Development Goal (MDG) target to reduce by half the proportion of population without access to safe sources of drinking water and basic sanitation facilities. In 2008, about 2.6 billion and 884 million people still had no access to improved sanitation and to improved sources of drinking water, respectively. Even as the report expects the MDG target for drinking water to be achieved, it anticipates that the target that for improved sanitation is likely to be missed (WHO and UNICEF, 2010). While the sustainable access to improved water sources and sanitation facilities is a worthy end in itself, it can also help achieve the MDG target for reducing infant mortality rate (IMR).

The IMR targets can be partly achieved through the prevention and cure of diarrheal diseases, which remain a top public health concern. According to the WHO[1], diarrheal diseases account for the deaths of 1.8 million people annually and about 4.1% of the disability-adjusted life years global burden of disease. Moreover, a significant share of that burden (88%) is borne by children in developing countries. In particular, diarrheal diseases were responsible in 2000 for 20.1% and 12% of all deaths among children younger than five years old in the WHO's Southeast Asia and Western Pacific Regions, respectively.[2] In 2008, it accounted for 13% and 4% of all child deaths in the same regions. In the Philippines, the overall health toll and especially for the under-5 children is equally significant. During the period 2000-2004, around 928 for every 100,000 population each year had acute watery diarrhea. By 2005, still around 708 out of 100,000 Filipinos had the same health problem.[3] The under-5 children accounted for about 61% of the 7,505 cases of acute bloody diarrhea in 2005, and 50% of the 5,435 cases of the same in 2007. In 2003 and 2004, out of every 1,000 live births, 0.5 to 0.6 infants died due to diarrheal diseases (Department of Health 2000, 2005 and 2007). An effective way to break the fecal-oral transmission of bacteria and other microbial pathogens that cause diarrhea diseases is to provide access to safe drinking water and sanitation facilities and to promote better hygiene practices (WHO and UNICEF, 2010; Prüss, Kay, Fewtrell and Bartram, 2002).

Thus, the developing countries that invested in water and sanitation likewise have taken a crucial step to improve their children's health outcomes. However, their public investments are constrained by inadequate information about coverage, quality and cost-effectiveness of various possible water and sanitation programs and of the actual hygiene practices of the target population. Although recent systemic reviews and meta-analyses of interventions affirm the effectiveness of water, sanitation and hygiene interventions in general, these studies also report that different types of interventions vary in effectiveness (Gundry, Wright and Conroy, 2004; Clasen et al., 2007; Waddington et al., 2009; Clasen et al., 2010). For example, information on piped water shows that water quality deteriorates from the point source to the point of use because of leaky pipes or contaminated storage. While some households attempt to mitigate the effects of contaminated water, hand washing and water treatment practices are found to have varying impact. For example, Günther and Fink (2010), using pooled survey data from 72 countries, found that the effects of water and sanitation technology on child diarrhea varied across sub-regional country groups, a finding that supports an earlier point made that the most cost-effective intervention could be country-specific (Kremer and Zwame, 2007).

To provide country-specific evidence, we assess in this paper the impact of water and sanitation interventions on child health in the Philippines. To check further if such interventions have consistent impact, we apply the same evaluation methodology on a cross-section samples from nationwide surveys done in 1993, 1998, 2003 and 2008. Our analysis extends previous studies on the Philippines that found some evidence of the beneficial child health effects of proper excreta disposal and improved water quality (Baltazar et al., 1988; Moe et al., 1991; Van Derslice, Popkin and Briscoe, 1994 and 1995). While these earlier studies applied case-controlled methods, their samples are limited (mostly from Cebu province and before 1998). Using a more recent 1998 household survey data, Cuesta (2007) found that water and sanitation facilities have positive but not large effects on the nutritional status of children. Arguably, the child's nutritional status improves with access to safe water and sanitation especially when these facilities reduce the incidence of diarrhea.[4] We substantiate this channel in this paper.

Like Cuesta (2007), we also apply propensity score matching but on all the last four rounds of the National Demographic and Health Survey (NDHS) to estimate the mean effects of improved sources of drinking water and sanitation facilities on the incidence of diarrhea among under-5 children. We find that the incidence of child diarrhea is lower among households with access to improved water sources in 1993 and 2003, and in households with access to improved toilet facilities in 1993 and 2008. However, we do not find similar effects for improved water sources in 1998 and 2008 as well as for improved toilet facilities in 1998 and 2003. These results support the recent policy thrust to expand the access of more households to safe water and sanitation facilities to attain the target for MDG 7 (*Ensure environmental sustainability*), and also to complement the government's health interventions to achieve the target for MDG 4 *(Reduce child mortality*). However, the health gains from water and sanitation interventions are secured only if the quality of water are regularly monitored not only at the point or source but at the point of use as well.

2. THE PHILIPPINES' PROGRESS WITH MDGs 4 & 7

With only five years to go until the MDG target date, the Philippines in 2010 appeared likely to achieve its targets for Goals 4 and 7. According to NEDA (2010), both the infant mortality rate (IMR) and under-5 mortality rate (U5MR) have improved from 1990 to 2008. From 57 deaths per 1,000 live births in 1990, the IMR rate has declined to 25 deaths in 2008. The U5MR also fell, from 80 to 34 over the same period, a rate of improvement that if sustained will meet the target two-third reduction in U5MR between 1990 and 2015.

By 2015, the Philippines also aim to reduce by half the proportion of population without sustainable access to safe drinking water and basic sanitation. With regard to accomplishing the second objective, the government gives itself a high chance. Data from the various rounds of the Annual Poverty Indicators Survey (APIS) conducted by the National Statistics Office, the proportions of households that had access to water sealed toilets or close pit latrines, whether their own or shared with others, were 82% in 1999, 86% in 2004 and 87% in 2008. With regard to accomplishing the first objective, the government however gives itself only a moderate chance. Again based on the results of several APIS rounds, the proportions of households that are connected to community water systems were 49% in 1999, 48% in 2004 and 53% in 2008. Although these figures suggest an uptrend, the proportions were higher in 2002 (52%) and 2007 (55%). To overcome these setbacks, the national government and local governments units together jumpstarted in late 2010 the President's Priority Program on Water to expand the access of some 1.5 million households in the poorest areas, including 200 *barangays* (villages) in Metro Manila and 200 municipalities outside it where water supply coverage is below 50%.

Besides ensuring wider physical access, the government's water supply and basic sanitation program emphasizes the quality aspect as well. This is important because of the possible health tolls of unsafe water and poor sanitation facilities. According to a 2005 report of the Environmental Management Bureau 27 wells of the 88 shallow wells inspected in nine regions have failed to meet the country's fecal coliform standard. The report identified as possible sources of contaminants as "defective septic tanks without bottom lining, garbage dumps, animal wastes, and inadequately treated wastewater." While drinking water from community water systems may appear safe at the point of source, it may not always be so at the point of use because leaky pipes or contaminated water storage. Interestingly, Bennet (2008) reports that in Metro Cebu the expansion of piped water may have inadvertently aggravated unsanitary faecal and garbage disposal, and thus worsen diarrheal disease. Since diarrheal diseases persist to be among the top causes of child deaths and illnesses in the country, evidence on the possible health benefits of safe water and sanitation will help guide government interventions for Goal 7 towards achieving Goal 4 as well.

