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Do Water and Sanitation Interventions Reduce Childhood Diarrhoea? New Evidence from Bangladesh

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The incidence of diarrhoea has declined over time in Bangladesh but still it persists as a major cause of infant mortality, morbidity and acute child malnutrition. Much of the public policy thinking in the past was guided by public investment in providing improved access to safe water. While this measure has paid off, the paper provides evidence that the relevance of water as a tool for fighting diarrhoea may have changed over time. Its changing role now needs to be seen in the broader context of *combined access* with other inputs such as improved sanitation. The paper uses the Bangladesh Demographic and Health Survey data and the propensity score matching technique to suggest that only combined access to improved water and sanitation can lead to reduced incidence of diarrhoea among children in contrast to their isolated use. Mere accesses to safe water, or for that matter, access to sanitation do not have any statistically significant impact on the incidence of childhood diarrhoea. The results suggest a strong case for rethinking public policy by way of joint investment in water and sanitation measures to reduce diarrhoea along with bringing about favourable change in health-seeking behaviour to support such combined access policy.

I. INTRODUCTION

Diarrhoea is recognised as a major health problem in children throughout the developing world. Most of the pathogenic organisms that cause diarrhoea and all

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the pathogens that are known to be the major causes of diarrhoea in many countries are transmitted primarily or exclusively through faecal-oral route (Faechem 1984).[1] In developing countries transmission of cholera/diarrhoea is believed to be associated with poor quality of water for drinking, bathing, washing utensils, etc. with faecal pollution of water sources and the quality of home environment are identified as the key source of pathogens causing diarrhoea (Spira, Sayeed, Khan and Sattar 1980). Hence, for diarrhoeal disease control, the improvement of water supply and excreta disposal facilities has attracted much interest and the governments of poor countries have undertaken the water and sanitation improvement programmes with the confidence that such physical investments in water/sanitation areas will surely result in substantial improvements in the diarrhoeal incidence. The historical experience of the developed countries also supported this policy stance. The improvements in water/sanitation environments, together with rise in living standards, have played a major role in reducing diarrhoea rates and controlling epidemic of typhoid and cholera in Europe and North America between 1860 and 1920 (Esrey, Faechem and Hughes 1985).

Scepticism in the validity of the conventional wisdom, however, surfaced in the recent years. Although the access to improved water supply and sanitation is long advocated to have contributed to better health of the people, particularly that of the children, a recent review of literature shows that the evidence base, especially with regard to the sanitation, is rather weak (World Bank 2006, Pattanayak *et al.* 2007, Waddigton *et al.* 2009). The evidence base on water is also found to be ambiguous: even though unsafe water is almost universally held to be the major cause of diarrhoea, many apparent contradictions are noticeable in the findings of the published studies exploring this relationship. After a review of 67 studies from 28 countries, Esrey, Faechem and Hughes (1985) could see a favourable impact of improved water and sanitation on diarrhoea, but they also found improvements in *water quality* to be less important than improvements in *water availability* or excreta disposal. Studies also expressed the opinion that for the purpose of controlling cholera and other water borne diseases, the quality sources of water are not enough (Briscoe 1977): it is likely to be affected more by the water quantity than by water quality. A number of subsequent studies have failed to find any health benefit when the water quality alone was improved (Wall and Keeve 1974, Levine, Khan, D'Souza and Nalin 1976, Baltazar *et al.* 1988, Young and Briscoe 1988). This is in contrast to studies which have previously detected significant health benefits of the improved quality of water (see, for instance, Wagner and Lanoix 1959). In short, the effectiveness of

[1] The literature review, as presented here, draws heavily on Waddington *et al.* (2009).

improved water supply and sanitation on diarrhoea and other water related diseases in the developing countries has been extensively discussed and debated over the last several decades (Saunders and Warford 1976, McJunkin 1982, Faechem *et al.* 1983, Blum and Faechem 1983, Merrick 1983, Esrey and Habicht 1985) without however reaching a firm conclusion.

1.1 Objective of the Study

In the backdrop of conflicting evidence the present study revisits the issue of the impact of improved water and sanitation interventions on reducing the prevalence of child diarrhoea. The objective of the study is to obtain *unbiased* estimate of the impact of improved water and sanitation in Bangladesh on the prevalence of childhood diarrhoea by using the Propensity Score Matching (PSM) technique. The main question of the investigation of the study is whether and to what extent "the children from households with access to improved drinking water source and improved sanitation face less vulnerability to diarrhoeal attack than those from potentially similar households who do not have such access."

1.2 Structure of the Paper

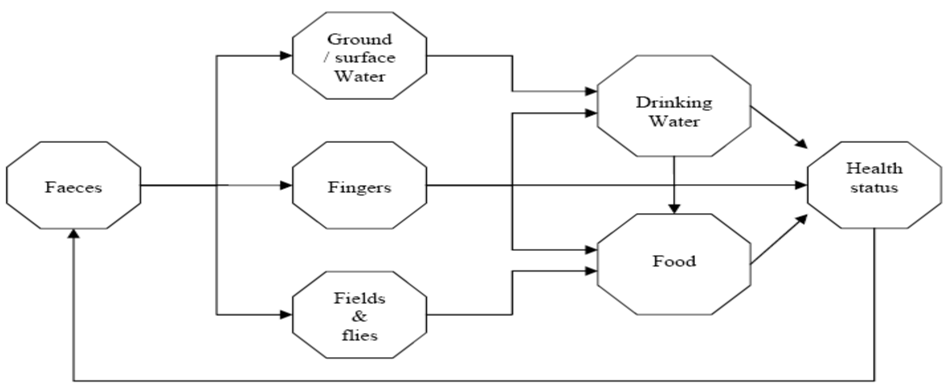
The paper is divided into seven sections. Section I summarises the relevant literature and presents the conflicting findings regarding the effects of improved water and sanitation on child diarrhoea, thus foregrounding the analytical relevance of the present exercise. Section II discusses the causal link that connects water-sanitation interventions with diarrhoea incidence by tracing the transmission routes for pathogens. Section III describes the data sets used in the present paper. Section IV provides information on the current pattern of access to improved water and sanitation in both rural and urban areas. It also draws attention to "puzzles" in the bivariate association between water/sanitation interventions with diarrhoea incidence based on both BDHS and MICS data. Method of estimation based on the Propensity Score Matching (PSM) technique, its advantage over the OLS technique, and related methodological issues in implementing PSM in a household survey data setting are discussed in Section V. The PSM results using the 2007 round of BDHS are presented in Section VI. The magnitude of the "treatment effects" on diarrhoea incidence of children is captured separately for three household level interventions, namely, (a) isolated use of improved water access, (b) isolated use of improved sanitation access, and (c) the combined access to both improved water and sanitation (or WatSan measure). Section VI also presents the results of the "balancing test" undertaken to examine the quality of correspondence between the treatment and control groups generated through propensity score matching and Section VII contains the concluding remarks on the main results.

II. UNDERSTANDING THE LINK BETWEEN DIARRHEAL DISEASES AND WATER-SANITATION

Improving communities' health and living conditions by reducing the incidence of water related diseases is a common goal of water supply and sanitation. Important characteristics of the improved water services are quantity, accessibility, reliability and quality. The water washed diseases are prevalent in areas with inadequate water supplies for people to keep their hands, bodies, and environments clean. Diarrhoeal diseases, as well as skin and eye infections, are easily spread under these conditions. Water-borne disease transmission occurs through the consumption of contaminated water, and can affect those illnesses transmitted by the faecal-oral route, including diarrhoea.

Diarrhoea is caused by infectious organisms, including viruses, bacteria, protozoa, and helminthes that are transmitted from the stool of one individual to the mouth of another termed the fecal-oral transmission. Human faeces are the primary source of diarrhoeal pathogens although the animal faeces too contain the micro-organisms that can cause diarrhoea. Consequently, these diseases are combated through water quality improvements and by the prevention of casual ingestion of water from contaminated sources (Briscoe 1977). The diarrhoea can spread from person to person as well, aggravated by poor personal hygiene. Food is another major cause of diarrhoea when it is prepared or stored in unhygienic conditions (Keusch *et al.* no date). In short, poor sanitation, lack of access to clean water, inadequate personal hygiene including unsafe food are frequently cited as the key factors underlying the occurrence and spread of diarrhoea. Figure 1 depicts the transmission routes of diarrhoea pathogens.

Figure 1: Water Treatment, Sanitation and Hygiene Barriers to Disease Transmission: Faecal-Oral Contamination



Source: Waddington *et al*. (2009), 3ie.
Note: Arrows represent transmission routes for pathogens.

III. DATA

To assess the impact of improved drinking water and sanitation/toilet facility on the diarrhoea incidence among children, the study has used the data from two sources, namely, from the country's two largest household sample surveys. One of them is the well known Bangladesh Demographic and Health Survey (BDHS). The present study used the BDHS data for 2007 round (NIPORT *et al.* 2009). The other data source is the "Multiple Indicator Cluster Survey" (MICS) that the Bangladesh Bureau of Statistics (BBS) and the UNICEF jointly conduct periodically since 1995 to monitor the situation of women and children in Bangladesh. The present study has used the information collected in 2006 round of survey (BBS/UNICEF, 2007). For the impact analysis through the PSM technique, the paper uses BDHS data only. The MICS data set is used mainly to generate descriptive statistics on diarrhoea incidence.

Both the surveys contain information on drinking water sources and access to sanitation at the household level as well as data on the incidence of diarrhoea among children aged below 5 years during the last 15 days prior to the interview. Both the surveys have used standard definition of diarrhoea viz., three or more loose or watery stools per day and/or blood in stool, and this information was collected from mother or caretaker. Besides information on water, sanitation and diarrhoea, the BDHS collects other information on household socio-economic condition, fertility, fertility preference, family planning, infant and child mortality, maternal, new-born and child health, nutrition of children and mother, HIV/AIDS, women empowerment and domestic violence. MICS contains information on socio-economic characteristics of the household, nutrition of the children, child health, hygienic behaviour like hand-wash practice after defecation, disposal of child's faeces, reproductive health, child development, education and child protection.

Both the BDHS and MICS are nationally representative sample household surveys. The BDHS 2007 has covered the entire population residing in private dwelling units and is based on two-stage stratified sample of households. At the first stage of sampling, 361 PSUs were selected and the selection was done independently for each stratum with probability proportional to PSU size in terms of number of households. At the second stage, 10,819 households were selected from the selected PSUs using equal probability systematic sample. In total, 11,458 women aged between 10 and 49 were interviewed from these selected households. In this study we have considered the cohort of *currently married women* aged 15-49 years. The number of such women interviewed from these households was 8,319 with corresponding 8,585 children aged under 5 years (NIPORT *et al.* 2009).[2]

[2] In the case of selecting samples for MICS, the country was divided into 5 strata: municipal, City Corporation, rural, slum, and tribal areas. From these strata, 1,950 PSUs were selected using probability proportional to size (PPS) method. The number of

IV. WATER, SANITATION AND CHILDHOOD DIARRHOEA: ACCESS, PATTERN AND PREVALENCE

Before making an effort to estimate the impact of improved water-sanitation interventions on the incidence of childhood diarrhoea, it may be useful to have an idea about the current sources of drinking water and access to sanitation as well as the status of diarrhoeal sickness among children in Bangladesh.

4.1 Access to "Safe" Water

In Bangladesh, drinking water supply is predominantly based on ground water sources. In the context of very high prevalence of diarrhoeal diseases in Bangladesh, bacteriological quality received priority as a criterion for drinking water supply. Ground water being free from pathogenic micro-organisms and being available in adequate quantity in the shallow aquifers, the water supply through shallow tube wells for scattered rural population soon appeared a viable option (DPHE, no date). This enabled even the private drillers to install hand-pump tube wells at affordable cost. The external donors also generously supported the construction of hand-pump tube wells throughout the country. Through the expansion of low-cost shallow tube wells Bangladesh achieved a remarkable success in providing safe drinking water, especially in rural areas.

Currently, the overwhelming majority of the households have access to such improved sources of water for drinking purpose. At the national level, 97 per cent of the households fetch drinking water from these improved sources. There is very little variation between rural and urban areas in this respect as per the BDHS 2007 data. The 99.5 per cent of the households in urban areas and 96.5 per cent houholds in rural areas have access to improved water sources for drinking purpose; the breakdown of urban access to improved sources shows that 27.3 per cent of the household fetch drinking water from piped water inside dwelling, 3 per cent from public tap/standpipe and 69.1 per cent from tube well. In rural area, 95.7 per cent households collect drinking water from tube well, 0.3 per cent from piped water inside or outside dwelling, and another 0.3 per cent from protected well (BDHS 2007). Access of rural/urban areas to different drinking water sources is given in Table I.

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households interviewed from these PSUs was 62,463 and the number of women aged 15-49 interviewed from these households was 69,860. The MICS 2006 survey has collected complete information on 31,566 children aged under 5.

TABLE I
SOURCE OF HOUSEHOLD DRINKING WATER

Source of drinking water	Per cent households		
	Urban	Rural	Total
Improved sources	99.5	96.5	97.1
Piped water into dwelling/yard/plot	27.3	0.1	6.0
Public tap/standpipe	3.0	0.2	0.9
Tube well	69.1	95.7	89.9
Protected drug well	0.1	0.3	0.2
Rainwater	0.0	0.1	0.1
Non-improved sources (unprotected drug well/spring, surface water, etc.)	0.5	3.5	2.8

Source: NIPORT *et al.* (2009).

However, the scenario of the coastal, hilly, urban slums and some of the so-called "pocket areas" such as charland—together these diverse categories actually cover a large geographical space—is somewhat different in this respect. In the coastal belt, high salinity in the surface and ground water remains a major cause of safe water scarcity. The hilly and stony features of some areas are also hampering the supply of safe drinking water. Studies carried out in the mid-2000s show that only about two-third of the households of the Chittagong Hill Tracts (CHT) have access to tube well facilities within a mile distance of their house, and as few as 3 per cent of the households in these areas own a tube well (Ministry of Health and Family Welfare 2004).[3]

New challenges have also surfaced in the area of safe drinking water provisioning. Arsenic contamination of shallow aquifers in many parts of the country has made shallow tube well water unsafe for drinking. Arsenic in the tube well water was first identified in 1993. At present, 280 out of 463 Upazilas (sub-district) report arsenic problem, although the degree of contamination varies across regions (DPHE, no date). Excess amount of arsenic intake above the permissible limit in human body makes "Arsenicosis diseases." Interestingly, the maximum permissible limit for Bangladesh is 0.05 mg/l, which is more liberal than the WHO guideline value, 0.01 mg/l. As reported by the Bangladesh

[3]The implementation of the Chittagong Hill Tracts Development Facility (CHTDF) project by GoB/ UNDP may have increased this access figure in the recent years, but the relative disadvantage with respect to water and sanitation access in these belts vis-a-vis the rest of the country still remains valid.