3. DATA

To provide the evidence of the health effects of safe water sources and toilet facilities, we use the observational data culled from the 1993, 1998, 2003 and 2008 rounds of the National Demographic and Health Survey (NDHS)[5] for the Philippines. The NDHS rounds cover nationally representative samples of households with female members of reproductive age (i.e., 15 to 49 years old). These surveys are conducted to provide demographic, health and socioeconomic information at the level of both the household and the woman-respondent for the evaluation and design of government policies. In this study, we used the sub-samples of households with children younger than five years old in the 1993-2008 NDHS rounds.

Table 1 shows the sample sizes of the 1993-2008 NDHS rounds. In the 1993 round, there were 15,029 women respondents belonging to 12,995 sample households. In the succeeding three survey rounds, the corresponding samples of women and households are 13,983 and 12,407 in 1998, 13,633 and 12,586 in 2003, and 13,594 and 12,469 in 2008. Of the sample households, between 44% (in 1993) and 37% (in 2008) had children younger than five years old. There were a sample of 9,195 such children in 1993, 8,083 in 1998, 7,145 in 2003 and 6,572 in 2008.

[Insert Table 1 here.]

Measuring diarrhea in children

We measure child health using a binary indicator of diarrhea incidence to denote if an under-5 child did or did not have diarrhea in the last two weeks prior to the survey interview. The sample children were all alive at the time of the interview. In 1993, about 908 under-5 children (or 10.34% of the sample) had diarrhea (Table 1). In 2003, a slightly higher proportion (10.97%) had watery stool. The proportions of under-5 children with diarrhea were relatively lower in 1998 and 2008 at 7.88% and 9.02%, respectively. Note that the figures reported here exclude respondents with missing information (i.e., no answers to the relevant survey questions) and those who are not de jure members of the households (i.e., excluding temporary visitors).

Defining improved water sources and sanitation facilities

Table 1 shows that for each survey year at least 97% of the sample children had access to water and sanitation facilities. Table 2 and Table show the distributions of sample children by their households' main source of drinking water and toilet facilities, respectively. In Table 2, the biggest proportion of children belong to households that have access to water piped into dwellings, yards or plots, or to public taps. This proportion however fell from 57% in 1993 to 41% in 1998. While this proportion rose to 49% in 2003, it declined steeply to 32% in 2008. The second biggest proportion of children belong to households that get water from tube wells, bore holes or protected wells. In 2008, this group accounted for around 30% of the children. Between 5-9% of the samples rely on protected springs. Noticeably, bottled water has become more popular in recent years. By 2008, around 17% of the children belong to households that drink mainly bottled water.

Table 3 shows that around 43% of sample children in 1993 belong to households that have access to their own flush toilets. This proportion has steadily increased to around 75% in 2008. The proportion of children with access to flush toilets shared with other households also increased from 11% in 1993 to 16% in 2003. In each NDHS survey round, about 15% or more of the sample children had no access to sanitary toilet facilities. Instead, they used unsafe methods like hanging toilets or defecation in bushes, fields or rivers, which may have contaminated water sources or food supply and thus led to more diarrhea cases.

[Insert Table 2 and Table 3 here.]

Adapting the classification of the World Health Organization and UNICEF (2010), we construct three binary indicators to distinguish improved water supply and sanitation facilities, namely *improved water1*, *improved water2*, and *improved sanitation*. Each of these indicators assumes a value of 1 if the main source of drinking water (sanitation facility) is improved and 0 if it is not improved. As shown in Table 2, *improved water1* classifies as improved the following sources: piped water, tube well, protected well, protected spring, rainwater, tanker truck or cart with small tank. A similar definition of improved water sources is employed in *improved water2* except for the inclusion of rainwater, tanker truck and carts with small tank as improved water sources. The water obtained from sources defined as improved by *improved water1* or *improved* *water2* is presumably safe at the point of source, although water from some improved sources in *improved water2* may be contaminated due to possible storage problems.

In Table 3, *improved sanitation* defines flush toilets (connected to piped sewer system, septic tank, pit latrine), pit latrine (ventilated, improved, with slab, closed pit) or composting toilet that the household own or use exclusively as improved or sanitary toilet facilities. We also examine in each NDHS round the possible impact of piped water (into dwelling or yard/plot) and own flush toilets on the incidence of diarrhea on the hypothesis that these are more sanitary than all the other types of water sources and toilet facilities. Lastly, we evaluate the impact of bottled water in 2008 to account for its increasing popularity.

Covariates

Following similar studies (e.g., Jalan and Ravallion, 2003; Cuesta, 2007; Rauniyar, Orbeta and Sugiyarto, 2011), the list of covariates used here includes indicators of parental preferences, household-level characteristics and community-level factors that affect the children's access to safe water supply and sanitary toilets, and which in turn determine their susceptibility to diarrheal diseases. This is based on the assumption that parents, particularly mothers, generally decide on the allocation of family resources and on matters that affect their children's health. In the four NDHS rounds, about 25% to 49% of the mothers finished at least high school, 35% to 49% of them were employed, and 75% to 89% were married. Between 47% to 57% of the household heads completed at least secondary education and their ages ranged from 16 to 98 years.

Following Gwatkin et al. (2007), we used principal component analysis in computing for the asset factor scores to construct household wealth/asset quintiles. Unlike in Gwatkin et al. (2007), however, we excluded water source and toilet facility indicators from the factors list. Our own factor scores correlate highly (0.96) with the factor scores reported in either the 2003 and 2008 NDHS rounds. In all NDHS rounds, the average household size is about six members, with a standard deviation of around 2.4 members. As a proxy for water consumption, we used the reported distance (measured in number of minutes) to and from the main source water for drinking in 1993 and 2003 and for hand washing or cooking in 1998 and 2008. We recoded the distance to zero minute for households who did not report the time but said that their main source was piped water (into dwelling or yard). The average time to water source was about 4.7 minutes in 2008, down from 6.5 minutes in 2003. In 1998 and 1993, the average time to water was 9.14 and 6.22 minutes, respectively.

The households (i.e., women respondents) were classified according to religion, ethnicity (or language spoken at home) and place of residence. In each year, at least 75% were Catholics, around 5% to 9% were Muslims, and around 3% to 5% belonged to an indigenous Christian sect (Iglesia ni Kristo). The principal ethnic groups are Cebuano (24% to 31%), Tagalog (15% to 22%), Ilonggo (8% to11%), and Bicolano (6% to 8%). Presumably, these characteristics account for some of the differences in practices or attitudes towards child-rearing or hygiene.

Urbanity and regional classification are included in the covariate list to control for fixed community-level factors, such as public water and sanitation infrastructures. While less than half of the sample households live in urban areas (38% to 46%), urban households have proportionally greater access to piped water relative to rural households, e.g., in the 2008 NDHS round, the proportion of households with access to piped water was 33% in urban areas and only 19% in rural areas. Access to water and sanitation facilities also varies across the country's 17 administrative regions[6] possibly due to geography and economic development. Some regions, particularly those in the Visayas, comprise of numerous island groups. Likewise, the National

Capital Region (Metro Manila) surpasses all other regions in terms of Gross Domestic Product and population density, while the Administrative Region of Muslim Mindanao (ARMM) performed poorly in terms of human development indicators (Human Development Network 2005).