Arsenic Mitigation Water Supply Project (BAMWSP), 29 per cent of the tube wells tested had arsenic contamination (DPHE, no date). The Bangladesh Demographic and Health Survey of 2004 round by physical verification of the household drinking water could find that one in twelve (8.5 per cent) households had elevated arsenic level in the drinking water (NIPORT *et al.* 2005).

Although an overwhelming proportion of the country's population has access to improved water sources for drinking purpose, many still continue to use water from unsafe sources to meet their "non-drinking" personal and domestic needs such as cooking, bathing, and washing utensils. According to the Bangladesh Bureau of Statistics (BBS), only 55 per cent of the households at the national level used water from improved sources to meet such needs in 2008. The proportion of households using improved sources for meeting other water needs was 48 per cent in rural area and 73 per cent in urban area (BBS 2009). Of the unimproved sources, the major supplier of water for other use has been the surface water from the "pond." Every day 20,000 metric tons of human excreta are deposited on the public lands and waterways, which serve as the major source of contamination of surface water (Ministry of Health and Family Welfare 2004). Given these accounts, notwithstanding notable success of Bangladesh in making provisions for drinking water, many challenges are still ahead to ensure *safe water provision for all and for all types of use*.

4.2 Access to Sanitation

In contrast to accessing safe water, the degree of success achieved in respect of sanitation access has been much more modest in Bangladesh. As is known, access to sanitary toilet has strong relevance for diseases like diarrhoea, dysentery, typhoid, etc. The improved access to sanitation is defined in the present paper as provisions having a system of "flush/pour flush to piped sewer system/septic tank/pit latrine," combined with "pit latrine with slab" (see, Table II). If one adopts this definition, only about one-fourth of the households at national level would be classified as having access to improved sanitation in 2007. The matched figures for urban and rural areas are 37 per cent and 22 per cent, respectively. This implies that the overwhelming majority households in both urban and rural areas still use non-improved facilities only; in fact, 2 per cent of urban households and 10 per cent of rural households do not have any facility even (BDHS 2007). The "pit latrine with slab" represents the most important category among the improved toilet types in rural areas, while the latrine with "flush/pour flush provision to septic tank" is the dominant category among improved toilet types in urban areas. Table II presents the pattern of toilet provisions of the rural and urban households as it existed in the country in 2007.

TABLE II
HOUSEHOLD SANITATION FACILITIES

Type of toilet/latrine facility	Per cent households		
	Urban	Rural	Total
Improved facility	37.4	22.0	25.3
Flush/pour flush to piped sewer system	5.9	0.1	1.4
Flush/pour flush to septic tank	20.3	5.7	8.9
Flush/pour flush to pit latrine	3.9	3.0	3.2
Pit latrine with slab	7.3	13.1	11.8
Non-improved facility	62.5	78.0	74.6
No facility (bush/field)	1.8	10.2	8.4

Source: NIPORT *et al.* (2009).

4.3 Prevalence of Childhood Diarrhoea

Due to lack of civil registration system, little is known about the causes of child death in Bangladesh, while data for morbidity is even scarce. Yet, as the evidence suggests, diarrhoea, measles, fever and acute respiratory diseases account for most of the child deaths in Bangladesh (Chen, Rahman and Sardar 1980, Salway and Nasim 1994, Baqui *et al.* 1998, 2001). The available evidence further suggests that with the decline in child mortality in recent decades there has been a decline in child mortality in all categories of causes of death (Baqui *et al.* 2001). The importance of leading causes of child death has therefore remained largely unchanged in the country. Thus, the diarrhoea, which was once the number one killer, is still one of the top five leading causes of child death in the country (Rahman *et al.* 2005, NIPORT *et al.* 2005). It may be noted, however, that over the past three decades, the country has experienced a significant decline in child mortality; the rate has come down from 200 in 1978-84 to 155 in 1991, dropping further to 65 in 2007[4] (Salway and Nasim 1994, NIPORT *et al.* 2009). This suggests a more than two-third decline in under-5 mortality in the country since the late 1970s.

In the mid-1970s, the diarrhoea was responsible for about 44 per cent of the deaths among children aged 1-4 (Chen, Rahman and Sardar 1980); in the mid-1990s, this share came down to around one-fifth (Baqui *et al.* 1998, 2001). In 2004, as per the BDHS data, 9.3 per cent of the deaths among children aged 1-4 years were due to diarrhoea; the latter accounted for 10 per cent of the postnatal deaths and 5 per cent of under 5 deaths. The virulence of the diarrhoea in causing child death has come down therefore substantially in recent decades.

1 rates are per 1000 live births

The present diarrhoea situation in Bangladesh looks favourably even in cross-country comparisons too. The recent statistics gathered from the DHS studies confirm this: the matched rate for Bangladesh (i.e. 9.8 per cent as per the BDHS 2007) is much lower than that in many contemporary African countries. It is lower than that in Nepal (11.9 per cent), half of that in Pakistan (21.8 per cent) and Cambodia (19.5 per cent), and roughly similar to the level observed in India (9 per cent), Philippines (9 per cent), and Egypt (8.5 per cent) (see, Table III).

TABLE III
INCIDENCE RATE OF DIARRHOEA IN DIFFERENT COUNTRIES

Country and year	Incidence rate (%)
Bangladesh - 2007	9.8
Cambodia - 2005	19.5
Egypt - 2008	8.5
Ethiopia - 2005	18.0
India – 2005-06	9.0
Indonesia - 2007	13.7
Kenya - 2003	16.0
Nepal - 2006	11.9
Pakistan – 2006-07	21.8
Philippines - 2008	9.0

Source: DHS Reports for different countries.

The BDHS data also suggests that the diarrhoea incidence in Bangladesh is highest among children aged between 6 and 23 months. The male children are more vulnerable to these diseases compared to the female children. The incidence rate is roughly similar across rural and urban areas, though some regional variation can be observed. According to BDHS 2007, the incidence rate is highest in Chittagong, Dhaka and Sylhet divisions (around 11 per cent), while Rajshahi division reports the lowest incidence (7.6 per cent). As expected, mother's education is inversely associated with the incidence of diarrhoea among children, but threshold effects seem to be important here. According to BDHS 2007, mother's education up to primary level has no impact on the occurrence of these diseases. The BDHS 2007 survey also suggests very little wealth quintile effects: except for the richest quintile, the household wealth position matters little for the incidence of childhood diarrhoea in Bangladesh. However, MICS data tell a different story in this regard, indicating more systematic progression of the diarrhoea incidence according to the wealth quintiles (see, Annex Table 2).

4.4 Water, Sanitation and Diarrhoea: Puzzles in the Bi-variate Association

Both BDHS and MICS data show that the improved sources of drinking water and improved sanitation have (surprisingly) little association with the occurrence of childhood diarrhoea in Bangladesh (see, Table IV). Access to improved sources for drinking water in Bangladesh is *not* associated with lower incidence of diarrhoea among children; rather, the pattern is quite reverse apparently. This may be observed from both BDHS 2007 and MICS 2006 rounds. Not only the improved drinking water sources but most of the water related variables signifying water quality (such as quality of non-drinking water, treatment of water before drinking) show no expected association with the diarrhoea incidence. The only water related variable showing an expected association with diarrhoea is the distance of quality drinking water source from the household location i.e. the higher the distance of water source, the greater is the diarrhoea incidence. This association perhaps reflects, among other things, the higher availability/non-availability of water for domestic and other use. Most importantly, the difference in the group mean between the "improved" and "not-improved" water categories/variables is found to be statistically insignificant, suggesting variation in water quality apparently matters little in explaining the variation in the diarrhoea incidence among children in Bangladesh. This is not a new finding entirely though. The access to improved water sources for drinking purpose did not exhibit any favourable relationship with reduced rate of diarrhoea in Bangladesh even in the past literature (Khan *et al.* 1978, Levine, Khan, D'Souza and Nalin 1976, Curlin, Aziz and Khan 1977, Briscoe 1977).

In contrast to the role of improved water supply, the improved access to sanitation shows the expected association with diarrheal incidence among children in Bangladesh. Children from the households with improved toilet facility report lower incidence of diarrhoea. Both BDHS and MICS data sets reveal the same pattern in this respect. The nature of toilet use (such as "whether the facility is shared or not") also displays expected association with diarrhoea (see, Table IV). However, as with water access, the differences in the group mean between "improved" and "non-improved" categories again turn out to be statistically insignificant. Hence, based on mere bivariate association at the descriptive level, it is difficult to ascertain whether improved water or sanitation access have any desirable effects on the incidence of diarrhoea.

Interestingly, the hygienic behaviour/practice has expected association with lower incidence of diarrhoea. Thus, the practice of hand wash after defecation using soap or ash, and hygienic disposal of child stool are associated with lower incidence of diarrhoea. But these differences are not statistically significant again (see, Table V).

TABLE IV
DIARRHOEA INCIDENCE AMONG CHILDREN BY WATER AND SANITATION VARIABLES

Water and sanitation variables	BDHS 2007		MICS 2006	
	% attacked by diarrhoea	Number of cases	% attacked by diarrhoea	Number of cases
Drinking water				
Improved	10.0	4,961	7.2	2,177
Not-Improved	8.3	757	6.3	73
Non-drinking water				
Improved	10.1	3,927	na	-
Not-Improved	9.0	1,791	na	-
If treated water before drink				
Yes	12.7	251	7.3	128
No	10.0	3,801	7.1	2,116
Distance of drinking water				
On premise or within 15 minutes' distance	na	-	6.9	1,874
More than 15 minutes dist.	na	-	8.5	376
Toilet facility				
Improved	9.4	1,918	6.2	661
Not-improved	10.0	3,801	7.6	1,585
Whether toilet is shared				
Yes	na	-	7.6	940
No	na	-	6.7	1,089

Note: na- data not available on that particular variable.

TABLE V
INCIDENCE OF DIARRHOEA BY HYGIENIC PRACTICE

	Prevalence rate (%)
Hand wash after defecation	
Water or water and soil	8.1
water and soap or water and ash	6.7
Disposal of stool of the child	
Hygienic	7.1
Not- hygienic	9.1

Source: MICS 2006.

V. METHOD OF ESTIMATION: RELEVANCE OF THE PSM TECHNIQUE FOR IMPACT EVALUATION

As is well known, the above observations gathered from bi-variate analysis of the data are less than perfect. To evaluate the ultimate impact of water and sanitation on diarrhoea prevalence among children, we have used the propensity score matching (PSM) technique—an evaluation technique that gained increased application in the field of impact evaluation (See, Ravallion 2003 for a succinct review). Rosenbaum and Rubin (1983) introduced the PSM technique in the field of labour economics and it is now considered as an appealing tool for impact evaluation, as it ensures the similarity of treatment and control groups based on observable characteristics. PSM also liberated us from the potential rise of selectivity problem which is a common concern in impact evaluation studies using cross-section data.

PSM has overwhelming advantage over OLS. While OLS takes all the observations into account, PSM only takes the matched observations—matched on the basis of observable characteristics. Using only the matched samples, PSM reduces estimation bias. Besides, the estimators are generally found to be more robust to model misspecification (Conniffe, Gash and O'Connell 2000, Rubin and Thomas 2000). While PSM controls for observed heterogeneity through matching of the propensity scores, it assumes conditional independence from unobserved heterogeneity.

The propensity score (PS) measures the conditional probability of household's participation in an intervention given its observable characteristics, X. In other words,

$$PS= P(X) =P(T=1 \mid X)=f(X) \tag{1}$$

The predicted value of standard binomial logit model is drawn as propensity score and PSM results are robust to alternative specifications for the logistic regression (Dehejia and Wahba 1999). However, choice of covariates in the estimation of propensity score should maintain two assumptions of '*Conditional Independence Assumption'* (CIA) and common support. CIA requires the outcome variables must be independent of treatment assignment. Hence, implementing matching requires choosing a set of observable covariates X which are unaffected by participation in the programme. To maintain CIA, we used a set of observable characteristics of households- all of which are unaffected by participation in water and sanitation treatment.

Besides CIA, a further requirement of common support needs to be maintained in propensity score matching. This condition rules out the perfect predictability of covariates in participation of water and sanitation programme and it ensures that persons with the identical characteristics have a positive probability of being both participants and non-participants to the programme (Heckman, LaLonde and Smith 1999).

So long CIA and common support conditions hold, estimated propensity score would allow us to construct "comparison groups" by matching propensity scores of households with water and sanitation and households without water and sanitation. Once programme samples are matched with control samples, the difference between the mean outcome of the programme samples and the mean outcome of the matched control samples can be measured. This difference is defined as "the average effect of treatment on the treated" (ATT).

The PSM estimate of ATT can be obtained as follows:

$$ATT= E_{P(X)|T=1}\{E[Y(1)|T=1, P(X)]-E[Y(0)|T=1, P(X)]\} \quad (2)$$

ATT can be interpreted as the mean difference in outcome over the common support—appropriately weighted (in case of Kernel Matching)—by the propensity distribution of participants.

However, estimation of propensity score only is not enough to estimate the ATT of interest using equation (2). This is because the possibility of observing two samples, one from treatment and other from control, with same propensity score is in principle zero, since propensity score, P(X), is a continuous variable. Several matching methods have been proposed in the PSM literature to overcome this problem. We do not discuss the technical details of all methods[5] here; rather we will discuss two most widely used matching methods, nearest neighbour matching (NNM) and kernel matching (KM), and select one matching method for our evaluation purpose. When there is substantial overlap in the distribution of propensity score between the control and treatment groups, both of the matching algorithms will yield similar results.