4. EVALUATION METHODOLOGY

Given that the NDHS provides only observational data, the reported access to improved water sources (or improved sanitation facility) may not have been randomized in the sample. Therefore, the impact analysis should account for possible self-selection biases. Here, we employ a similar method applied in previous studies based on observational data (e.g., Jalan and Ravallion 2003; Rauniyar, Orbeta and Sugiyarto 2011). Our impact measure is the mean effect for the children in households that had access to the appropriate facility, or the so-called average treatment effect on the treated. Following the convention (e.g., Heckman, Ichimura and Todd, 1997; Dehejia and Wahba, 2002), we indicate health outcome with a binary variable, say, D that takes on a value of 0 (or simply D_0) and 1 (or simply D_1) to denote whether the child did or did not have diarrhea, respectively, during the reference period. Further, we denote the household (and therefore the child) as having or not having access to improved sources of drinking water (or improved sanitation facility) with T=1 and T=0, respectively. The average treatment effect on the treated (ATT) is defined as:

$$\text{ATT} = E(D_1 - D_0 | T = 1) = E(D_1 | T = 1) - E(D_0 | T = 1).$$

Since the child can only have one of the two health outcomes at any given time, an estimator is needed for the mean of the unobserved counterfactual $E(D_0 | T = 1)$ to be able to identify the ATT. To obtain an estimate of this, we first match the children with access (referred to as "treated" here) to those without access (referred to as "control" here) but who otherwise share the same covariates. The two groups of children are matched using propensity scores defined as:

$$p(\boldsymbol{X}) = \mathrm{Prob}(T = 1|\boldsymbol{X}) = E(T|\boldsymbol{X}),$$

where $\boldsymbol{X}$ is vector of observable covariates (Rosenbaum and Rubin 1983). In other words, the propensity score is the conditional probability that a child has access to improved water or sanitation facility. Rosenbaum and Rubin (1984) proved that if for each individual (here, child) the outcome (here, diarrhea) is independent of treatment status (here, access to improved water supply or sanitation facility) after controlling for $\boldsymbol{X}$, then the outcome remains independent of treatment status after conditioning on the propensity scores defined over the vector of covariates. That is,

$$D_1, D_0 \perp T|\boldsymbol{X} \rightarrow D_1, D_0 \perp p(\boldsymbol{X}).$$

With this property of propensity scores, then $E\left(D_0|T = 0, p(\boldsymbol{X})\right)$ becomes a valid estimator of $E(D_0|T = 1, p(\boldsymbol{X}))$. For the matching to be valid, two conditions however must be satisfied first, namely, the conditional mean independence $\left(E(D_0|T = 1, p(\boldsymbol{X})) = E(D_0|p(\boldsymbol{X}))\right)$, and matching along common support (for values 0<$p(\boldsymbol{X})$<1) (Dehejia and Wahba, 2002; Caliendo and Kopeinig, 2008). Essentially, the first condition ensures that all the characteristics that could have influenced treatment are taken into account in the estimation of the propensity scores and that, after matching, the treated and paired control units have balanced (i.e., same or very close) characteristics. The common support assumption ensures that each treated unit, as it were, has a chance of not being treated. If these two conditions are satisfied, then the ATT is redefined as (Wooldridge, 2002):

$$\mathrm{ATT}(\boldsymbol{X}) = E(D_1|T = 1, p(\boldsymbol{X})) - E(D_0|T = 0, p(\boldsymbol{X})).$$

If the ATT($\boldsymbol{X}$)<0, it can be said then that, in our case, the access to the improved water or sanitation facility led to a lower incidence of child diarrhea.

In our calculation of the ATT($\boldsymbol{X}$), we first obtained the propensity scores from the logit regressions of the dataset of children below five years old (described in the earlier section). Then, we matched each treated child with up to five control children whose propensity scores are within some distance away from that of the treated child. In this so-called nearest-5 neighbor (NN5) matching, we set the threshold distances (or caliper sizes) to 0.001, 0.01, 0.02 and 0.03. To check the robustness of the results, we also used kernel matching (caliper sizes = 0.03 and 0.05), which essentially attaches greater weights to the matched controls that are closest to the treated unit. We obtained our estimates using the PSMATCH2 routine in STATA (Leuven and Sianesi, 2003).

5. BALANCE DIAGNOSTICS

To illustrate how we verified the balancing and common support requirements, we show here the means of the covariates after matching and the histograms of the paired children for *improved water1* and *improved sanitation* for all years. Table 4 and Table 5 show the means of the covariates used in the logit regressions of *improved water1* and *improved sanitation*, respectively, obtained after matching each treated unit (child with access) with the nearest five or fewer control units (children without access). In general, the matching achieved a significant reduction in the standardized bias[8] which led to smaller differences in the means of the covariates between the two groups. In Table 4, however, the average time to water source is still about 2-3 minutes shorter for the children with access than for the children without access.

[Insert Table 4 and 5 here.]

Figure 1 (a - d) and Figure 2 (a - d) show for *improved water1* and *improved sanitation*, respectively, the distributions of the children with and without access after NN5(0.001)-matching in each survey year. As desired, the propensity scores in all figures are between 0 and 1. In both figures, the distribution of the children with access generally appears to be unimodal and the greater mass is at propensity scores greater than 0.4. In contrast, the distribution of children without access to either improved water or improved toilet appears to be bimodal in 1993 and, again for improved toilet, in 2003. Some of the treated units that belong to the upper end of the distribution were excluded because they do not have suitable matches. This may indicate that the excluded children have unobserved characteristics that account for their wider access to safe water sources or sanitary latrines.

[Insert Figure 1 and Figure 2 here.]

We applied the same similar diagnostic procedures on *improved water2*, *piped water*, *bottled water* and *flush toilet own*. While we do not show here the detailed results to save space[6], the means and standard deviations of the standardized bias however are found generally below 5 and 3, respectively, for *improved water1*, *improved water2*, *bottled water* and *piped water*, *improved sanitation* and *flush toilet own* in most years. The only exceptions are those of *improved water1* and *improved water2* in 1998, *improved sanitation* in 2008 when the means and standard deviations were between 5 and 7, which suggest that there might still be differences in some possibly unobserved characteristics between the two sets of children after matching.

6. IMPACT ESTIMATES

Improved water

Table 6 shows for each survey year the estimates of the average treatment effect on the treated (ATT(***X***)) of the various sources of drinking water. In the top row, the ATT(***X***) estimates for *improved water1* are negative and statistically significant (mostly at $p<0.05$) in 1993 and 2003. Specifically, the WHO-classified safe water sources as a group helped prevent diarrhea incidence by 1.9% to 2.6% in 1993 and by 3.3% to 4.6% in 2003, the same years when the proportions of under-5 children with diarrhea were relatively higher than in other years. In 1998 and 2008 when the proportions were lower, the same water sources do not show statistically significant impact on diarrhea incidence.

[Insert Table 6 here.]

The second row shows the estimated impact of *improved water2*, which encompasses all improved sources except rainwater, small tanks or carts. As in the top row, the ATT(***X***) estimates for 1993 are still negative, although only weakly significant ($p<0.10$) and lower in absolute values (1.3% to 1.6%). Those for 2003 likewise have lower absolute values (2.9% to 3.9%), but still highly statistically significant ($p<0.05$). These results suggest that in both NDHS years, rainwater and water from tanker trucks were still as safe as the other improved sources.

In 1998 or 2008, however, improved water sources (i.e., both for *improved water1* and *improved water2*) do not show differential impact on diarrhea incidence. While the ATT(***X***) estimates are mostly positive, they are all statistically insignificant. These results indicate that these improved sources are not better in preventing child diarrhea than the other water sources.

The ATT(***X***) estimates for *piped water* are negative in 1993 (-0.002 to -0.006) and 1998 (-0.002 to -0.010), and positive in 2003 (0.009 to 0.01) and 2008 (0.001 to 0.013). However, all the ATT(***X***) estimates are statistically insignificant. These results imply that piped water may not have been better in quality when compared to other water sources, including those considered as improved as well as those considered unimproved sources. Further, the ATT(***X***) estimates for bottled water are all positive (0.002 to 0.016) albeit statistically insignificant. This particular result is consistent with that of *piped water* in 2008 since bottled water is widely believed to be just filtered or recycled tap water.

Improved sanitation

Table 7 contains the ATT(***X***) estimates for the improved sanitation facilities. The estimates in the top row indicate that improved toilet facilities helped prevent child diarrhea by 1.4% to 2.1% in 1993 and by 3.1% to 4.7% in 2008. In 1998, some evidence of impact (1.3% to 1.4%) is found as well. While most of the ATT(***X***) estimates in 2008 are highly statistically significant (at $p<0.05$), these should be taken with caution since the paired children with and without access still have significant differences in some covariates after matching.

The results in the bottom row of Table 7 indicate that *flush toilet own* reduced diarrhea incidence by 2.2% to 2.8% in 1993 and by 4.3% to 4.8% in 2008, and possibly by as much as 1.5% in 1998. The findings are statistically significant mostly at $p<0.05$ and robust across matching algorithms.

[Insert Table 7 here.]

7. DISCUSSION

In summary, the estimates indicate that improved sources of drinking water and sanitation facilities had their desired impact, though not always, on child health. In particular, improved water sources as a whole helped reduce the incidence of child diarrhea by 1.3% to

2.6% in 1993 and 2.9 to 4.6% in 2003. In addition, improved toilet facilities as a whole helped reduce diarrhea by 1.2% to 2.1% in 1993 and, 3.1% to 4.7% in 2008. However, we did not find any statistically significant impact for improved water in 1998 and 2008, and neither as well as for improved toilet in 2003 and in 1998 (when only two of the six matching algorithms yielded statistically significant impact estimates).

When compared to other sources of drinking water, piped water or bottled water does not yield any differential health impact consistently across years. It could well be that this particular result is innocuous since piped water (and its derivative, bottled water) is compared here to alternative water sources, including those considered improved as well. In contrast, the incidence of child diarrhea in households with their own flush toilets is found lower by 2.2% to 2.8% in 1993 and 4% to 5.6% in 2008.

Our estimates are qualitatively similar to but lower in magnitudes than those previously reported on the Philippines. In particular, Van Derslice and Briscoe (1995) found the provision of private excreta disposal reduced by 42% the incidence of diarrhea in infants within their first six months of life with the provision of private excreta disposal. Balthazar et al. (1988) reported that improvements in water quality and excreta disposal together can reduce by 20% the episodes of diarrhea in below two years old. These bigger, previous estimates may be to their younger samples, who may be less resistant to pathogens than the sample of under-5 children included here.

Some of our impact estimates are also consistent with those in Cuesta (2007), which were likewise obtained by applying propensity score matching on the 1998 NDHS. Specifically, he found that "the aggregate impact of community and point sources of water has a negative impact on the probability of low birthweights" and "that any form sanitation facility has a negative impact on the probability of birthweight stunting." Though of the desired signs, the estimated aggregate impacts however are not statistically significant. Our estimates for 1998 based also on kernel-matching for *improved water1*, *improved water 2* and improved sanitation are likewise negative, small (less than 2%) and statistically insignificant. Together these results indicate that what is considered an improved water source or sanitation facility may not always be safe for child health. Either because the same facility do not protect children from diarrheal diseases that could weaken their nutritional status or they do not help secure their nutritional well-being which render children more prone to experience watery stool.

One possible explanation for the weak, inconsistent effect of improved water and sanitation facilities on child diarrhea is the inherent weakness of the observational data used here. In particular, the list of available covariates may not be complete to account for all possible confounding factors. If the unobserved factors are time-invariant, their confounding effects can be eliminated using difference-in-difference technique after matching (Khandker, Koolwal and Samad 2010). If not, then randomized control trials to fully eliminate biases may be necessary in future studies.

Another possible reason could be a deterioration in the quality of water from the point of source to the point of use. An indirect evidence is the high percentage of the NDHS sample children that live in households who treat their drinking water, including water from improved sources, presumably to make it safer. In 1998, 26% and 39% of those with access to improved water sources and piped water, respectively, still boiled, filtered or treated with chlorine their drinking water. In 2003, the corresponding figures are 50% and 57%. By 2008, the rates somewhat improved to 44% and 49% in 2008, but still higher than those in 1998. Moreover, more and more households use bottled water, which is usually more expensive but could be perceived to be safer than tap water.

However, it is not possible to ascertain the quality of drinking water from the NDHS. To ascertain the quality control procedures at the point of source, we interviewed in May 2011 several local water utility managers in selected urban (East Zone of Metro Manila and Los Baños in Laguna) and rural (Baliwag in Bulacan and Indang in Cavite) areas in the Philippines. According to these managers, their companies filter the water first then treat it with chlorine before pumping water to households. In addition, these local water utilities regularly send water samples to accredited laboratories for microbial and other tests, and monitor and repair pipes for leakages. However, they do not normally monitor the quality of piped water at the household level until there is an outbreak of diarrheal diseases and only in places where such happen.

8. CONCLUDING REMARKS

In this paper we find some evidence that improved water sources and toilet facilities had their desired impact on child health, although the impact could vary across types of interventions and across years. This suggest the importance of periodic monitoring of quality of presumed safe water and toilet facilities. The comparability of the results obtained for each of the four years is ensured by the use of the same impact evaluation method and the consistency in the sampling design in the four NDHS. The dataset also covers more households, places and in more years than previously analyzed in the Philippines. Nonetheless, since this is a post-intervention evaluation using observational data, some unobserved covariates still possibly confound our estimates.

Using the impact estimates for *improved water1* in 2003, a simple calculation would show that there could have been up 34 less children of the total 749 found with diarrhea in the sample had they only had access to the corresponding safe sources of drinking water. Using the impact estimates for *improved sanitation* in 2008, there could have been up 27 children saved from experiencing water stools had they had access to safe toilet facilities. While these figures indicate that achieving the target Goal 7 could also help achieve the targets for Goal 4, the health payoffs for children may not be always positive or large.