With kernel matching all untreated observations are used to estimate the missing counterfactual outcome and greatest weight is given to people with closer scores, whereas with NNM method only the closest neighbours within caliper are used. NNM method faces the risk of bad matches if the closest neighbour is far away. This can be avoided by imposing a tolerance level on the maximum propensity score distance which is known as caliper. However, it is difficult to know *a priori* what choice for the tolerance level is reasonable (Smith and Todd 2005). Moreover, estimation of ATT is sensitive to the sort order of

[5] See Smith and Todd (2005) or Imbens (2004) for more technical details.

data. Since the weighted average of all samples from the control group is used to construct the counterfactual outcome, kernel matching has an advantage of lower variance because more information is used (Heckman, Ichimura, Smith and Todd 1998). Hence, *we decided to estimate ATT using 'kernel matching technique' with a view to analyse the effect of water and sanitation interventions on the diarrhoea prevalence* among the children in Bangladesh.

In order to get unbiased estimate of ATT and to assess the matching quality, we have also done the "balancing test," which is primarily concerned with the extent to which the differences in the covariates between the treated and control groups have been eliminated so that any difference in outcome variables between the two groups can be inferred as coming mainly from the treatment or intervention (Heckman and Smith 1995). There are two ways through which balancing of the covariates can be examined. First, t stats of difference in means of covariates in the treated and non-treated groups—before and after matching—are used to examine the quality of the matching. Before matching, differences between the groups are expected; but after matching, the covariates should be similar (balanced) in both groups and hence no significant differences should be found (Caliendo and Kepeinig 2005). And standardised bias,[6] before and after matching, together with the achieved percentage reduction in bias, is also used to assess the matching quality. The percentage reduction in bias in the selected covariates after matching for the present exercise is given in Annex Table 3.

Under the PSM approach, we have matched households who actually participated in the intervention of improved water and improved sanitation with households that share similar characteristics but did not participate in such water and sanitation intervention in anyway. Once the matching is made, we computed the average effect of treatment on the treated (ATT). In the application of PSM technique, we used STATA 10.0 version using psmatch2 package, a PSM function, developed by Leuven and Sianesi (2009).

VI. ESTIMATES OF WATSAN INTERVENTIONS ON DIARRHOEA INCIDENCE: EVIDENCE FROM DHS DATA

We estimate the impacts by using DHS data in three stages: (a) at the first stage, we estimate a participation equation to derive the "propensity score" across

[6] Standardised bias is defined as the difference of sample means in the treated and matched control sub samples as a percentage of the square root of the average of sample variances in both groups.

all the DHS households irrespective of their "treatment status;"[7] (b) at the second stage, we estimate the magnitude of ATT using alternative matching methods such as common support, caliper and the kernel; (c) at the third stage, the "balancing test" has been performed to assess the matching quality between the treatment and the control groups in the matched sample.

6.1 Correlates of Participation and Estimation of Propensity Score

As a first step, impact evaluation through propensity score matching requires the estimation of propensity score using standard probability model with a binary dependent variable to indicate the presence (or absence) of intervention with a number of independent covariates. In our case, we estimate binomial logit model to estimate propensity scores for the purpose of matching the treatment and control groups. We generate three sets of propensity scores using three different binary outcome variables. These variables are access to improved source of water, access to improved sanitation, and access to both improved water and improved sanitation (denoted by "WatSan," henceforth). The binary outcome for water intervention takes a value of one if the household has access to improved water sources and zero otherwise. Similarly, binary outcome for sanitation treatment takes a value of one if the household has access to improved sanitary latrines and zero otherwise. The third binary outcome combines water and sanitation treatment and it takes a value of one if the household has access to both improved water sources and improved sanitation, and zero otherwise.

The covariates comprised a wide range of controls such as demographics, education, religion, wealth and regional dummy variables. From the variables in the DHS 2007, we consider age and gender of the household head, household size, religion, education status of women respondents[8] and their partners. The education status has been defined as the "categorical dummies" to capture the "threshold effects" of human capital rather than as a continuous variable. We also consider the employment status of the women respondents (as paid work can have implications for time devoted to child care). We control for the wealth status of the households (the summary wealth score for each household has already been included in the DHS data set) as proxy indicator of income. It has

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[7]The "treatment status" in this case defined as whether a particular household has adopted improved drinking water or improved access to sanitation or both.

[8]We have been suggested by the referee to include hygiene variables into the model. As no hygiene variable is available in the DHS data set, we use mother's education (respondent's schooling years) as a proxy of the hygienic behaviour of the households. MICS 2006 data suggested a strong correlation between mother's education and hygienic practices.

been argued that wealth is a more accurate measure of economic status than income due to under-reporting of income (Khanna 2008, Carter and Barrett 2005). We also separately consider the ownership of homestead land and access to media (television) as additional variables. Finally, we include regional dummies to account for geographic fixed effects.

The estimation of propensity score was calculated by applying the procedure discussed previously in the section on methodology. The estimates of the logit regressions for generating propensity scores are reported in Table VI. Most of the covariates are statistically significant (at least up to 10 per cent level) in influencing the likelihood of participation in the "treatment" however defined. All significant variables appear with expected signs in all three alternative specifications of the dependent binary variable regarding water and sanitation.

TABLE VI
COEFFICIENTS OF BINOMIAL LOGIT MODEL ESTIMATED FOR GENERATING PROPENSITY SCORE (CALIPER 0.0005)

Dependent Variable: Treatment=1, Control=0	Water		Sanitation		WatSan	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
Constant	2.380	0.561***	-0.887	0.368**	-1.653	0.360***
Age of Household Head (HH)	-0.074	0.018***	0.018	0.012	0.043	0.012***
Squared Age of HH	0.001	0.000***	-0.000	0.000	-0.000	0.000***
Gender of HH (Male=1)	0.560	0.147***	-0.103	0.112	-0.080	0.109
Household Size	-0.073	0.014***	0.011	0.011	-0.019	0.011*
Respondent's Education (Reference Category: Below Primary)						
Respondent Completed Primary Education	0.182	0.137	0.018	0.088	0.105	0.087
Respondent Completed Secondary Education	0.144	0.150	0.210	0.097**	0.334	0.095***
Respondent Completed Higher Education	-0.102	0.245	0.305	0.179*	0.691	0.162***

(Cont. Table VI)