Notwithstanding the data limitations, the results shed a few inputs to policy. First, there is a need re-evaluate the quality of safe and clean water and sanitation facilities at the household level. In the Philippines, the government considers community water system and protected wells as improved sources, and flush toilet (either owned or shared) and closed pits as sanitary facilities. Our findings indicate that this broad classification, although consistent with international standards, do not ensure quality. Second, hygiene practices should be mapped and better practices should be promoted. In the Philippines, less is known about actual hygiene practices. Last, and to reiterate Cuesta (2007), water and sanitation interventions can complement but cannot substitute for health programs for MDG 4.

ENDNOTES

[1] *http://www.who.int/water_sanitation_health diseases/burden/en/index.html*. Accessed May 16, 2011.

[2] World Health Organization. World Health Statistics 2011. *http://www.who.int/whosis/whostat/EN_WHS2011_Full.pdf*. Accessed May 16, 2011.

[3] *http://www.doh.gov.ph/kp/statistics*. Accessed May 16, 2011.

[4] Guerant et al (1992) presents some evidence about the effects of diarrhea and malnutrition on each other.

[5] 5he NDHS datasets are obtained from ICF Macro (*http://www.measuredhs.com*).

[6] There have been changes in the number and composition of the regions between 1993 and 2008. To make the results comparable across years, we applied the 17-region classification in 2008 in all other NDHS rounds.

[7] In all, there are eight tables of summary statistics of the regression variables, six tables of logit regression results, 36 tables of after-matching means of the covariates (including tests of means) and two tables of the means and standard deviation of the standardized bias. The complete, detailed results are available from the authors upon request.

[8] Defined for each covariate, the standardized bias is "the difference of sample means in the treated and matched control subsamples as a percentage of the square root of the average sample variances in both groups" (Caliendo and Kopeinig, 2008).

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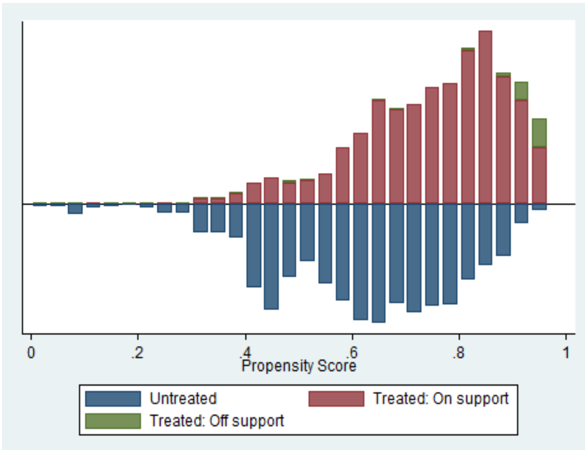
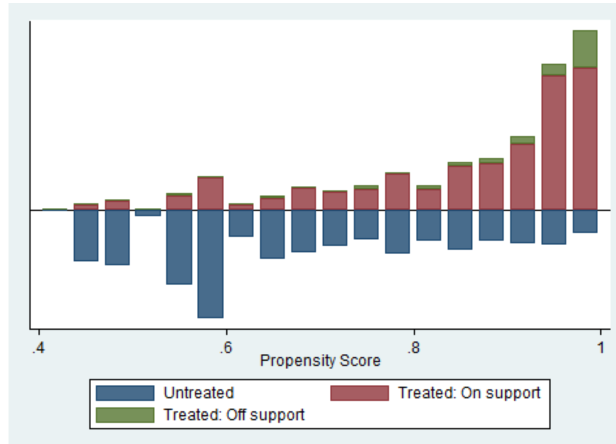
Figure 1. Histograms of matched sub-samples along common support: *Improved water1* (based on NN5(0.001) matching), 1993-2008



a. 1993



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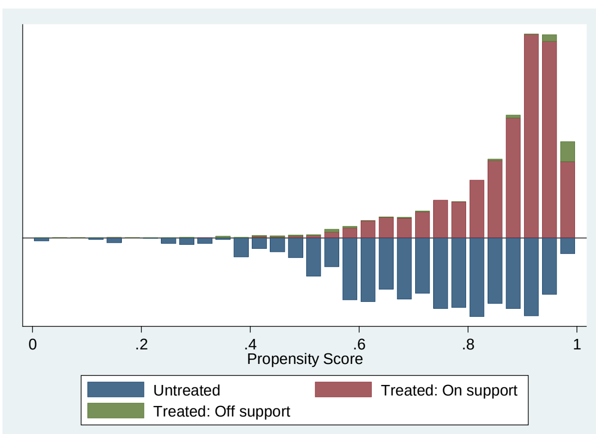
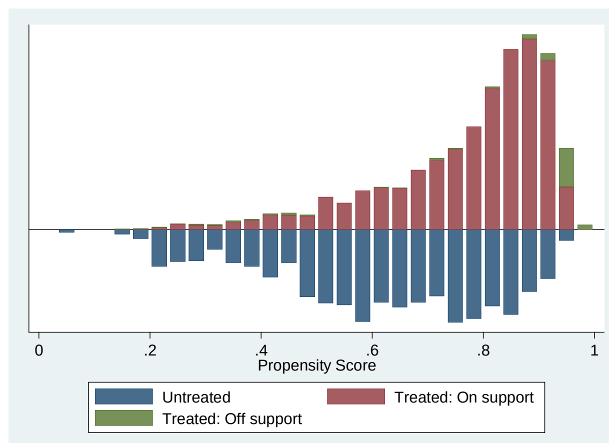
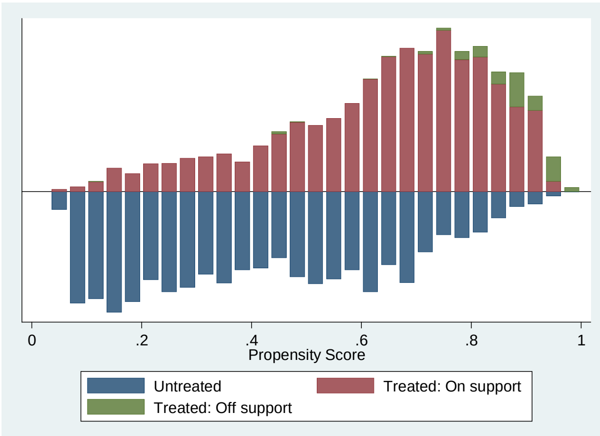


c. 2003

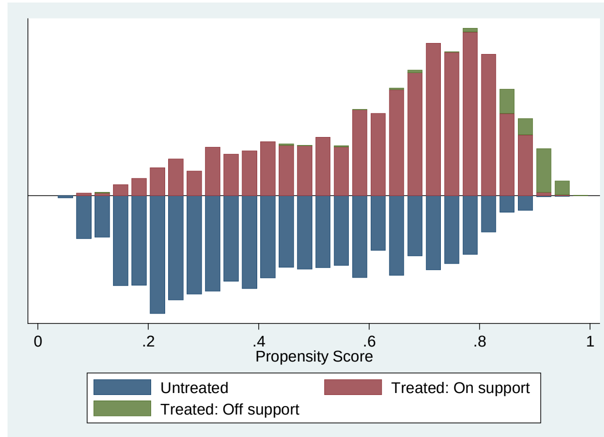


d. 2008

Figure 2. Histograms of matched sub-samples along common support: *Improved sanitation*, (based on NN5(0.001) matching) 1993-2008



a. 1993



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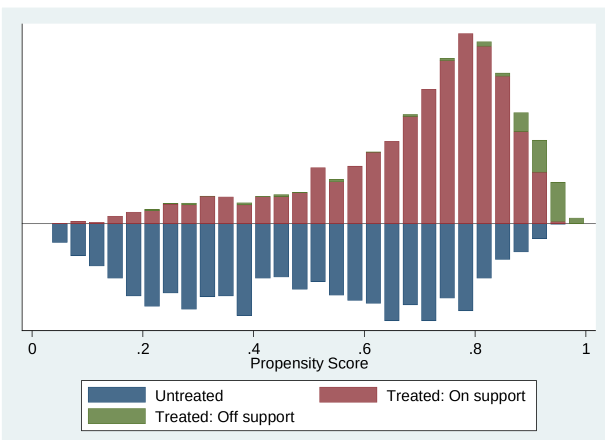