Dependent Variable: Treatment=1, Control=0	Water		Sanitation		WatSan	
	Coeff.	Std. Err.	Coeff.	Std. Err.	Coeff.	Std. Err.
Partner's Education (Reference Category: Below Primary)						
Partner Completed Primary Education	0.018	0.130	0.085	0.084	0.125	0.083
Partner Completed Secondary Education	0.077	0.146	0.057	0.096	0.134	0.093
Partner Completed Higher Education	-0.382	0.202*	0.194	0.142	0.273	0.133**
Respondent Employed, (Yes=1)	0.455	0.131***	-0.078	0.078	-0.100	0.075
Urban or Rural (Urban=1)	0.534	0.114***	0.158	0.074**	0.338	0.070***
Religion (Muslim=1)	-0.127	0.160	-0.010	0.109	-0.060	0.106
Wealth Dummy (Reference Category: Richest Wealth Quintile)						
Poorest	0.750	0.222***	-1.945	0.141***	-2.204	0.134***
Poorer	0.195	0.184	-1.397	0.122***	-1.680	0.117***
Middle	-0.602	0.160***	-0.976	0.112***	-1.313	0.107***
Richer	0.003	0.147	-0.450	0.100***	-0.718	0.093***
Any Homestead Land (Yes=1)	2.204	0.114***	0.496	0.077***	0.713	0.075***
Whether have TV (Yes=1)	0.136	0.111	-0.004	0.074	0.095	0.072
Division Dummy (Reference Category: Dhaka)0						
Barisal	-0.306	0.178*	0.468	0.117***	0.587	0.112***
Chittagong	-0.098	0.151	0.226	0.101**	0.373	0.97***
Khulna	-0.357	0.174**	0.323	0.115***	0.292	0.112***
Rajshahi	-0.098	0.173	0.359	0.110***	0.524	0.104***
Sylhet	-0.269	0.156*	0.332	0.105***	0.356	0.103***
Whether living in slum (yes=1)	-	-	-0.387	0.305	-0.457	0.299
Pseudo- R^2	0.2335		0.0896		0.1617	
Log-likelihood	1540.9038		-3000.7343		-3297.1568	
Prob>Chi^2	0.000		0.000		0.000	

Note: *, **, and *** denote statistical significance at the 10, 5, and 1 per cent levels, respectively. WatSan=1 if both water and sanitation are improved, and WatSan=0 if otherwise.

Some of the results of the participation equation, as presented in Table VI, can be instructive for understanding household behaviour. Here we focus on the results of the third (the so-called "WatSan" model) variant, which focuses on the correlates of adopters of both improved water and sanitation. Four features of the adoption behaviour are noteworthy. *First*, the wealth status matters. The poorest and the poor have much lower chances of using WatSan compared with the richest category. One implication of the finding is that without addressing asset-poverty it would be difficult to achieve the universal coverage of WatSan just by relying on the behavioural change factors alone. Note, however, that for the water use, the wealth effects are not important. This may be because the poor and the poorest households often take advantage of community tubewells and/ or fetch water from their richer neighbours. *Second*, education seems to have threshold effects. Thus, primary education is not a significant correlate of adoption. It is only when the respondents have at least secondary education then the chances of adopting both improved water and sanitation measures increase significantly compared with households with "below primary" level of education. In the context of high adult illiteracy among the reference population only a very few have completed secondary education. Thus, achieving the target of universal WatSan coverage would be limited by the spread of secondary education. *Third*, larger household size is negatively correlated with the adoption of WatSan, although the precise channel through which such effects percolate need to be explored further.[9] *Fourth*, social characteristics such as religion or female headedness are not important correlates for the improved water/sanitation adoption behaviour.

6.2 Estimation of ATT for Water, Sanitation and WatSan

After generating the propensity scores, we proceed to estimate the average treatment effects on the treated by taking the mean difference in mean outcomes between treatment and control groups. In the estimation of ATT, we impose common support as well as caliper. Imposition of common support excluded the treatment observations with propensity scores outside the boundary of the highest and lowest propensity scores of the control group. Imposition of caliper ensures the matching of treatment observations with the control observations only within a limited range of probability and we arbitrarily determine the level of caliper in our case as 0.0005. Applying common support as well as caliper enhances the match quality as well as precise estimation of ATT. Use of common support and caliper reduces significant number of observations however. The number of

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[9] This is not to be attributed to poverty effects—poverty and household size is positively correlated in Bangladesh—as the model controls for the wealth status.

observations—from treated and control groups—that has been *off-supported* due to application of common support and caliper has been presented in Table VII. In estimation of ATT considering water treatment, 1,870 observations (127 from control and 1,743 from treated) have been off-supported out of 4,988 observations. In the case of sanitation treatment, 572 observations (391 from control and 181 from treated) have been off-supported out of 5,044 observations. Similarly, when we consider water and sanitation combined, 975 observations have been off-supported out of 6,019 observations.

TABLE VII
USE OF COMMON SUPPORT (CALIPER 0.0005)

Intervention		Common Support		Total
		Off support	On support	
Water	Control	127	566	693
	Treated	1,743	2,552	4,295
	Total	1,870	3,118	4,988
Sanitation	Control	391	2,837	3,228
	Treated	181	1,635	1,816
	Total	572	4,472	5,044
WatSan	Control	563	3,289	3,852
	Treated	412	1,755	2,167
	Total	975	5,044	6,019

The estimates of ATT are shown in Table VIII for the three categories of water and sanitation types using kernel matching. The choice of kernel matching as *the preferred method* for the estimation of ATT has been explained earlier in the methodology section in Section V. We find that, for water treatment, the difference in diarrhoea incidence between treatment and control groups is not statistically significant and this is true for both unmatched and matched samples. *This finding implies that only access to safe water does not make significant difference in diarrhoea incidence between the treatment and control groups.*

One plausible explanation is widely mentioned in literature that quality of non-drinking water might be important in explaining diarrhoea incidence. We examine the impact of using improved water for non-drinking purpose and the result shows no significant differences between ATTs of treatment and control households (see, Annex Table 1). The same applies to sanitation treatment. Here again, the ATT shows no significant difference between the treatment and control groups in both matched and unmatched samples. It is altogether a different story with respect to the *combined access* to improved water and sanitation. For WatSan, the difference in the mean of probabilities of diarrhoea incidence in the matched sample increases by about 5 percentage points in the control group compared to the treatment group. However, the more relevant measure would be to calculate *per cent differences*, especially from the perspective of cross-country comparison. The latter measure shows that the diarrhoea incidence is 41.8 per cent higher in the control group vis-à-vis the treatment group. This is a big effect by any measure. The ATT for WatSan is statistically significant at 5 per cent level. The results thus suggest a strong case for the combined use of water and sanitation measures to reduce diarrhoea with implications for public policy. Note that, for the unmatched sample, the difference between the two groups is not statistically significant. This shows the insights that the PSM method brings to the quality of impact assessment.

The above finding regarding the role of combined access of water and sanitation is found robust to the use of survey data. Thus, we find further support for the above from the analysis of the MICS 2006 data as well, which showed the importance of combining water, sanitation *and health-washing practices* in reducing the incidence of child diarrhoea.[10]

TABLE VIII
PSM ESTIMATES OF ATT FOR PROBABILITY OF DIARRHOEA INCIDENCE FOR DIFFERENT INTERVENTIONS BASED ON KERNEL MATCHING (CALIPER 0.0005)

		Treatment	Control	Δ	S.E.	T-Stat
Water	Unmatched	0.0936	0.0779	0.0157	0.0118	1.33
	Matched	0.0979	0.0944	0.0035	0.0332	0.11
Sanitation	Unmatched	0.0897	0.0926	-0.0029	0.0084	-0.34
	Matched	0.0905	0.1070	-0.0165	0.0145	-1.13
WatSan	Unmatched	0.0890	0.0914	-0.0023	0.0077	-0.30
	Matched	0.0912	0.1293	-0.0381	0.0143	-2.67**

Note: ** denotes statistical significance at the 5 per cent level.