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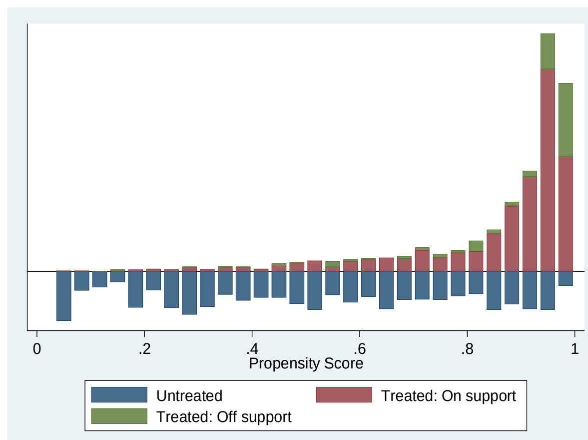

d. 2008

Table 1. Sample sizes of the National Demographic and Health Surveys, Philippines

Samples	1993	1998	2003	2008
Number of women of reproductive age (15-49 years old)	15,029	13,983	13,633	13,594
Number of households	12, 995	12,407	12,586	12,469
Number of households with children below 5 years old	5,795	5,240	4,920	4,712
Number of children below 5 years old	9,195	8,083	7,145	6,572
Under-5 children by diarrhea condition*	8,770	7,669	6,825	6,327
	(100%)	(100%)	(100%)	(100%)
No	7,871	7,065	6,076	5,756
	(89.66%)	(92.12%)	(89.03%)	(90.98%)
Yes	908	604	749	571
	(10.34%)	(7.88%)	(10.97%)	(9.02%)
Under-5 children with access to sources of drinking water (all types)*	9,160	8,075	7,034	6,408
Under-5 children with access to sanitation facilities (all types)*	9,179	8,052	7,031	6,408

Notes:
*Sub-samples limited to dejure members of households.
Source: National Demographic and Health Survey (various rounds). Authors' calculations.

Table 2. Distribution of children by main source of drinking water, 1993-2008

Sources	1993		1998		2003		2008		*improved water1*	*improved water2*
	No	%	No	%	No.	%	No.	%		
Total	9,160	100.0	8,075	100.0	7,034	100.0	6,408	100.0		
Piped water										
Piped into dwelling	3,463	37.8	1,666	20.6	1,909	27.1	1,206	18.8	I	I
Piped into yard/plot	848	9.3	517	6.4	377	5.4	409	6.4	I	I
Public tap/stand pipe	971	10.6	1,100	13.6	1,147	16.3	438	6.8	I	I
Tube well water										
Tube well or bore hole							1,500	23.4	I	I
Dug well										
Protected well	387	4.2	2,650	32.8	1,930	27.4	413	6.5	I	I
Unprotected well/open dug	2,259	24.7	790	9.8	422	6.0	253	4.0	U	U
Semi-protected well							94	1.5	U	U
Surface water										
Protected spring	812	8.9	580	7.2	374	5.3	515	8.0	I	I
Unprotected spring			459	5.7	291	4.1	250	3.9	U	U
River/lake/ponds/dam			96	1.0	82	1.2	48	0.8	U	U
Rainwater	82	0.9	36	0.5	41	0.6	48	0.8	I	U
Tanker truck							56	0.9	I	U
Cart with small tank			150	1.9	127	1.8	40	0.6	I	U
Bottled water			28	0.4	330	4.7	1,066	16.6	U	U
Neighbor's tap							58	0.9	U	U
Neighbor's tap (NAWASA)							13	0.2	U	U
Others	338	3.7	3	0.0	4	0.1	1	0.0	U	U

Notes:
Samples limited to de jure members of the household.
"I" and "U" mean improved source and unimproved source, respectively.
Source of raw data: National Demographic and Health Surveys (various years). Authors' calculations.

Table 3. Distribution of children by type of sanitation facility, 1993-2008

	1993		1998		2003		2008		*improved*
Sources	No	%	No	%	No.	%	No.	%	*toilet*
Total	9,179	100.0	8,052	100.0	7,031	100.0	6,408	100.0	
Flush or pour flush toilet									
to piped sewer system							151	2.4	I
to septic tank							3,741	58.4	I
to pit latrine							869	13.6	I
to somewhere else							48	0.8	U
flush, don't know where							12	0.2	U
own toilet	3,932	42.8	3,680	45.7	3,837	54.6			I
shared flush toilet	1,016	11.1	1,217	15.1	1,127	16.0			U
Pit latrine									
ventilated, improved							85	1.3	I
with slab							189	3.0	I
without slab/open pit							219	3.4	U
closed pit			731	9.1	484	6.9			I
open pit			825	10.3	362	5.2			U
own toilet (sanitary pit)	1,027	11.2							I
shared toilet (sanitary pit)	407	4.4							U
Open privy	797	8.7							U
Composting toilet							53	0.8	I
Bucket toilet							10	0.2	U
Drop/hanging toilet	354	3.9	301	3.7	257	3.7	102	1.6	U
No facility/bush/field/river	1,635	17.8	1,292	16.1	962	13.7	925	14.4	U
Other	11	0.1	6	0.1	2	0.0	4	0.1	U

Notes:
Samples limited to de jure members of the household.
"I" and "U" mean improved source and unimproved sanitation facilities, respectively.
Source of raw data: National Demographic and Health Surveys (various years). Authors' calculations.

Table 4. Means of covariates after matching (NN5 (0.001)): *Improved water1*, 1993 – 2008

Variable	1993			1998			2003			2008		
	Treated (*N*=5498)	Control (*N*= 2,336)	% Reduc-tion |bias|	Treated (*N*= 5601)	Control (*N*= 1284)	% Reduc-tion |bias|	Treated (*N*= 5292)	Control (*N*= 1050)	% Reduc-tion |bias|	Treated (*N*= 4287)	Control (*N*= 1621)	% Reduc-tion |bias|
Time to water source	3.588	5.196	77.7				4.626	7.590	64.7	4.125	5.356	39.9
Household size	6.535	6.480	68.8	6.341	6.381	19.8	6.198	5.809	-787.8	6.269	6.324	65.3
If mother is employed	0.371	0.364	92.2	0.370	0.421	73.9	0.437	0.438	99.4	0.485	0.465	61.4
If mother finished high school	0.420	0.444	87.1	0.455	0.485	89.7	0.519	0.550	66.5	0.221	0.205	89.1
If mother is married	0.896	0.890	37.9	0.877	0.879	79.2	0.825	0.822	92.5	0.757	0.736	4.1
If urban	0.484	0.504	86.9	0.419	0.439	93.7	0.491	0.475	91.0	0.379	0.338	79.9
Wealth quintile 2 (Poor)	0.142	0.126	45.2	0.159	0.157	94.2	0.238	0.224	84.9	0.254	0.252	97.4
Wealth quintile 3 (Middle)	0.212	0.214	97.2	0.225	0.222	97.4	0.204	0.242	68.1	0.213	0.193	72.2
Wealth quintile 4 (Rich)	0.209	0.219	89.3	0.193	0.205	92.7	0.200	0.218	84.9	0.160	0.145	39.2
Wealth quintile 5 (Richest)	0.139	0.166	77.3	0.132	0.159	76.2	0.141	0.115	27.7	0.098	0.097	99.2
Tagalog	0.187	0.190	96.2	0.166	0.127	66.6	0.234	0.238	94.2	0.206	0.222	64.4
Bicolano	0.080	0.083	74.4	0.070	0.091	36.4	0.066	0.054	33.4	0.064	0.061	-5.2
Catholic	0.826	0.821	80.7	0.775	0.769	80.8	0.787	0.798	79.4	0.753	0.745	51.6
Iglesia Ni Kristo	0.029	0.033	35.0	0.026	0.024	82.7	0.024	0.032	-228.9	0.026	0.020	6.2
Islam	0.036	0.027	78.7	0.074	0.058	61.7	0.065	0.073	76.0	0.077	0.076	95.9
Ilocos Region	0.071	0.067	89.6	0.050	0.041	70.6	0.044	0.054	71.7	0.056	0.037	-10.9
Cagayan Region	0.052	0.049	40.9	0.046	0.060	-99.1	0.044	0.068	16.0	0.048	0.039	73.1
Central Luzon Region	0.091	0.095	87.6	0.055	0.048	88.5	0.077	0.102	14.3	0.083	0.071	58.9
Bicol Region	0.074	0.068	76.9	0.075	0.077	25.5	0.062	0.045	-15.3	0.069	0.066	53.7
Western Visayas Region	0.063	0.067	94.2	0.059	0.047	60.2	0.052	0.046	81.6	0.059	0.057	89.3
Central Visayas Region	0.064	0.062	97.4	0.069	0.112	-647.5	0.065	0.094	-642.2	0.048	0.039	87.4
Eastern Visayas Region	0.065	0.070	-24.0	0.073	0.075	94.9	0.060	0.069	0.8	0.059	0.067	70.4
Zamboanga Peninsula Region	0.044	0.044	99.0	0.047	0.041	91.7	0.041	0.028	47.7	0.060	0.064	79.4
Northern Mindanao Region	0.068	0.068	-73.5	0.083	0.059	-21846.3	0.050	0.045	75.4	0.053	0.056	31.9
Davao Region	0.056	0.061	67.3	0.040	0.049	-781.3	0.042	0.041	95.4	0.058	0.067	61.4
SOCCSKSARGEN Region	0.053	0.045	34.1	0.057	0.063	76.4	0.060	0.054	45.6	0.053	0.065	51.3
Cordillera Administrative Region	0.039	0.035	71.3	0.050	0.065	36.6	0.036	0.031	16.4	0.044	0.031	-37.3
ARMM	0.037	0.028	71.1	0.063	0.048	74.8	0.046	0.048	96.5	0.052	0.050	96.2
CARAGA Region	0.030	0.033	-206.0	0.055	0.051	70.8	0.045	0.035	71.3	0.052	0.058	86.5
CALABARZON Region	0.070	0.067	86.2	0.071	0.037	16.8	0.091	0.080	51.2	0.089	0.099	38.3
MIMAROPA Region	0.022	0.020	25.5	0.023	0.022	86.1	0.041	0.040	96.8	0.056	0.063	81.5

Note: SOCCSKARGEN means South Cotabato, Cotabato City, Sultan Kudarat, Sarangani, and General Santos City; ARMM means Autonomous Region of Muslim Mindanao; MIMAROPA means Mindoro, Marinduque, Romblon and Palawan.

Table 5. Means of covariates after matching (NN5 (0.001)): *Improved sanitation*, 1993 - 2008

Variable	1993			1998			2003			2008		
	Treated (*N* = 4406)	Control (*N* = 3905)	% Reduc-tion |bias|	Treated (*N* = 3921)	Control (*N* = 3438)	% Reduc-tion |bias|	Treated (*N* = 3849)	Control (*N* = 2547)	% Reduc-tion |bias|	Treated (*N* = 3933)	Control (*N* = 1293)	% Reduc-tion |bias|
Age of household head	39.302	38.804	88.7	39.088	39.045	99.0	38.229	37.771	90.1	40.088	39.343	81.4
If hh. head finished high school	0.566	0.589	89.4	0.605	0.635	88.5	0.645	0.663	92.4	0.633	0.628	98.6
If urban	0.516	0.534	87.9	0.459	0.441	91.1	0.520	0.495	85.6	0.466	0.413	79.1
If mother is married	0.907	0.915	76.8	0.881	0.876	54.0	0.840	0.846	82.3	0.740	0.688	4.9
Wealth quintile 1 (Poorest)	0.207	0.201	98.1	0.226	0.224	99.5	0.156	0.157	99.9	0.168	0.165	99.4
Tagalog	0.213	0.208	94.1	0.185	0.182	96.5	0.263	0.247	86.2	0.249	0.240	94.8
Cebuano	0.292	0.292	96.6	0.275	0.258	74.0	0.251	0.268	50.3	0.255	0.265	-501.8
Ilonggo	0.097	0.096	95.7	0.094	0.099	31.1	0.089	0.089	93.9	0.081	0.089	-25.8
Bicolano	0.077	0.083	57.4	0.066	0.069	-29.2	0.065	0.064	82.0	0.073	0.075	92.5
Catholic	0.830	0.834	87.9	0.792	0.788	95.6	0.809	0.824	82.0	0.795	0.805	94.8
Iglesia Ni Kristo	0.029	0.027	9.0	0.032	0.033	81.6	0.029	0.027	79.9	0.028	0.032	32.0
Islam	0.026	0.032	88.1	0.049	0.054	94.3	0.033	0.034	99.5	0.037	0.037	99.7
Ilocos Region	0.077	0.085	83.9	0.055	0.059	83.7	0.051	0.049	92.6	0.033	0.022	80.1
Cagayan Region	0.047	0.046	86.0	0.052	0.073	30.0	0.042	0.062	30.7	0.050	0.050	97.5
Central Luzon Region	0.107	0.096	61.2	0.080	0.082	94.2	0.084	0.075	76.9	0.085	0.083	98.2
Bicol Region	0.068	0.070	90.7	0.066	0.064	84.0	0.063	0.060	69.8	0.069	0.057	1.3
Western Visayas Region	0.056	0.046	83.8	0.062	0.062	95.8	0.054	0.052	91.0	0.049	0.046	91.5
Central Visayas Region	0.053	0.047	91.1	0.067	0.055	-210.8	0.058	0.057	95.2	0.069	0.051	10.8
Eastern Visayas Region	0.052	0.044	66.4	0.065	0.069	85.8	0.047	0.043	89.1	0.037	0.029	87.7
Zamboanga Peninsula Region	0.051	0.045	-1.4	0.057	0.061	56.0	0.045	0.052	-13.0	0.048	0.040	35.5
Northern Mindanao Region	0.077	0.085	85.6	0.072	0.060	59.5	0.045	0.054	-6.0	0.052	0.055	32.5
Davao Region	0.051	0.062	-758.7	0.046	0.046	33.1	0.050	0.055	51.6	0.055	0.088	-74.7
SOCCSKSARGEN Region	0.054	0.055	61.9	0.057	0.063	-65.0	0.047	0.043	87.0	0.051	0.063	-79.3
Cordillera Administrative Region	0.042	0.044	72.3	0.042	0.037	83.9	0.041	0.039	70.3	0.046	0.056	68.0
ARMM	0.027	0.029	95.6	0.036	0.041	94.3	0.025	0.026	98.9	0.020	0.023	98.4
CARAGA Region	0.033	0.040	46.5	0.062	0.071	66.1	0.049	0.055	53.3	0.056	0.062	65.8
CALABARZON Region	0.082	0.079	90.3	0.079	0.054	51.2	0.105	0.103	97.2	0.113	0.151	53.6
MIMAROPA Region	0.022	0.023	96.6	0.012	0.012	99.6	0.036	0.032	87.3	0.046	0.038	74.8