6.3 Balancing Test

In order to assess the matching quality, the "balancing test" has been performed. Before matching, differences in observable characteristics between treated and control households are expected. However, when kernel type matching has been performed, differences in observable characteristics between treated and control households should be reduced significantly. Table IX presents observable characteristics (e.g. age of household head, parent's education, wealth status, etc.) of both treated and control households before matching and after matching for the WatSan example. Before matching, in all cases, observable characteristics of households significantly differ between treated and control groups. However, after kernel type matching is performed, difference in

[10] The MICs results do not form the core of the present paper. However, the relevant results are available from the authors on request.

observable characteristics has become considerably smaller, and in most cases, statistically insignificant. This is expected, as ATT has been estimated based on the propensity scores of those households who share similar observable characteristics. It may be noted that the control and treated groups are comparable in terms of both age and sex of the child.[11] Before matching, age showed significant variation between the two groups but after kernel matching, the difference has become insignificant. The sex of the child variable was insignificant in both before and after matching (Table IX).

"Balancing test" also provides reduction of standardised bias which has been reported in Table IX. Reduction in standardised bias is much higher for all observable characteristics of the households under consideration. The results of "balancing test" thus confirm the quality of kernel type matching and support that the estimates of ATT are reliable based on the data from the 2007 round of BDHS.

TABLE IX
MAJOR OBSERVABLE CHARACTERISTICS OF HOUSEHOLDS BEFORE AND AFTER MATCHING (CALIPER 0.0005)

		Water			Sanitation			WatSan		
		Treated	Control	|t/z| stat	Treated	Control	|t/z| stat	Treated	Control	|t/z| stat
Age of Household Head (HH)	Unmatched	40.80	48.92	14.21	42.52	41.54	2.35	42.58	41.56	2.69
	Matched	41.35	42.47	2.75	42.49	42.57	0.16	42.38	42.52	0.29
Sex of h'hold head	Unmatched	0.92	0.86	5.30	0.90	0.92	2.57	0.90	0.92	2.66
	Matched	0.92	0.92	0.21	0.91	0.90	0.77	0.90	0.90	0.62
Household Size	Unmatched	6.12	8.50	18.27	6.66	6.33	3.45	6.48	6.40	0.92
	Matched	6.26	6.03	3.14	6.61	6.30	2.58	6.54	6.15	3.89
Mother Education (% of Mothers in Each Category)										
Illiterate	Unmatched	0.28	0.21	3.53	0.21	0.31	7.89	0.17	0.32	13.20
	Matched	0.29	0.24	3.76	0.22	0.22	0.34	0.20	0.20	0.17
Primary	Unmatched	0.33	0.27	3.40	0.29	0.35	4.49	0.25	0.34	7.29
	Matched	0.32	0.38	4.65	0.30	0.29	0.96	0.29	0.28	0.79
Secondary	Unmatched	0.34	0.42	4.31	0.42	0.31	8.32	0.43	0.29	10.35
	Matched	0.34	0.34	0.09	0.41	0.42	0.71	0.42	0.42	0.44
Higher	Unmatched	0.04	0.09	5.04	0.08	0.03	7.20	0.15	0.03	16.38
	Matched	0.05	0.04	2.33	0.06	0.06	0.00	0.08	0.10	1.93

(Cont. Table IX)

[11] One of the key comments of the anonymous referee was to check in the balancing test whether age and sex of the child vary between the treated and control groups.

		Water			Sanitation			WatSan		
		Treated	Control	|t/z| stat	Treated	Control	|t/z| stat	Treated	Control	|t/z| stat
Father Education (% of Fathers in Each Category)										
Illiterate	Unmatched	0.35	0.26	4.60	0.25	0.39	9.78	0.21	0.40	15.30
	Matched	0.35	0.34	0.62	0.27	0.27	0.12	0.25	0.23	1.14
Primary	Unmatched	0.30	0.28	1.33	0.29	0.31	1.22	0.25	0.30	3.87
	Matched	0.30	0.34	3.20	0.31	0.29	1.14	0.29	0.28	0.45
Secondary	Unmatched	0.25	0.29	1.98	0.30	0.23	5.54	0.31	0.22	7.74
	Matched	0.25	0.25	0.48	0.30	0.33	1.81	0.30	0.31	0.44
Higher	Unmatched	0.09	0.16	6.44	0.15	0.07	9.29	0.21	0.06	17.23
	Matched	0.09	0.06	3.61	0.12	0.11	0.77	0.15	0.16	1.44
Living in Urban	Unmatched	0.33	0.28	2.48	0.41	0.27	10.15	0.49	0.26	18.79
	Matched	0.31	0.26	4.05	0.39	0.40	0.64	0.42	0.41	0.79
Wealth Status (% of Households in Each Category)										
Poorest	Unmatched	0.21	0.07	8.78	0.09	0.25	14.49	0.07	0.27	18.77
	Matched	0.18	0.14	3.53	0.09	0.10	1.47	0.09	0.10	0.98
Poor	Unmatched	0.22	0.17	3.22	0.15	0.25	8.55	0.12	0.25	12.06
	Matched	0.23	0.16	7.24	0.16	0.14	1.64	0.15	0.15	0.23
Middle	Unmatched	0.19	0.30	6.51	0.20	0.21	1.52	0.15	0.20	4.95
	Matched	0.20	0.18	1.48	0.21	0.21	0.39	0.19	0.19	0.09
Richer	Unmatched	0.19	0.23	1.98	0.26	0.16	8.61	0.24	0.16	7.71
	Matched	0.20	0.32	10.44	0.28	0.28	0.19	0.27	0.25	1.00
Richest	Unmatched	0.18	0.23	3.45	0.30	0.12	16.55	0.41	0.11	28.46
	Matched	0.18	0.19	0.51	0.25	0.26	0.52	0.30	0.30	0.22
Having Homestead Land	Unmatched	0.73	0.20	29.88	0.66	0.66	0.45	0.70	0.64	4.50
	Matched	0.72	0.73	0.66	0.65	0.65	0.11	0.67	0.67	0.07
Having TV	Unmatched	0.51	0.56	2.54	0.62	0.46	10.71	0.49	0.47	0.68
	Matched	0.51	0.47	2.18	0.60	0.61	0.50	0.49	0.50	0.57
Age of child (in month)	Unmatched	30.14	28.97	1.61	28.27	30.96	5.21	28.38	31.00	5.58
	Matched	30.08	28.61	3.04	28.39	27.85	0.89	28.28	27.46	1.41
Sex of child (% female)	Unmatched	0.49	0.51	0.76	0.49	0.49	0.38	0.49	0.50	0.68
	Matched	0.49	0.48	0.36	0.49	0.49	0.10	0.49	0.50	0.57

Note: In most empirical studies a bias reduction below 3% or 5% is seen as sufficient (see, Caliendo and Kopeining 2005).

VII. CONCLUDING REMARKS

The combined access to improved water and sanitation has strong effects on reducing the incidence of diarrhoea among children aged below five years. The fact is that it is only the combined access—and not the isolated use of either improved water or improved sanitation—that matters in reducing childhood diarrhoea. The combined access to improved water and sanitation only emerged as the statistically significant factor underlying the difference in diarrhoea incidence between the treatment and control groups in the PSM-matched sample.

In the case of the combined access to improved water and sanitation, the mean probability of diarrhoea incidence for the control group is about *42 per cent* higher than in the case of the treatment group in the matched sample. The ATT for WatSan is statistically significant at 5 per cent level. This is a big effect by any measure.

The results thus suggest a strong case for rethinking public policy by way of encouraging joint public and private (household) investments in water and sanitation measures to reduce diarrhoea. This may be supported by promoting favourable change in hygienic health-seeking behaviour such as sanitary hand-washing practices and in general underscoring the importance of health-conscious home environment. However, it may be noted that the BDHS data do not contain any information on hygienic practices; hence, the effectiveness of these behavioural factors on diarrhoea incidence could not be assessed. The study, therefore, recommends that BDHS collects such information in the future rounds.

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ANNEX TABLE 1

PSM ESTIMATES OF ATT FOR PROBABILITY OF DIARRHOEA INCIDENCE FOR DIFFERENT INTERVENTIONS

		Treatment	Control	Δ	S.E.	T-Stat
Non-drinking Water (Improved=1, 0 Otherwise)	Unmatched	0.093	0.0871	0.005	0.008	0.68
	Matched	0.095	0.057	.037	0.045	0.84
Drinking and Non-drinking Water (Improved=1, 0 Otherwise)	Unmatched	0.093	0.087	0.006	0.008	0.79
	Matched	0.091	0.051	0.040	0.044	0.91

Note:*, **, and *** denote statistical significance at the 10, 5, and 1per cent levels, respectively.

ANNEX TABLE 2

INCIDENCE OF DIARRHOEA AMONG CHILDREN UNDER 5 WITH REFERENCE TO TWO WEEKS PRECEDING THE SURVEY BY BACKGROUND CHARACTERISTICS: BANGLADESH

Background characteristics	BDHS 2007	MICS 2006
Bangladesh	9.8	7.1
Child's age in months		
< 6	4.6	4.7
6-11	13.9	11.1
12-23	14.2	10.1
24-35	10.2	7.0
36-47	7.6	5.7
48-59	7.0	4.9
Sex of the child		
Male	11.0	7.4
Female	8.5	6.9
Residence		
Rural	9.7	7.1
Urban	10.2	7.4
Region/Admn. Division		
Barisal	9.2	8.9
Chittagong	10.9	7.6
Dhaka	10.6	7.1
Khulna	8.7	4.4
Rajshahi	7.6	7.4

(Cont. Annex Table 2)

Background characteristics	BDHS 2007	MICS 2006
Sylhet	10.7	7.5
Mother's Education		
No education	10.0	7.9
Primary incomplete	10.7	8.3
Primary complete	10.4	6.7
Secondary incomplete	9.3	6.2
Secondary complete & higher	8.5	5.5
Wealth Index		
lowest	10.2	8.6
Second	9.6	7.6
Middle	11.2	7.1
Fourth	9.6	5.6
Highest	8.1	6.2

ANNEX TABLE 3

BALANCING TEST: PER CENT OF REDUCTION IN STANDARDIZED BIAS (SB)

Dependent Variable: Treatment=1, Control=0	Water			Sanitation			WatSan*		
	Unmatched Bias	Matched Bias	%reduct |Bias|	Unmatched Bias	Matched Bias	%reduct |Bias|	Unmatched Bias	Matched Bias	%reduct |Bias|
Age of Household Head (HH)	-57.1	-7.9	86.1	6.9	-0.6	91.8	7.2	-1.0	86.2
Gender of HH	19.6	0.5	97.4	-7.4	2.8	62.2	-7.0	2.2	68.4
Household Size	-59.6	5.7	90.4	9.7	9.0	7.6	2.5	12.2	-393.8
Respondent is Illiterate	14.9	10.8	27.3	-23.6	-1.1	95.2	-36.5	-0.5	98.5
Respondent Completed Primary Education	14.2	-13.5	5.0	-13.3	3.3	75.2	-19.8	2.6	86.8
Respondent Completed Secondary Education	-17.4	0.2	98.6	24.2	-2.6	89.4	27.5	1.6	94.3
Respondent Completed Higher Education	-18.2	5.3	71.0	20.0	0.0	100.0	40.2	-6.7	83.4
Partner is Illiterate	19.4	1.8	90.8	-29.1	0.4	98.6	-42.1	3.7	91.3
Partner Completed Primary Education	5.5	-9.2	-67.5	-3.6	4.0	-11.5	-10.5	1.5	85.5
Partner Completed Secondary Education	-8.0	1.3	83.5	16.1	-6.7	58.6	20.5	-1.5	92.4
Partner Completed Higher Education	-23.7	8.2	65.3	26.0	2.8	89.3	43.2	-5.2	88.0
Respondent Employed, Yes=1	28.5	11.9	58.1	-10.6	-5.6	47.5	-11.1	-3.7	66.8
Barisal	4.3	3.6	16.4	-3.5	-2.7	23.1	-1.5	-2.7	-85.4
Chittagong	-11.1	-17.7	-59.3	1.4	3.0	-117.8	4.5	1.8	59.2

(Cont. Annex Table 3)

Dependent Variable: Treatment=1, Control=0	Water			Sanitation			WatSan*		
	Unmatched Bias	Matched Bias	%reduct |Bias|	Unmatched Bias	Matched Bias	%reduct |Bias|	Unmatched Bias	Matched Bias	%reduct |Bias|
Khulna	-4.2	-3.6	13.5	6.8	-1.3	80.3	6.0	0.4	94.1
Rajshahi	9.7	10.4	-8.1	-3.0	-2.2	26.6	3.4	-0.5	86.3
Sylhet	-11.3	-7.2	36.4	2.6	7.6	-187.9	-3.4	12.7	-273.8
Dhaka	14.5	16.8	-15.6	-3.6	-5.0	-36.4	-4.5	6.8	-51.0
Urban or Rural	10.3	11.2	-8.3	29.4	-2.3	92.0	49.5	2.8	94.4
Religion	1.4	-4.6	-224.2	-1.1	1.9	-80.4	-2.9	7.4	-156.8
Poorest	41.1	10.6	74.1	-44.9	-4.2	90.7	-53.7	-2.7	95.0
Poorer	13.7	20.2	-47.9	-25.8	5.2	79.7	-33.6	-0.7	97.8
Middle	-25.2	3.8	84.7	-4.5	1.4	69.6	-13.5	0.3	97.8
Richer	-7.9	-31.3	-290.3	24.6	-0.8	96.9	20.2	3.7	81.5
Richest	-13.6	-1.4	90	46.2	-2.0	95.7	71.9	-0.8	98.8
Any Homestead Land	126.9	-2.0	98.5	1.3	-0.4	70.6	12.2	-0.2	98.0
Whether have TV	-10.4	6.1	41.2	31.5	-1.7	94.5	48.2	1.4	97.1
Sex of the Child (Male=1)	-3.1	1.0	67.1	-1.1	-0.4	67.1	-1.8	-1.9	-6.3
Age of the Child	6.7	8.5	-26.1	-15.7	3.1	80.2	-15.4	4.5	68.8

Note: In most empirical studies a bias reduction below 3% or 5% is seen as sufficient (see, Caliendo and Kopeining, 2005).