Note: SOCCSKARGEN means South Cotabato, Cotabato City, Sultan Kudarat, Sarangani, and General Santos City; ARMM means Autonomous Region of Muslim Mindanao; MIMAROPA means Mindoro, Marinduque, Romblon and Palawan.

Table 6. Estimates of the impact of improved sources of drinking water, 1993-2008

Source of drinking water	1993		1998		2003		2008	
	ATT (***X***)	Std. errors	ATT (***X***)	Std. errors	ATT (***X***)	Std. errors	ATT (***X***)	Std. errors
Improved water1								
NN5 (0.001)	-0.026[a]	0.011	0.016	0.018	-0.046[a]	0.019	0.010	0.013
NN5 (0.01)	-0.022[a]	0.011	0.019	0.016	-0.034[a]	0.017	0.011	0.012
NN5 (0.02)	-0.020[a]	0.011	0.018	0.016	-0.033[a]	0.017	0.012	0.012
NN5 (0.03)	-0.021[a]	0.011	0.016	0.016	-0.034[a]	0.017	0.009	0.012
Kernel (0.03)	-0.019[a]	0.010	0.012	0.014	-0.034[a]	0.016	0.0003	0.011
Kernel (0.05)	-0.016[b]	0.010	0.007	0.014	-0.037[a]	0.016	-0.0005	0.011
Improved water2								
NN5 (0.001)	-0.013	0.012	0.002	0.014	-0.036[a]	0.016	0.009	0.011
NN5 (0.01)	-0.016[b]	0.012	0.006	0.013	-0.037[a]	0.015	0.012	0.011
NN5 (0.02)	-0.014	0.012	0.006	0.014	-0.039[a]	0.015	0.012	0.011
NN5 (0.03)	-0.015[b]	0.012	0.004	0.013	-0.036[a]	0.015	0.013	0.011
Kernel (0.03)	-0.016[b]	0.010	-0.001	0.012	-0.028[a]	0.015	0.009	0.010
Kernel (0.05)	-0.013[b]	0.010	-0.005	0.012	-0.029[a]	0.014	0.009	0.010
Piped water								
NN5 (0.001)	-0.006	0.009	-0.002	0.010	0.009	0.010	0.013	0.010
NN5 (0.01)	-0.004	0.009	-0.006	0.010	0.011	0.010	0.009	0.010
NN5 (0.02)	-0.002	0.009	-0.010	0.010	0.013	0.010	0.010	0.010
NN5 (0.03)	-0.004	0.009	-0.007	0.010	0.010	0.010	0.009	0.010
Kernel (0.03)	-0.006	0.008	-0.003	0.009	0.007	0.010	0.001	0.010
Kernel (0.05)	-0.005	0.008	-0.003	0.009	0.008	0.010	0.001	0.010
Bottled water								
NN5 (0.001)							0.016	0.014
NN5 (0.01)							0.005	0.013
NN5 (0.02)							0.006	0.013
NN5 (0.03)							0.002	0.013
Kernel (0.03)							0.008	0.013
Kernel (0.05)							0.009	0.013

Notes:
"NN5" means nearest five neighbors. Figures in parentheses are the sizes of the caliper and bandwidth in the cases of NN5-matching and kernel matching, respectively.
[a] indicates significance at $p<0.05$.
[b] indicates significance at the $p<0.10$.

Table 7. Estimates of the impact of improved sanitation facilities, 1993-2008

Type of toilet	1993		1998		2003		2008	
	ATT (***X***)	Std. errors	ATT (***X***)	Std. errors	ATT (***X***)	Std. errors	ATT (***X***)	Std. errors
Improved sanitation								
NN5 (0.001)	-0.014[b]	0.010	-0.007	0.009	-0.003	0.012	-0.031[b]	0.023
NN5 (0.01)	-0.021[a]	0.010	-0.014[b]	0.009	-0.000	0.011	-0.045[a]	0.022
NN5 (0.02)	-0.019[a]	0.010	-0.011	0.009	-0.000	0.011	-0.044[a]	0.022
NN5 (0.03)	-0.021[a]	0.010	-0.013[b]	0.009	-0.001	0.011	-0.044[a]	0.022
Kernel (0.03)	-0.014[b]	0.009	-0.008	0.008	-0.005	0.011	-0.047[a]	0.020
Kernel (0.05)	-0.013[b]	0.009	-0.007	0.008	-0.005	0.010	-0.044[a]	0.019
Flush toilet own								
NN5 (0.001)	-0.022[a]	0.010	-0.011	0.009	-0.010	0.012	-0.048[a]	0.019
NN5 (0.01)	-0.029[a]	0.010	-0.010	0.009	-0.014	0.012	-0.056[a]	0.019
NN5 (0.02)	-0.027[a]	0.010	-0.010	0.009	-0.012	0.012	-0.052[a]	0.019
NN5 (0.03)	-0.028[a]	0.010	-0.009	0.009	-0.014	0.012	-0.056[a]	0.019
Kernel (0.03)	-0.027[a]	0.010	-0.009	0.009	-0.015[b]	0.011	-0.043[a]	0.017
Kernel (0.05)	-0.027[a]	0.010	-0.008	0.008	-0.014[b]	0.011	-0.040[a]	0.017

Notes:
"NN5" means nearest five neighbors. Figures in parentheses are the sizes of the caliper and bandwidth in the cases of NN5-matching and kernel matching, respectively.
[a] indicates significance at the $p<0.05$.
[b] indicates significance at the $p<0.10$.